Contents

Chapter 1 COMMISSION RULES

1.1 Introduction to the Amateur Radio Service

The Amateur Radio Service, often referred to as ham radio, is a popular hobby and service that brings people, electronics, and communication together. It is a unique blend of technical skill, public service, and international camaraderie. This section introduces the fundamental concepts of the Amateur Radio Service, including its purpose, regulatory framework, and key definitions.

Basis and Purpose of the Amateur Radio Service

The Amateur Radio Service is governed by a set of principles and purposes that guide its operation. According to the Federal Communications Commission (FCC), the primary purpose of the Amateur Radio Service is to advance skills in the technical and communication phases of the radio art. This includes fostering experimentation, improving technical proficiency, and providing a pool of trained operators who can assist in times of emergency. The service also promotes international goodwill by allowing operators to communicate across borders.

Regulatory Authority of the FCC

The FCC is the primary regulatory body responsible for overseeing the Amateur Radio Service in the United States. The FCC establishes and enforces the rules that govern amateur radio operations, ensuring that the service operates in the public interest. These rules are codified in Title 47 of the Code of Federal Regulations, Part 97 (FCC Part 97). The FCC also maintains the Universal Licensing System (ULS), a database that contains information about all licensed amateur radio operators and stations.

Phonetic Alphabet Usage

The use of a phonetic alphabet is encouraged in the Amateur Radio Service, particularly for station identification. The phonetic alphabet helps to ensure clarity and accuracy in communication, especially when dealing with weak signals or noisy conditions. While not mandatory in all situations, its use is a best practice that enhances the effectiveness of amateur radio communications.

License Grants and Documentation

An individual may hold only one operator/primary station license grant at any given time. This license is documented in the FCC ULS database, which serves as the official record of the license grant. The appearance of the license in the ULS database is the definitive proof that the FCC has issued the license. Printed copies or email notifications are not considered official documentation.

Definitions of Beacon and Space Station

FCC Part 97 provides specific definitions for key terms used in the Amateur Radio Service. A *beacon* is defined as an amateur station that transmits communications for the purposes of observing propagation or related experimental activities. A *space station*, on the other hand, is an amateur station located more than 50 km above Earth's surface. These definitions are important for understanding the scope and limitations of amateur radio operations.

Figure 1.1: FCC Regulatory Structure

Term	**Definition**
Beacon	An amateur station transmitting communications for observing propagation
Space Station	An amateur station located more than 50 km above Earth's surface.
License Documentation	The official record of a license grant in the FCC ULS database.

Table 1.1: Key Definitions from FCC Part 97

Questions

T1A01

Which of the following is part of the Basis and Purpose of the Amateur Radio Service?

- A Providing personal radio communications for as many citizens as possible
- B Providing communications for international non-profit organizations
- C **Advancing skills in the technical and communication phases of the radio art**
- D All these choices are correct

The Basis and Purpose of the Amateur Radio Service, as defined by the FCC, includes advancing skills in the technical and communication phases of the radio art. This is the primary goal of the service, making option C correct. Options A and B are not part of the official basis and purpose.

T1A02

Which agency regulates and enforces the rules for the Amateur Radio Service in the United States?

- A FEMA
- B Homeland Security
- C **The FCC**
- D All these choices are correct

The Federal Communications Commission (FCC) is the agency responsible for regulating and enforcing the rules for the Amateur Radio Service in the United States. This is clearly stated in FCC Part 97.

T1A03

What do the FCC rules state regarding the use of a phonetic alphabet for station identification in the Amateur Radio Service?

A It is required when transmitting emergency messages
B **It is encouraged**
C It is required when in contact with foreign stations
D All these choices are correct

The FCC encourages the use of a phonetic alphabet for station identification, but it is not mandatory in all situations. This practice helps to ensure clear communication, especially under challenging conditions.

T1A04

How many operator/primary station license grants may be held by any one person?

A **One**
B No more than two
C One for each band on which the person plans to operate
D One for each permanent station location from which the person plans to operate

An individual may hold only one operator/primary station license grant at any given time. This is a fundamental rule in the Amateur Radio Service.

T1A05

What proves that the FCC has issued an operator/primary license grant?

A A printed copy of the certificate of successful completion of examination
B An email notification from the NCVEC granting the license
C **The license appears in the FCC ULS database**
D All these choices are correct

The official proof of an operator/primary license grant is its appearance in the FCC ULS database. Printed copies or email notifications are not considered official documentation.

T1A06

What is the FCC Part 97 definition of a beacon?

- A A government transmitter marking the amateur radio band edges
- B A bulletin sent by the FCC to announce a national emergency
- C A continuous transmission of weather information authorized in the amateur bands by the National Weather Service
- D **An amateur station transmitting communications for the purposes of observing propagation or related experimental activities**

A beacon, as defined by FCC Part 97, is an amateur station that transmits communications for the purposes of observing propagation or related experimental activities. This definition is specific to the Amateur Radio Service.

T1A07

What is the FCC Part 97 definition of a space station?

- A Any satellite orbiting Earth
- B A manned satellite orbiting Earth
- C **An amateur station located more than 50 km above Earth's surface**
- D An amateur station using amateur radio satellites for relay of signals

A space station, according to FCC Part 97, is an amateur station located more than 50 km above Earth's surface. This definition distinguishes space stations from other types of amateur stations.

Summary

This section introduced the Amateur Radio Service, its purpose, and the regulatory framework established by the FCC. Key concepts include:

- **Purpose of the Amateur Radio Service**: Advancing technical and communication skills, fostering experimentation, and providing emergency communications.
- **Regulatory authority of the FCC**: The FCC regulates and enforces the rules for amateur radio operations in the United States.
- **Phonetic alphabet usage**: Encouraged for clear and accurate station identification.
- **License grants and documentation**: Only one operator/primary station license grant is allowed per person, and the license must appear in the FCC ULS database.
- **Definitions of beacon and space station**: A beacon is an amateur station for propagation observation, while a space station is located more than 50 km above Earth's surface.

1.2 Frequency Coordination and Band Usage

Role of Frequency Coordinators

Volunteer frequency coordinators play a crucial role in managing the allocation of transmit/receive channels and other parameters for auxiliary and repeater stations. These coordinators are recognized by local amateur operators and are responsible for ensuring efficient use of the frequency spectrum. They are selected by amateur operators in a local or regional area whose stations are eligible to be repeater or auxiliary stations. This decentralized approach allows for flexibility and adaptability to local needs.

Frequency Ranges for Technician Licensees

Technician class licensees have access to specific frequency ranges for phone operation. These include the 28.300 MHz to 28.500 MHz segment of the 10-meter band. This range is particularly useful for voice communication and is a key privilege for Technician licensees.

International Space Station (ISS) Communication

Amateur radio operators holding a Technician class or higher license are permitted to contact the International Space Station (ISS) on VHF bands. This privilege allows for direct communication with astronauts and participation in educational outreach programs.

Amateur Band Segments and Their Usage

Amateur radio bands are divided into segments, each with specific uses. For example, the 6-meter band includes frequencies such as 52.525 MHz, while the 2-meter band includes 146.52 MHz. The 219 to 220 MHz segment of the 1.25-meter band is reserved for fixed digital message forwarding systems only.

Figure 1.2: Amateur Radio Frequency Allocation

Frequency Range	**Privileges**
28.300 MHz - 28.500 MHz	Phone operation for Technician licensees
52.525 MHz	6-meter band
146.52 MHz	2-meter band
219 MHz - 220 MHz	Fixed digital message forwarding systems

Table 1.2: Technician License Frequency Privileges

Questions

T1A08

Which of the following entities recommends transmit/receive channels and other parameters for auxiliary and repeater stations?

- A Frequency Spectrum Manager appointed by the FCC
- B **Volunteer Frequency Coordinator recognized by local amateurs**
- C FCC Regional Field Office
- D International Telecommunication Union

Volunteer frequency coordinators are recognized by local amateur operators and are responsible for recommending transmit/receive channels and other parameters for auxiliary and repeater stations. The FCC does not appoint these coordinators; they are selected by the local amateur community.

T1A09

Who selects a Frequency Coordinator?

- A The FCC Office of Spectrum Management and Coordination Policy
- B The local chapter of the Office of National Council of Independent Frequency Coordinators
- C **Amateur operators in a local or regional area whose stations are eligible to be repeater or auxiliary stations**
- D FCC Regional Field Office

Frequency coordinators are selected by amateur operators in a local or regional area whose stations are eligible to be repeater or auxiliary stations. This ensures that the coordinators are familiar with the specific needs and conditions of their area.

T1B01

Which of the following frequency ranges are available for phone operation by Technician licensees?

- A 28.050 MHz to 28.150 MHz
- B 28.100 MHz to 28.300 MHz
- C **28.300 MHz to 28.500 MHz**
- D 28.500 MHz to 28.600 MHz

Technician licensees have phone operation privileges on the 28.300 MHz to 28.500 MHz segment of the 10-meter band. This range is specifically allocated for voice communication.

T1B02

Which amateurs may contact the International Space Station (ISS) on VHF bands?

A Any amateur holding a General class or higher license
B **Any amateur holding a Technician class or higher license**
C Any amateur holding a General class or higher license who has applied for and received approval from NASA
D Any amateur holding a Technician class or higher license who has applied for and received approval from NASA

Any amateur holding a Technician class or higher license may contact the ISS on VHF bands. No additional approval from NASA is required for this privilege.

T1B03

Which frequency is in the 6 meter amateur band?

A 49.00 MHz
B **52.525 MHz**
C 28.50 MHz
D 222.15 MHz

The 6-meter amateur band includes the frequency 52.525 MHz. This band is commonly used for local and regional communication.

T1B04

Which amateur band includes 146.52 MHz?

A 6 meters
B 20 meters
C 70 centimeters
D **2 meters**

The 2-meter amateur band includes the frequency 146.52 MHz. This band is widely used for local communication and is a popular choice for repeater operations.

T1B05

How may amateurs use the 219 to 220 MHz segment of 1.25 meter band?

A Spread spectrum only
B Fast-scan television only
C Emergency traffic only
D **Fixed digital message forwarding systems only**

The 219 to 220 MHz segment of the 1.25-meter band is reserved for fixed digital message forwarding systems only. This ensures efficient use of the spectrum for specific applications.

T1B06

On which HF bands does a Technician class operator have phone privileges?

A None
B **10 meter band only**
C 80 meter, 40 meter, 15 meter, and 10 meter bands
D 30 meter band only

Technician class operators have phone privileges on the 10-meter band only. This band is allocated for voice communication and is a key privilege for Technician licensees.

Summary

This section covered the role of frequency coordinators, the frequency ranges available for Technician licensees, the rules for contacting the ISS on VHF bands, and key amateur band segments and their specific uses. Understanding these concepts is essential for effective frequency coordination and band usage in amateur radio.

- **Role of frequency coordinators**: Volunteer coordinators manage channel allocation for auxiliary and repeater stations, selected by local amateur operators.
- **Frequency ranges for Technician licensees**: Includes the 28.300 MHz to 28.500 MHz segment for phone operation.
- **International Space Station (ISS) communication**: Technician class or higher licensees can contact the ISS on VHF bands.
- **Amateur band segments and their usage**: Key segments include the 6-meter and 2-meter bands, each with specific uses.

1.3 Licensing and Call Sign Protocols

License Classes and Availability

The Federal Communications Commission (FCC) currently offers three license classes for amateur radio operators: Technician, General, and Amateur Extra. Each class grants specific operating privileges, with the Technician class being the entry-level license. The General class provides additional frequency privileges, while the Amateur Extra class offers the most extensive operating privileges, including access to all amateur radio bands.

Vanity Call Sign Rules

Amateur radio operators may select a desired call sign under the vanity call sign rules. Any licensed amateur, regardless of license class, is eligible to apply for a vanity call sign. The process involves submitting an application to the FCC, which is then reviewed for compliance with the rules. Figure 1.3 illustrates the vanity call sign application process.

Figure 1.3: Vanity Call Sign Application Process

International Communications

FCC-licensed amateur radio stations are permitted to make international communications that are incidental to the purposes of the Amateur Radio Service. This includes remarks of a personal character, but excludes communications for business purposes. These rules ensure that amateur radio remains a non-commercial service.

License Renewal and Revocation

Maintaining accurate contact information with the FCC is crucial. Failure to provide and maintain a correct email address can result in the revocation of the station license or suspension of the operator license. Additionally, amateur radio licenses are typically issued for a term of ten years and must be renewed before expiration.

Table 1.3: Amateur Radio License Classes and Privileges

License Class	**Privileges**	**Renewal Term**
Technician	Entry-level privileges	10 years
General	Additional frequency access	10 years
Amateur Extra	Full privileges	10 years

Questions

T1C01

For which license classes are new licenses currently available from the FCC?

A Novice, Technician, General, Amateur Extra
B Technician, Technician Plus, General, Amateur Extra
C Novice, Technician Plus, General, Advanced
D **Technician, General, Amateur Extra**

The FCC currently offers new licenses for the Technician, General, and Amateur Extra classes. The Novice and Technician Plus classes are no longer available.

T1C02

Who may select a desired call sign under the vanity call sign rules?

A Only a licensed amateur with a General or Amateur Extra Class license
B Only a licensed amateur with an Amateur Extra Class license
C Only a licensed amateur who has been licensed continuously for more than 10 years
D **Any licensed amateur**

Any licensed amateur, regardless of license class, may apply for a vanity call sign.

T1C03

What types of international communications are an FCC-licensed amateur radio station permitted to make?

A **Communications incidental to the purposes of the Amateur Radio Service and remarks of a personal character**
B Communications incidental to conducting business or remarks of a personal nature
C Only communications incidental to contest exchanges; all other communications are prohibited
D Any communications that would be permitted by an international broadcast station

FCC-licensed amateur radio stations are permitted to make international communications that are incidental to the purposes of the Amateur Radio Service, including personal remarks. Business communications are not allowed.

T1C04

What may happen if the FCC is unable to reach you by email?

A Fine and suspension of operator license
B **Revocation of the station license or suspension of the operator license**
C Revocation of access to the license record in the FCC system
D Nothing; there is no such requirement

Failure to maintain a correct email address with the FCC can result in the revocation of the station license or suspension of the operator license.

Summary

This section covered the current license classes available from the FCC, including Technician, General, and Amateur Extra. It also explained the rules for selecting a vanity call sign and the types of international communications permitted for amateur radio stations. Finally, it outlined the importance of maintaining accurate contact information with the FCC to avoid license revocation or suspension.

1.4 Operating Rules and Restrictions

Introduction

This section discusses the operating rules and restrictions that govern amateur radio communications. These rules ensure that amateur radio operations are conducted in a manner that is consistent with international regulations and best practices.

Prohibited Communications

Amateur radio stations licensed by the FCC are prohibited from exchanging communications with any country whose administration has notified the International Telecommunication Union (ITU) that it objects to such communications. This restriction is in place to respect the sovereignty and regulatory frameworks of other nations. The ITU plays a crucial role in facilitating international communication agreements and resolving disputes.

One-Way Transmissions

One-way transmissions by amateur stations are generally prohibited, especially in the context of broadcasting. Broadcasting refers to the transmission of audio or video content intended for reception by the general public. However, there are exceptions, such as international Morse code practice and telecommand or telemetry transmissions, which are permitted under specific conditions.

Encoded Messages and Music Transmissions

Encoded messages are only permitted when transmitting control commands to space stations or radio control craft. This ensures that the primary purpose of amateur radio communications remains non-commercial and technical. Similarly, music transmissions are only allowed when incidental to an authorized retransmission of manned spacecraft communications. This exception is narrowly defined to prevent the misuse of amateur frequencies for entertainment purposes.

Equipment Sales

Amateur radio operators may use their stations to notify other amateurs of the availability of equipment for sale or trade, provided that such notifications are not made on a regular basis. This rule prevents amateur radio frequencies from being used for commercial purposes.

Questions

T1D01

With which countries are FCC-licensed amateur radio stations prohibited from exchanging communications?

A **Any country whose administration has notified the International Telecommunication Union (ITU) that it objects to such communications**
B Any country whose administration has notified the American Radio Relay League (ARRL) that it objects to such communications
C Any country banned from such communications by the International Amateur Radio Union (IARU)
D Any country banned from making such communications by the American Radio Relay League (ARRL)

FCC-licensed amateur radio stations are prohibited from exchanging communications with any country that has notified the ITU of its objection. This ensures compliance with international regulations and respects the sovereignty of other nations.

T1D02

Under which of the following circumstances are one-way transmissions by an amateur station prohibited?

A In all circumstances
B **Broadcasting**
C International Morse Code Practice
D Telecommand or transmissions of telemetry

One-way transmissions are prohibited in the context of broadcasting, as amateur radio frequencies are not intended for public entertainment. However, exceptions exist for specific technical purposes such as Morse code practice and telecommand transmissions.

T1D03

When is it permissible to transmit messages encoded to obscure their meaning?

A Only during contests
B Only when transmitting certain approved digital codes
C **Only when transmitting control commands to space stations or radio control craft**
D Never

Encoded messages are only permitted when transmitting control commands to space stations or radio control craft. This ensures that the primary purpose of amateur radio communications remains technical and non-commercial.

T1D04

Under what conditions is an amateur station authorized to transmit music using a phone emission?

A **When incidental to an authorized retransmission of manned spacecraft communications**
B When the music produces no spurious emissions
C When transmissions are limited to less than three minutes per hour
D When the music is transmitted above 1280 MHz

Music transmissions are only allowed when incidental to an authorized retransmission of manned spacecraft communications. This exception is narrowly defined to prevent the misuse of amateur frequencies for entertainment purposes.

T1D05

When may amateur radio operators use their stations to notify other amateurs of the availability of equipment for sale or trade?

A Never
B When the equipment is not the personal property of either the station licensee, or the control operator, or their close relatives
C When no profit is made on the sale
D **When selling amateur radio equipment and not on a regular basis**

Amateur radio operators may use their stations to notify others of equipment for sale or trade, provided that such notifications are not made on a regular basis. This rule prevents amateur radio frequencies from being used for commercial purposes.

T1D06

What, if any, are the restrictions concerning transmission of language that may be considered indecent or obscene?

A The FCC maintains a list of words that are not permitted to be used on amateur frequencies
B **Any such language is prohibited**
C The ITU maintains a list of words that are not permitted to be used on amateur frequencies
D There is no such prohibition

The transmission of indecent or obscene language is strictly prohibited on amateur radio frequencies. This rule ensures that amateur radio communications remain respectful and appropriate.

T1D07

What types of amateur stations can automatically retransmit the signals of other amateur stations?

A Auxiliary, beacon, or Earth stations
B Earth, repeater, or space stations
C Beacon, repeater, or space stations
D **Repeater, auxiliary, or space stations**

Repeater, auxiliary, and space stations are authorized to automatically retransmit the signals of other amateur stations. This capability is essential for extending the range and reliability of amateur radio communications.

T1D08

In which of the following circumstances may the control operator of an amateur station receive compensation for operating that station?

A When the communication is related to the sale of amateur equipment by the control operator's employer
B **When the communication is incidental to classroom instruction at an educational institution**
C When the communication is made to obtain emergency information for a local broadcast station
D All these choices are correct

The control operator of an amateur station may receive compensation when the communication is incidental to classroom instruction at an educational institution. This exception supports the educational use of amateur radio.

Summary

This section covered the following key concepts:

- **Prohibited communications**: Amateur radio stations must avoid communications with countries that have notified the ITU of their objection.
- **One-way transmissions**: Broadcasting is generally prohibited, with exceptions for specific technical purposes.
- **Encoded messages**: Permitted only for control commands to space stations or radio control craft.
- **Music transmission**: Allowed only when incidental to authorized retransmissions of manned spacecraft communications.
- **Equipment sales**: Notifications of equipment for sale or trade are permitted, provided they are not made on a regular basis.

1.5 Control Operator Responsibilities

Introduction

This section discusses the responsibilities and requirements of control operators in amateur radio stations. It also covers the rules for operating through amateur satellites or space stations, the determination of transmitting frequency privileges, and the definition of a control point.

Control Operator Requirements

The control operator is responsible for ensuring that the station operates in compliance with FCC regulations. The station licensee must designate the control operator, and this operator must hold the appropriate class of license for the frequencies being used. The control operator and the station licensee share responsibility for the proper operation of the station when the control operator is not the licensee.

Satellite and Space Station Operations

When operating through an amateur satellite or space station, the control operator must be authorized to transmit on the satellite's uplink frequency. There are no additional certifications required beyond the operator's license class.

Transmitting Frequency Privileges

The transmitting frequency privileges of an amateur station are determined by the class of operator license held by the control operator. This ensures that the station operates within the frequency bands authorized for the control operator's license class.

Control Point Definition

The control point is the location at which the control operator function is performed. This is distinct from the location of the transmitting apparatus or antenna. The control point is crucial for ensuring that the station is operated in compliance with regulations.

Questions

T1E01

When may an amateur station transmit without a control operator?

- A When using automatic control, such as in the case of a repeater
- B When the station licensee is away and another licensed amateur is using the station
- C When the transmitting station is an auxiliary station
- D **Never**

An amateur station must always have a control operator when transmitting. This is a fundamental rule in amateur radio operations to ensure compliance with regulations.

T1E02

Who may be the control operator of a station communicating through an amateur satellite or space station?

- A Only an Amateur Extra Class operator
- B A General class or higher licensee with a satellite operator certification
- C Only an Amateur Extra Class operator who is also an AMSAT member
- D **Any amateur allowed to transmit on the satellite uplink frequency**

Any licensed amateur who is authorized to transmit on the satellite's uplink frequency may act as the control operator. No additional certifications are required.

T1E03

Who must designate the station control operator?

- A **The station licensee**
- B The FCC
- C The frequency coordinator
- D Any licensed operator

The station licensee is responsible for designating the control operator. This ensures that the operator is aware of and complies with the station's operational parameters.

T1E04

What determines the transmitting frequency privileges of an amateur station?

- A The frequency authorized by the frequency coordinator
- B The frequencies printed on the license grant
- C The highest class of operator license held by anyone on the premises
- D **The class of operator license held by the control operator**

The transmitting frequency privileges are determined by the class of operator license held by the control operator. This ensures that the station operates within the authorized frequency bands.

T1E05

What is an amateur station's control point?

- A The location of the station's transmitting antenna
- B The location of the station's transmitting apparatus
- C **The location at which the control operator function is performed**
- D The mailing address of the station licensee

The control point is the location where the control operator function is performed. This is distinct from the physical location of the transmitting apparatus or antenna.

T1E06

When, under normal circumstances, may a Technician class licensee be the control operator of a station operating in an Amateur Extra Class band segment?

- A **At no time**
- B When designated as the control operator by an Amateur Extra Class licensee
- C As part of a multi-operator contest team
- D When using a club station whose trustee holds an Amateur Extra Class license

A Technician class licensee cannot be the control operator for a station operating in an Amateur Extra Class band segment. The control operator must hold the appropriate license class for the frequency band being used.

T1E07

When the control operator is not the station licensee, who is responsible for the proper operation of the station?

A All licensed amateurs who are present at the operation
B Only the station licensee
C Only the control operator
D **The control operator and the station licensee**

Both the control operator and the station licensee are responsible for the proper operation of the station when the control operator is not the licensee.

T1E08

Which of the following is an example of automatic control?

A **Repeater operation**
B Controlling a station over the internet
C Using a computer or other device to send CW automatically
D Using a computer or other device to identify automatically

Repeater operation is an example of automatic control, where the station operates without direct human intervention.

Summary

This section covered the key responsibilities and requirements of control operators in amateur radio stations. The main concepts discussed include:

- **Control operator requirements**: The control operator must be designated by the station licensee and must hold the appropriate license class for the frequencies being used.
- **Satellite and space station operations**: Any licensed amateur authorized to transmit on the satellite's uplink frequency may act as the control operator.
- **Transmitting frequency privileges**: These are determined by the class of operator license held by the control operator.
- **Control point definition**: The control point is the location where the control operator function is performed, distinct from the physical location of the transmitting apparatus or antenna.

1.6 Station Identification and Third-Party Communications

Station Identification Rules

Station identification is a critical requirement for amateur radio operators to ensure compliance with FCC regulations. The rules mandate that operators transmit their FCC-assigned call sign at specific intervals and under certain conditions. When using tactical call signs, such as "Race Headquarters," the FCC-assigned call sign must still be used at the end of each communication and every ten minutes during a communication. This ensures that the station's identity is clearly established, even when using temporary or situational identifiers.

Third-Party Communications

Third-party communications involve transmitting messages on behalf of someone who is not the control operator. The control operator must ensure that the foreign station is in a country with which the U.S. has a third-party agreement. The control operator is also responsible for station identification during such communications. This rule ensures accountability and compliance with international agreements.

Language Restrictions

When operating in a phone sub-band, station identification must be in English. This requirement ensures clarity and consistency in communication, particularly in international contexts where multiple languages may be in use.

Self-Assigned Indicators

Self-assigned indicators, such as "KL7CC/W3," are acceptable in call signs during phone transmissions. These indicators can be used to denote location, club affiliation, or other relevant information. However, the FCC-assigned call sign must still be transmitted as required.

Figure 1.4: Flowchart of station identification rules and procedures. The flowchart illustrates the steps for proper station identification, including the use of tactical call signs and the timing of FCC-assigned call sign transmissions.

Rule	**Description**
Station Identification	Transmit FCC-assigned call sign at the end of each communication a
Tactical Call Signs	Use FCC-assigned call sign with tactical identifiers as needed.
Third-Party Communications	Ensure foreign station is in a country with a third-party agreement.
Language Restrictions	Use English for station identification in phone sub-bands.
Self-Assigned Indicators	Acceptable in call signs, but FCC-assigned call sign must still be tra

Table 1.4: Station Identification and Third-Party Communication Rules

Questions

T1F01

When must the station and its records be available for FCC inspection?

A At any time ten days after notification by the FCC of such an inspection
B **At any time upon request by an FCC representative**
C At any time after written notification by the FCC of such inspection
D Only when presented with a valid warrant by an FCC official or government agent

The station and its records must be available for inspection at any time upon request by an FCC representative. This ensures compliance with FCC regulations and allows for immediate verification of station operations.

T1F02

How often must you identify with your FCC-assigned call sign when using tactical call signs such as "Race Headquarters"?

A Never, the tactical call is sufficient
B Once during every hour
C **At the end of each communication and every ten minutes during a communication**
D At the end of every transmission

When using tactical call signs, the FCC-assigned call sign must be transmitted at the end of each communication and every ten minutes during a communication. This ensures proper identification even when using temporary call signs.

T1F03

When are you required to transmit your assigned call sign?

A At the beginning of each contact, and every 10 minutes thereafter
B At least once during each transmission
C At least every 15 minutes during and at the end of a communication
D **At least every 10 minutes during and at the end of a communication**

The assigned call sign must be transmitted at least every 10 minutes during and at the end of a communication. This rule ensures consistent identification of the station.

T1F04

What language may you use for identification when operating in a phone sub-band?

A Any language recognized by the United Nations
B Any language recognized by the ITU
C **English**
D English, French, or Spanish

When operating in a phone sub-band, station identification must be in English. This ensures clarity and consistency in communication.

T1F05

What method of call sign identification is required for a station transmitting phone signals?

A Send the call sign followed by the indicator RPT
B **Send the call sign using a CW or phone emission**
C Send the call sign followed by the indicator R
D Send the call sign using only a phone emission

For phone transmissions, the call sign must be sent using either CW (Morse code) or phone emission. This ensures that the call sign is clearly transmitted and understood.

T1F06

Which of the following self-assigned indicators are acceptable when using a phone transmission?

A KL7CC stroke W3
B KL7CC slant W3
C KL7CC slash W3
D **All these choices are correct**

All the listed self-assigned indicators (stroke, slant, slash) are acceptable in call signs during phone transmissions. These indicators can be used to denote additional information about the station.

T1F07

Which of the following restrictions apply when a non-licensed person is allowed to speak to a foreign station using a station under the control of a licensed amateur operator?

A The person must be a U.S. citizen
B **The foreign station must be in a country with which the U.S. has a third party agreement**
C The licensed control operator must do the station identification
D All these choices are correct

The primary restriction is that the foreign station must be in a country with which the U.S. has a third-party agreement. This ensures compliance with international regulations.

T1F08

What is the definition of third party communications?

- A **A message from a control operator to another amateur station control operator on behalf of another person**
- B Amateur radio communications where three stations are in communications with one another
- C Operation when the transmitting equipment is licensed to a person other than the control operator
- D Temporary authorization for an unlicensed person to transmit on the amateur bands for technical experiments

Third-party communications involve a control operator transmitting a message on behalf of another person. This ensures that the communication is properly managed and compliant with regulations.

Summary

This section covered the following key concepts:

- **Station identification requirements**: Operators must transmit their FCC-assigned call sign at specific intervals and under certain conditions.
- **Tactical call signs**: Temporary identifiers can be used, but the FCC-assigned call sign must still be transmitted as required.
- **Third-party communications**: Messages can be transmitted on behalf of non-licensed individuals, provided the foreign station is in a country with a third-party agreement.
- **Language restrictions**: Station identification in phone sub-bands must be in English.

Chapter 2 OPERATING PROCEDURES

2.1 Repeater and Communication Basics

Repeater Frequency Offsets

Repeater frequency offsets are a fundamental concept in amateur radio operations. A repeater is a device that receives a signal on one frequency and retransmits it on another frequency. The difference between the repeater's transmit and receive frequencies is known as the *repeater offset*. This offset is crucial because it allows the repeater to receive and transmit simultaneously without interference. For example, in the 2 meter band, a common repeater frequency offset is ±600 kHz. This means that if the repeater is receiving on 146.000 MHz, it will transmit on 146.600 MHz or 145.400 MHz, depending on the direction of the offset.

The significance of repeater frequency offsets lies in their ability to extend the range of communication. By using a repeater, operators can communicate over much greater distances than would be possible with direct, simplex communication. This is particularly useful in areas with challenging terrain, where direct communication might be obstructed.

National Calling Frequency for FM Simplex Operations

In the 2 meter band, the national calling frequency for FM simplex operations is 146.520 MHz. This frequency is designated as a common channel where operators can initiate contact with other stations. The importance of this frequency lies in its universal recognition among amateur radio operators. When an operator calls on 146.520 MHz, they are essentially broadcasting a signal to any station within range, inviting a response.

Procedural Signal 'CQ'

The procedural signal 'CQ' is used in amateur radio to indicate a general call to any station. When an operator transmits 'CQ', they are essentially saying, "I am calling any station that can hear me." This signal is particularly useful when an operator is looking to make contact with any available station, rather than a specific one. The term 'CQ' has its origins in maritime communication, where it was used as a general call to all ships.

Repeater Offset

The term 'repeater offset' refers to the difference between a repeater's transmit and receive frequencies. This offset is necessary to prevent the repeater from interfering with its own transmissions. For example, if a repeater is receiving on 147.000 MHz, it might transmit on 147.600 MHz, resulting in an offset of +600 kHz. This offset allows the repeater to operate efficiently, ensuring that the transmitted signal does not interfere with the received signal.

Questions

T2A01

What is a common repeater frequency offset in the 2 meter band?

A Plus or minus 5 MHz
B **Plus or minus 600 kHz**
C Plus or minus 500 kHz
D Plus or minus 1 MHz

A common repeater frequency offset in the 2 meter band is ±600 kHz. This offset is widely used to ensure that the repeater can transmit and receive simultaneously without interference. The other options are not standard offsets for the 2 meter band.

T2A02

What is the national calling frequency for FM simplex operations in the 2 meter band?

A **146.520 MHz**
B 145.000 MHz
C 432.100 MHz
D 446.000 MHz

The national calling frequency for FM simplex operations in the 2 meter band is 146.520 MHz. This frequency is universally recognized and used by amateur radio operators to initiate contact with other stations. The other frequencies listed are not designated as national calling frequencies.

T2A03

What is a common repeater frequency offset in the 70 cm band?

A **Plus or minus 5 MHz**
B Plus or minus 600 kHz
C Plus or minus 500 kHz
D Plus or minus 1 MHz

A common repeater frequency offset in the 70 cm band is ±5 MHz. This offset is necessary to prevent interference between the repeater's transmit and receive frequencies. The other options are not standard offsets for the 70 cm band.

T2A04

What is an appropriate way to call another station on a repeater if you know the other station's call sign?

A Say "break, break," then say the station's call sign
B **Say the station's call sign, then identify with your call sign**
C Say "CQ" three times, then the other station's call sign
D Wait for the station to call CQ, then answer

The appropriate way to call another station on a repeater is to say the station's call sign, followed by your own call sign. This method ensures that the other station knows who is calling and who is responding. The other options are either incorrect or not standard procedures.

T2A05

How should you respond to a station calling CQ?

A Transmit "CQ" followed by the other station's call sign
B Transmit your call sign followed by the other station's call sign
C **Transmit the other station's call sign followed by your call sign**
D Transmit a signal report followed by your call sign

When responding to a station calling CQ, you should transmit the other station's call sign followed by your own call sign. This method ensures that the other station knows who is responding to their call. The other options are either incorrect or not standard procedures.

T2A06

Which of the following is required when making on-the-air test transmissions?

A **Identify the transmitting station**
B Conduct tests only between 10 p.m. and 6 a.m. local time
C Notify the FCC of the transmissions
D All these choices are correct

When making on-the-air test transmissions, it is required to identify the transmitting station. This is a fundamental rule in amateur radio operations to ensure that all transmissions are properly identified. The other options are either incorrect or not required for test transmissions.

T2A07

What is meant by "repeater offset"?

A **The difference between a repeater's transmit and receive frequencies**
B The repeater has a time delay to prevent interference
C The repeater station identification is done on a separate frequency
D The number of simultaneous transmit frequencies used by a repeater

The term "repeater offset" refers to the difference between a repeater's transmit and receive frequencies. This offset is necessary to prevent the repeater from interfering with its own transmissions. The other options do not accurately describe the concept of repeater offset.

T2A08

What is the meaning of the procedural signal "CQ"?

A Call on the quarter hour
B Test transmission, no reply expected
C Only the called station should transmit
D **Calling any station**

The procedural signal "CQ" means "calling any station." It is used to initiate contact with any station that can hear the transmission. The other options do not accurately describe the meaning of "CQ."

Summary

This section covered several key concepts related to repeater and communication basics in amateur radio:

- **Repeater frequency offsets**: The difference between a repeater's transmit and receive frequencies, which is essential for preventing interference and extending communication range.

- **Simplex operations**: Direct communication between two stations without the use of a repeater, with the national calling frequency for FM simplex operations in the 2 meter band being 146.520 MHz.

- **Calling procedures**: The correct way to call another station on a repeater and how to respond to a station calling CQ.

- **Repeater terminology**: Understanding terms like "repeater offset" and the procedural signal "CQ" is crucial for effective communication in amateur radio.

Figures and Tables

Figure 2.1: Repeater Frequency Offset Diagram

Band	Common Repeater Frequency Offset
2 meter	±600 kHz
70 cm	±5 MHz

Table 2.1: Common Repeater Frequency Offsets

2.2 Radio Operating Essentials

Band Plans

A band plan is a voluntary guideline for using different modes or activities within an amateur radio band. It helps operators organize their use of the frequency spectrum, ensuring that various types of communications (such as voice, digital, and Morse code) can coexist without interference. Band plans are not enforced by the FCC but are widely adopted by the amateur radio community to promote efficient and harmonious use of the available frequencies.

Simplex vs. Duplex Communication

Simplex communication refers to a mode where transmission and reception occur on the same frequency. This is commonly used for direct communication between two stations without the need for a repeater. Duplex communication, on the other hand, involves transmitting and receiving on two different frequencies, often facilitated by a repeater. This allows for simultaneous two-way communication, which is particularly useful in scenarios where direct communication is not feasible due to distance or obstacles.

Figure 2.2: Simplex vs. Duplex Communication

Table 2.2: Simplex vs. Duplex Communication

Communication Mode	**Description**
Simplex	Transmission and reception occur on the same frequency.
Duplex	Transmission and reception occur on different frequencies.

CTCSS and DTMF Tones

CTCSS (Continuous Tone-Coded Squelch System) and DTMF (Dual-Tone Multi-Frequency) tones are used in repeater operations to control access and improve communication quality. CTCSS tones are sub-audible tones transmitted along with normal voice audio to open the squelch of a receiver, ensuring that only signals with the correct tone are heard. DTMF tones, on the other hand, are used for remote control of repeaters and other equipment, allowing operators to perform functions like changing frequencies or activating features.

Linked Repeater Networks

A linked repeater network is a system where multiple repeaters are interconnected, allowing signals received by one repeater to be transmitted by all the repeaters in the network. This extends the range of communication and enables operators to communicate over much larger areas than would be possible with a single repeater. Linked repeater networks are particularly useful in emergency situations where wide-area communication is essential.

Questions

T2A09

Which of the following indicates that a station is listening on a repeater and looking for a contact?

A "CQ CQ" followed by the repeater's call sign
B **The station's call sign followed by the word "monitoring"**
C The repeater call sign followed by the station's call sign
D "QSY" followed by your call sign

When a station is monitoring a repeater and looking for a contact, it typically identifies itself by its call sign followed by the word "monitoring." This indicates that the station is listening and available for communication.

T2A10

What is a band plan, beyond the privileges established by the FCC?

A **A voluntary guideline for using different modes or activities within an amateur band**
B A list of operating schedules
C A list of available net frequencies
D A plan devised by a club to indicate frequency band usage

A band plan is a voluntary guideline that helps amateur radio operators organize their use of the frequency spectrum. It is not enforced by the FCC but is widely adopted to ensure efficient and harmonious use of the available frequencies.

T2A11

What term describes an amateur station that is transmitting and receiving on the same frequency?

A Full duplex
B Diplex
C **Simplex**
D Multiplex

Simplex communication involves transmitting and receiving on the same frequency. This is commonly used for direct communication between two stations without the need for a repeater.

T2A12

What should you do before calling CQ?

A Listen first to be sure that no one else is using the frequency
B Ask if the frequency is in use
C Make sure you are authorized to use that frequency
D **All these choices are correct**

Before calling CQ, it is important to listen to ensure the frequency is not in use, ask if the frequency is in use, and confirm that you are authorized to use that frequency. All these steps are essential to avoid interference and ensure proper operation.

T2B01

How is a VHF/UHF transceiver's "reverse" function used?

A To reduce power output
B To increase power output
C **To listen on a repeater's input frequency**
D To listen on a repeater's output frequency

The "reverse" function on a VHF/UHF transceiver is used to listen on a repeater's input frequency. This allows the operator to hear what is being transmitted directly to the repeater, which can be useful for troubleshooting or monitoring.

T2B02

What term describes the use of a sub-audible tone transmitted along with normal voice audio to open the squelch of a receiver?

A Carrier squelch
B Tone burst
C DTMF
D **CTCSS**

CTCSS (Continuous Tone-Coded Squelch System) uses a sub-audible tone transmitted along with normal voice audio to open the squelch of a receiver. This ensures that only signals with the correct tone are heard, reducing interference from other transmissions.

T2B03

Which of the following describes a linked repeater network?

A **A network of repeaters in which signals received by one repeater are transmitted by all the repeaters in the network**
B A single repeater with more than one receiver
C Multiple repeaters with the same control operator
D A system of repeaters linked by APRS

A linked repeater network is a system where multiple repeaters are interconnected, allowing signals received by one repeater to be transmitted by all the repeaters in the network. This extends the range of communication and is particularly useful in emergency situations.

T2B04

Which of the following could be the reason you are unable to access a repeater whose output you can hear?

A Improper transceiver offset
B You are using the wrong CTCSS tone
C You are using the wrong DCS code
D **All these choices are correct**

If you can hear a repeater's output but cannot access it, the issue could be due to an improper transceiver offset, using the wrong CTCSS tone, or using the wrong DCS code. All these factors can prevent successful communication with the repeater.

Summary

- **Band Plans**: Voluntary guidelines for organizing the use of different modes and activities within amateur radio bands.
- **Simplex vs. Duplex**: Simplex involves transmitting and receiving on the same frequency, while duplex uses separate frequencies for transmission and reception.
- **CTCSS and DTMF Tones**: Used in repeater operations to control access and improve communication quality.
- **Linked Repeater Networks**: Systems where multiple repeaters are interconnected to extend communication range and improve reliability.

2.3 Advanced Operating Techniques

FM Transmission Distortion

FM transmission distortion on voice peaks can occur when the input audio signal is too loud, causing over-modulation. This results in distorted audio at the receiving end. To avoid this, ensure that your microphone gain is properly adjusted and avoid speaking too loudly into the microphone. Over-modulation can also be caused by excessive transmit power, but this is less common in modern equipment.

DTMF Signaling

Dual-Tone Multi-Frequency (DTMF) signaling uses pairs of audio tones to represent numbers, letters, or special characters. This signaling method is commonly used in amateur radio for remote control of repeaters, accessing voicemail systems, and other automated functions. Each DTMF tone is a combination of two frequencies, one from a low-frequency group and one from a high-frequency group.

Digital Repeater Talkgroups

To join a digital repeater's talkgroup, you need to program your radio with the group's ID or code. Talkgroups allow multiple users to communicate on the same digital repeater without interfering with each other. Each talkgroup has a unique identifier, and your radio must be configured to use the correct ID to access the group. This system is commonly used in DMR (Digital Mobile Radio) networks.

Frequency Interference Management

When two stations transmit on the same frequency and interfere with each other, they should negotiate continued use of the frequency. This is a common practice in amateur radio to ensure fair and efficient use of the spectrum. The Q signal **QRM** indicates that you are receiving interference from other stations, while **QSY** indicates that you are changing frequency to avoid interference.

Figure 2.3: Joining a Digital Repeater Talkgroup

Q Signal	**Meaning**
QRM	Interference from other stations
QSY	Changing frequency
QTH	Location
QSB	Fading signal

Table 2.3: Common Q Signals

Questions

T2B05

What would cause your FM transmission audio to be distorted on voice peaks?

A Your repeater offset is inverted
B You need to talk louder
C **You are talking too loudly**
D Your transmit power is too high

Distortion on voice peaks in FM transmission is typically caused by over-modulation, which occurs when the input audio signal is too loud. This can be avoided by adjusting the microphone gain and speaking at a normal volume. Excessive transmit power is less likely to cause distortion in modern equipment.

T2B06

What type of signaling uses pairs of audio tones?

A **DTMF**
B CTCSS
C GPRS
D D-STAR

DTMF (Dual-Tone Multi-Frequency) signaling uses pairs of audio tones to represent numbers, letters, or special characters. This method is widely used in amateur radio for remote control and automated systems.

T2B07

How can you join a digital repeater's "talkgroup"?

A Register your radio with the local FCC office
B Join the repeater owner's club
C **Program your radio with the group's ID or code**
D Sign your call after the courtesy tone

To join a digital repeater's talkgroup, you need to program your radio with the group's ID or code. This allows you to communicate within the designated group without interfering with other users on the same repeater.

T2B08

Which of the following applies when two stations transmitting on the same frequency interfere with each other?

A **The stations should negotiate continued use of the frequency**
B Both stations should choose another frequency to avoid conflict
C Interference is inevitable, so no action is required
D Use subaudible tones so both stations can share the frequency

When two stations interfere on the same frequency, they should negotiate to determine who will continue using the frequency. This is a common practice in amateur radio to ensure fair use of the spectrum.

T2B09

Why are simplex channels designated in the VHF/UHF band plans?

A **So stations within range of each other can communicate without tying up a repeater**
B For contest operation
C For working DX only
D So stations with simple transmitters can access the repeater without automated offset

Simplex channels are designated in the VHF/UHF band plans to allow stations within range of each other to communicate directly without using a repeater. This is useful for local communication and reduces the load on repeater systems.

T2B10

Which Q signal indicates that you are receiving interference from other stations?

A **QRM**
B QRN
C QTH
D QSB

The Q signal **QRM** indicates that you are receiving interference from other stations. This is a common issue in crowded frequency bands, and operators may need to change frequencies to avoid the interference.

T2B11

Which Q signal indicates that you are changing frequency?

A QRU
B **QSY**
C QSL
D QRZ

The Q signal **QSY** indicates that you are changing frequency. This is often used to avoid interference or to move to a clearer frequency for communication.

T2B12

What is the purpose of the color code used on DMR repeater systems?

A **Must match the repeater color code for access**
B Defines the frequency pair to use
C Identifies the codec used
D Defines the minimum signal level required for access

The color code in DMR repeater systems is used to ensure that your radio matches the repeater's color code for access. This helps prevent unauthorized access and ensures compatibility between radios and repeaters.

Summary

This section covered advanced operating techniques in amateur radio, including:

- **FM Transmission Distortion**: Caused by over-modulation due to excessive audio input. Adjust microphone gain to avoid distortion.
- **DTMF Signaling**: Uses pairs of audio tones for remote control and automated functions in amateur radio.
- **Digital Repeater Talkgroups**: Join by programming your radio with the group's ID or code to communicate within a specific group.
- **Frequency Interference Management**: Use Q signals like QRM and QSY to manage and avoid interference on shared frequencies.

2.4 Emergency Operations and Traffic Handling

Introduction

In emergency situations, amateur radio operators play a critical role in maintaining communication when traditional systems fail. This section discusses the application of FCC rules during emergencies, the duties of a Net Control Station, the importance of using a phonetic alphabet, and best practices for traffic handling.

FCC Rules in Emergencies

The FCC rules are designed to ensure orderly and efficient communication, especially during emergencies. These rules apply to all amateur radio operations, including those conducted under the Radio Amateur Civil Emergency Service (RACES) and the Amateur Radio Emergency Service (ARES). The FCC rules provide a framework for emergency communications, ensuring that all operators adhere to standardized procedures.

Duties of a Net Control Station

A Net Control Station (NCS) is responsible for managing communications during an emergency net. The primary duties of an NCS include:

- Calling the net to order and directing communications between stations.
- Ensuring that all stations checking into the net are properly licensed.
- Coordinating the exchange of messages and ensuring that traffic is handled efficiently.

Importance of Phonetic Alphabet

Clear communication is essential in emergency situations. The use of a standard phonetic alphabet ensures that voice messages containing unusual or technical words are received correctly. For example, the word "Bravo" is used to represent the letter "B," reducing the likelihood of miscommunication.

Table 2.4: Phonetic Alphabet

Letter	**Phonetic Representation**
A	Alpha
B	Bravo
C	Charlie
D	Delta

Traffic Handling Best Practices

Effective traffic handling is crucial for the smooth operation of an emergency net. Key characteristics of good traffic handling include:

- Passing messages exactly as received.

- Avoiding unnecessary modifications or interpretations of messages.
- Ensuring that messages are relayed promptly and accurately.

Figure 2.4: Traffic Handling Process

Questions

T2C01

When do FCC rules NOT apply to the operation of an amateur station?

A When operating a RACES station
B When operating under special FEMA rules
C When operating under special ARES rules
D **FCC rules always apply**

FCC rules are always applicable to amateur radio operations, regardless of the situation. This ensures consistency and reliability in communications, especially during emergencies.

T2C02

Which of the following are typical duties of a Net Control Station?

A Choose the regular net meeting time and frequency
B Ensure that all stations checking into the net are properly licensed for operation on the net frequency
C **Call the net to order and direct communications between stations checking in**
D All these choices are correct

The primary duty of a Net Control Station is to manage communications during a net, including calling the net to order and directing communications. Licensing verification is typically handled by the FCC, not the NCS.

T2C03

What technique is used to ensure that voice messages containing unusual words are received correctly?

A Send the words by voice and Morse code
B Speak very loudly into the microphone
C **Spell the words using a standard phonetic alphabet**
D All these choices are correct

Using a phonetic alphabet ensures clarity in communication, especially for unusual or technical terms. This reduces the likelihood of misunderstandings.

Summary

This section covered the following key concepts:

- **FCC rules in emergencies**: FCC rules always apply to amateur radio operations, ensuring consistency and reliability.
- **Net control station duties**: The NCS manages communications, directs traffic, and ensures orderly operations.
- **Phonetic alphabet usage**: A standard phonetic alphabet is essential for clear communication.
- **Traffic handling best practices**: Messages should be passed exactly as received, without unnecessary modifications.

2.5 Message Handling and Radiograms

Message Handling and Radiograms

Amateur radio operators play a crucial role in emergency communication, and understanding the rules and procedures for message handling is essential. This section covers the circumstances under which operators can operate outside their licensed frequency privileges, the structure of radiograms, and the purpose of the squelch function in receivers.

Frequency Privileges in Emergencies

Amateur station control operators are generally required to operate within the frequency privileges of their license class. However, there are exceptions in situations involving the immediate safety of human life or protection of property. According to FCC regulations, operators may operate outside their licensed privileges in such emergencies. This flexibility ensures that amateur radio can be effectively used in critical situations where communication is vital.

Radiogram Preamble

The preamble of a formal traffic message contains essential information needed to track and manage the message. This includes details such as the message number, precedence, handling instructions, and the station of origin. The preamble ensures that the message can be properly routed and delivered, even in complex networks.

Table 2.5: Radiogram Preamble Components

Component	Description
Message Number	Unique identifier for the message
Precedence	Indicates the urgency of the message
Handling Instructions	Special instructions for handling the message
Station of Origin	Call sign of the originating station

Meaning of 'Check' in a Radiogram Header

The term "check" in a radiogram header refers to the number of words or word equivalents in the text portion of the message. This information is crucial for ensuring that the message is transmitted and received accurately. The check value helps operators verify that the entire message has been correctly relayed without omissions or errors.

Squelch Function

The squelch function in a receiver is designed to mute the audio when no signal is present. This prevents the annoyance of hearing background noise when the receiver is not actively receiving a signal. By muting the audio in the absence of a signal, the squelch function improves the listening experience and reduces fatigue.

Figure 2.5: Radiogram Preamble Structure

Questions

T2C09

Are amateur station control operators ever permitted to operate outside the frequency privileges of their license class?

A No
B Yes, but only when part of a FEMA emergency plan
C Yes, but only when part of a RACES emergency plan
D **Yes, but only in situations involving the immediate safety of human life or protection of property**

Amateur operators are permitted to operate outside their licensed frequency privileges only in situations involving the immediate safety of human life or protection of property. This exception is crucial for emergency communications, where flexibility can save lives and protect property.

T2C10

What information is contained in the preamble of a formal traffic message?

A The email address of the originating station
B The address of the intended recipient
C The telephone number of the addressee
D **Information needed to track the message**

The preamble of a formal traffic message contains information needed to track the message, such as the message number, precedence, handling instructions, and the station of origin. This ensures that the message can be properly routed and delivered.

T2C11

What is meant by "check" in a radiogram header?

A **The number of words or word equivalents in the text portion of the message**
B The call sign of the originating station
C A list of stations that have relayed the message
D A box on the message form that indicates that the message was received and/or relayed

The "check" in a radiogram header refers to the number of words or word equivalents in the text portion of the message. This helps ensure that the message is transmitted and received accurately.

T2B13

What is the purpose of a squelch function?

A Reduce a CW transmitter's key clicks
B **Mute the receiver audio when a signal is not present**
C Eliminate parasitic oscillations in an RF amplifier
D Reduce interference from impulse noise

The squelch function mutes the receiver audio when no signal is present, preventing the annoyance of background noise. This improves the listening experience and reduces fatigue.

Summary

This section covered key concepts related to message handling and radiograms in amateur radio:

- **Frequency privileges in emergencies**: Operators may operate outside their licensed privileges in situations involving the immediate safety of human life or protection of property.

- **Radiogram preambles**: The preamble contains essential information needed to track and manage the message, such as the message number, precedence, handling instructions, and station of origin.

- **Message tracking**: The "check" in a radiogram header refers to the number of words or word equivalents in the text portion of the message, ensuring accurate transmission and reception.

- **Squelch function**: This function mutes the receiver audio when no signal is present, improving the listening experience by eliminating background noise.

Chapter 3 RADIO WAVE PROPAGATION

3.1 Signal Variability and Challenges

Multipath Propagation

Multipath propagation occurs when radio signals take multiple paths to reach the receiver due to reflections, refractions, and diffractions caused by obstacles such as buildings, hills, or other structures. This phenomenon can lead to signal cancellation or reinforcement, depending on the phase relationship between the arriving signals. For example, if two signals arrive at the receiver with a phase difference of 180 degrees, they will cancel each other out, resulting in a significant drop in signal strength. Conversely, if the signals arrive in phase, they will reinforce each other, increasing the signal strength. This is why VHF signal strengths can vary greatly when the antenna is moved only a few feet, as the relative phase of the multipath signals changes with the antenna's position.

Figure 3.1: Multipath propagation causing signal cancellation and reinforcement.

Signal Absorption by Vegetation

Vegetation can significantly affect UHF and microwave signals by absorbing the radio waves. The water content in leaves and branches acts as a dielectric, absorbing the energy of the signal and reducing its strength. This effect is more pronounced at higher frequencies, such as UHF and microwave bands, where the wavelength is shorter and more easily absorbed by the vegetation. As a result, the range of communication can be reduced when the signal path passes through dense foliage.

Figure 3.2: Effect of vegetation on UHF and microwave signals.

Antenna Polarization

Antenna polarization is crucial for long-distance VHF and UHF communications. Horizontal polarization is typically used for long-distance CW (Continuous Wave) and SSB (Single Sideband) contacts because it is less susceptible to ground reflections and provides better performance over long distances. Vertical polarization, on the other hand, is often used for local communications, especially in mobile and portable setups, as it is more effective in urban environments where signals may reflect off buildings and other structures.

Mismatched Antenna Polarization

When antennas at opposite ends of a VHF or UHF line-of-sight radio link are not using the same polarization, the received signal strength is significantly reduced. This is because the receiving antenna is not aligned with the polarization of the incoming signal, leading to a loss of signal energy. For optimal communication, both antennas should have the same polarization.

Overcoming Obstructions with Directional Antennas

Directional antennas can be used to overcome obstructions in line-of-sight communication by reflecting signals off nearby structures or terrain. By adjusting the antenna's orientation, it is possible to find a path that reflects the signal toward the repeater, bypassing the obstruction. This technique is particularly useful in urban environments where buildings may block the direct line of sight.

Picket Fencing

Picket fencing refers to the rapid flutter or variation in signal strength experienced by mobile stations due to multipath propagation. As the mobile station moves, the relative phase of the multipath signals changes, causing the signal to fluctuate rapidly. This effect is similar to the appearance of a picket fence when viewed from a moving vehicle, hence the name.

Weather Effects on Microwave Signals

Precipitation, such as rain or snow, can significantly reduce the range of microwave signals. Water droplets in the atmosphere absorb and scatter the microwave energy, leading to signal attenuation. This effect is more pronounced at higher frequencies, where the wavelength is shorter and more easily absorbed by the water droplets.

Weather Condition	Effect on Signal Propagation
High winds	Minimal effect on signal strength
Low barometric pressure	Minimal effect on signal strength
Precipitation	Significant signal attenuation
Colder temperatures	Minimal effect on signal strength

Table 3.1: Weather effects on signal propagation.

Irregular Fading in Ionospheric Signals

Irregular fading of signals propagated by the ionosphere is often caused by the random combining of signals arriving via different paths. As the ionosphere is a dynamic and irregular medium, signals can take multiple paths with varying delays and phase shifts. When these signals combine at the receiver, they can interfere constructively or destructively, leading to rapid and irregular variations in signal strength.

Questions

T3A01

Why do VHF signal strengths sometimes vary greatly when the antenna is moved only a few feet?

A The signal path encounters different concentrations of water vapor
B VHF ionospheric propagation is very sensitive to path length
C **Multipath propagation cancels or reinforces signals**
D All these choices are correct

Multipath propagation causes signals to arrive at the receiver via multiple paths, leading to constructive or destructive interference. Moving the antenna changes the relative phase of these signals, resulting in significant variations in signal strength.

T3A02

What is the effect of vegetation on UHF and microwave signals?

A Knife-edge diffraction
B **Absorption**
C Amplification
D Polarization rotation

Vegetation absorbs UHF and microwave signals due to the water content in leaves and branches, reducing signal strength.

T3A03

What antenna polarization is normally used for long-distance CW and SSB contacts on the VHF and UHF bands?

A Right-hand circular
B Left-hand circular
C **Horizontal**
D Vertical

Horizontal polarization is preferred for long-distance VHF and UHF communications because it is less affected by ground reflections and provides better performance over long distances.

T3A04

What happens when antennas at opposite ends of a VHF or UHF line of sight radio link are not using the same polarization?

A The modulation sidebands might become inverted
B **Received signal strength is reduced**
C Signals have an echo effect
D Nothing significant will happen

Mismatched polarization leads to a reduction in received signal strength because the receiving antenna is not aligned with the polarization of the incoming signal.

T3A05

When using a directional antenna, how might your station be able to communicate with a distant repeater if buildings or obstructions are blocking the direct line of sight path?

A Change from vertical to horizontal polarization
B **Try to find a path that reflects signals to the repeater**
C Try the long path
D Increase the antenna SWR

Directional antennas can reflect signals off nearby structures or terrain to bypass obstructions, allowing communication with the repeater.

T3A06

What is the meaning of the term "picket fencing"?

A Alternating transmissions during a net operation
B **Rapid flutter on mobile signals due to multipath propagation**
C A type of ground system used with vertical antennas
D Local vs long-distance communications

Picket fencing refers to the rapid flutter in signal strength experienced by mobile stations due to multipath propagation.

T3A07

What weather condition might decrease range at microwave frequencies?

A High winds
B Low barometric pressure
C **Precipitation**
D Colder temperatures

Precipitation, such as rain or snow, absorbs and scatters microwave signals, leading to signal attenuation and reduced range.

T3A08

What is a likely cause of irregular fading of signals propagated by the ionosphere?

A Frequency shift due to Faraday rotation
B Interference from thunderstorms
C Intermodulation distortion
D **Random combining of signals arriving via different paths**

Irregular fading is caused by the random combination of signals arriving via different paths through the ionosphere, leading to constructive or destructive interference.

Summary

This section discussed several key concepts related to signal variability and challenges in radio communication:

- **Multipath propagation**: Causes signal cancellation or reinforcement due to multiple signal paths.
- **Signal absorption**: Vegetation absorbs UHF and microwave signals, reducing their strength.
- **Antenna polarization**: Horizontal polarization is preferred for long-distance VHF and UHF communications.
- **Signal reflection**: Directional antennas can reflect signals to overcome obstructions.
- **Picket fencing**: Rapid signal flutter due to multipath propagation in mobile communications.
- **Weather effects**: Precipitation can significantly reduce microwave signal range.
- **Irregular fading**: Caused by random combining of signals arriving via different ionospheric paths.

3.2 Electromagnetic Essentials

Introduction

This section covers the fundamental concepts of electromagnetic waves, including the relationship between electric and magnetic fields, wave polarization, the velocity of radio waves, and the relationship between wavelength and frequency. These concepts are essential for understanding how radio waves propagate and how they are used in amateur radio.

Electric and Magnetic Fields

An electromagnetic wave consists of two perpendicular components: an electric field and a magnetic field. These fields oscillate at right angles to each other and to the direction of wave propagation. The relationship between the electric and magnetic fields is such that they are always perpendicular to each other, as shown in Figure 3.3.

Figure 3.3: Electric and magnetic fields in an electromagnetic wave.

Wave Polarization

The polarization of a radio wave is defined by the orientation of its electric field. For example, if the electric field oscillates vertically, the wave is said to be vertically polarized. Conversely, if the electric field oscillates horizontally, the wave is horizontally polarized. The magnetic field is always perpendicular to the electric field and does not determine polarization.

Components of a Radio Wave

A radio wave consists of two primary components: the electric field and the magnetic field. These fields are interdependent and propagate together through space. The electric field is responsible for the wave's interaction with matter, while the magnetic field plays a role in the wave's energy transfer.

Velocity of Radio Waves

In free space, radio waves travel at the speed of light, which is approximately 3×10^8 meters per second. This velocity is constant and does not depend on the frequency or wavelength of the wave.

Wavelength and Frequency Relationship

The wavelength (λ) and frequency (f) of a radio wave are inversely related. This relationship is expressed by the formula:

$$\lambda = \frac{c}{f} \tag{3.1}$$

where c is the speed of light. As frequency increases, wavelength decreases, and vice versa. This relationship is illustrated in Figure 3.4.

Figure 3.4: Wavelength vs. frequency relationship.

Frequency to Wavelength Conversion

To convert frequency to wavelength in meters, the following formula is used:

$$\lambda = \frac{300}{f_{\mathrm{MHz}}} \tag{3.2}$$

where f_{MHz} is the frequency in megahertz. For example, a frequency of 150 MHz corresponds to a wavelength of 2 meters.

Amateur Radio Band Identification

Amateur radio bands are often identified by their approximate wavelength in meters. For example, the 2-meter band corresponds to frequencies around 144 MHz. Table 3.2 summarizes the frequency ranges for VHF, UHF, and HF bands.

Band	**Frequency Range**
VHF	30 MHz to 300 MHz
UHF	300 MHz to 3000 MHz
HF	3 MHz to 30 MHz

Table 3.2: Frequency ranges for amateur radio bands.

Questions

T3B01

What is the relationship between the electric and magnetic fields of an electromagnetic wave?

A They travel at different speeds
B They are in parallel
C They revolve in opposite directions
D **They are at right angles**

The electric and magnetic fields of an electromagnetic wave are always perpendicular to each other and to the direction of propagation. This is a fundamental property of electromagnetic waves.

T3B02

What property of a radio wave defines its polarization?

A **The orientation of the electric field**
B The orientation of the magnetic field
C The ratio of the energy in the magnetic field to the energy in the electric field
D The ratio of the velocity to the wavelength

Polarization is determined by the orientation of the electric field. The magnetic field is always perpendicular to the electric field and does not influence polarization.

T3B03

What are the two components of a radio wave?

A Impedance and reactance
B Voltage and current
C **Electric and magnetic fields**
D Ionizing and non-ionizing radiation

A radio wave consists of electric and magnetic fields that propagate together through space. These fields are interdependent and oscillate perpendicular to each other.

T3B04

What is the velocity of a radio wave traveling through free space?

A **Speed of light**
B Speed of sound
C Speed inversely proportional to its wavelength
D Speed that increases as the frequency increases

Radio waves travel at the speed of light in free space, which is approximately 3×10^8 meters per second. This speed is constant and does not depend on the wave's frequency or wavelength.

T3B05

What is the relationship between wavelength and frequency?

A Wavelength gets longer as frequency increases
B **Wavelength gets shorter as frequency increases**
C Wavelength and frequency are unrelated
D Wavelength and frequency increase as path length increases

Wavelength and frequency are inversely related. As frequency increases, wavelength decreases, and vice versa. This relationship is described by the formula $\lambda = \frac{c}{f}$.

T3B06

What is the formula for converting frequency to approximate wavelength in meters?

A Wavelength in meters equals frequency in hertz multiplied by 300
B Wavelength in meters equals frequency in hertz divided by 300
C Wavelength in meters equals frequency in megahertz divided by 300
D **Wavelength in meters equals 300 divided by frequency in megahertz**

The correct formula for converting frequency to wavelength in meters is $\lambda = \frac{300}{f_{\text{MHz}}}$. This formula is derived from the relationship $\lambda = \frac{c}{f}$, where c is the speed of light.

T3B07

In addition to frequency, which of the following is used to identify amateur radio bands?

A **The approximate wavelength in meters**
B Traditional letter/number designators
C Channel numbers
D All these choices are correct

Amateur radio bands are often identified by their approximate wavelength in meters. For example, the 2-meter band corresponds to frequencies around 144 MHz.

T3B08

What frequency range is referred to as VHF?

A 30 kHz to 300 kHz
B **30 MHz to 300 MHz**
C 300 kHz to 3000 kHz
D 300 MHz to 3000 MHz

The VHF (Very High Frequency) range spans from 30 MHz to 300 MHz. This range is commonly used for FM radio, television broadcasting, and amateur radio.

Summary

This section introduced the essential concepts of electromagnetic waves, including:

- **Electric and magnetic fields**: These fields are perpendicular to each other and to the direction of wave propagation.
- **Wave polarization**: Determined by the orientation of the electric field.
- **Velocity of radio waves**: Radio waves travel at the speed of light in free space.
- **Wavelength and frequency relationship**: Wavelength and frequency are inversely related.
- **Frequency to wavelength conversion**: The formula $\lambda = \frac{300}{f_{\mathrm{MHz}}}$ is used to convert frequency to wavelength in meters.
- **Amateur radio band identification**: Bands are often identified by their approximate wavelength in meters.

3.3 Propagation Basics

UHF Signal Propagation

UHF signals are rarely heard beyond the radio horizon due to their limited propagation characteristics. Unlike lower frequency signals, UHF signals are not typically reflected or refracted by the ionosphere. Instead, they propagate primarily via line-of-sight, which restricts their range to the visual horizon. This is illustrated in Figure 3.5, which shows how UHF signals are absorbed or scattered by the Earth's atmosphere and terrain.

Figure 3.5: UHF signal propagation and horizon limitations.

HF vs. VHF Communication

High-frequency (HF) communication differs significantly from very high-frequency (VHF) and ultra high-frequency (UHF) communication. HF signals (3–30 MHz) are capable of long-distance ionospheric propagation, allowing them to travel thousands of kilometers by reflecting off the ionosphere. In contrast, VHF and UHF signals (30 MHz and above) are primarily limited to line-of-sight propagation, making them less suitable for long-distance communication.

Auroral Backscatter

VHF signals received via auroral backscatter exhibit unique characteristics. These signals are often distorted, and their strength varies considerably due to the irregular nature of the auroral ionization. This phenomenon occurs when VHF signals are scattered by the ionized regions of the aurora, resulting in fluctuating signal quality.

Sporadic E Propagation

Sporadic E propagation is a key mechanism for occasional strong signals on the 10, 6, and 2-meter bands from beyond the radio horizon. This phenomenon occurs when dense patches of ionization form in the E layer of the ionosphere, reflecting VHF signals over long distances. Sporadic E is particularly common during summer months and can enable communication over hundreds or even thousands of kilometers.

Knife-Edge Diffraction

Knife-edge diffraction allows radio signals to travel beyond obstructions such as mountains or buildings. When a signal encounters a sharp edge, it bends around the obstacle, enabling communication even when there is no direct line of sight. This effect is particularly useful in mountainous or urban environments where obstacles would otherwise block the signal.

Tropospheric Ducting

Tropospheric ducting is a propagation mechanism that enables over-the-horizon VHF and UHF communication, often extending ranges up to 300 miles. This phenomenon occurs when temperature inversions in the troposphere create a duct-like layer that traps and guides radio waves. Figure 3.6 illustrates the mechanism of tropospheric ducting.

Figure 3.6: Tropospheric ducting mechanism.

Meteor Scatter

The 6-meter band is particularly well-suited for meteor scatter communication. When meteors enter the Earth's atmosphere, they create ionized trails that can reflect VHF signals. These trails are short-lived but can enable communication over distances of up to 1,500 kilometers.

Temperature Inversions

Temperature inversions in the atmosphere are the primary cause of tropospheric ducting. These inversions occur when a layer of warm air lies above a layer of cooler air, creating a boundary that reflects radio waves back toward the Earth's surface.

Propagation Mechanisms Summary

Table 3.3 summarizes the different propagation mechanisms and their characteristics.

Mechanism	Characteristics
UHF Propagation	Limited to line-of-sight, rarely beyond horizon
HF Propagation	Long-distance ionospheric reflection
Auroral Backscatter	Distorted, variable signal strength
Sporadic E	Dense E-layer ionization, long-distance VHF
Knife-Edge Diffraction	Bends around obstacles
Tropospheric Ducting	Temperature inversions, 300-mile range
Meteor Scatter	Ionized meteor trails, 6-meter band

Table 3.3: Propagation mechanisms and their effects.

Questions

T3C01

Why are simplex UHF signals rarely heard beyond their radio horizon?

A They are too weak to go very far
B FCC regulations prohibit them from going more than 50 miles
C **UHF signals are usually not propagated by the ionosphere**
D UHF signals are absorbed by the ionospheric D region

UHF signals are primarily line-of-sight and are not reflected by the ionosphere, unlike HF signals. This limits their range to the radio horizon. Options A and D are incorrect because signal strength and D-region absorption are not the primary reasons. Option B is incorrect as FCC regulations do not impose such limits.

T3C02

What is a characteristic of HF communication compared with communications on VHF and higher frequencies?

A HF antennas are generally smaller
B HF accommodates wider bandwidth signals
C **Long-distance ionospheric propagation is far more common on HF**
D There is less atmospheric interference (static) on HF

HF signals are reflected by the ionosphere, enabling long-distance communication. VHF and UHF signals are primarily line-of-sight. Option A is incorrect because HF antennas are typically larger. Option B is incorrect as HF does not inherently accommodate wider bandwidths. Option D is incorrect because HF is more susceptible to atmospheric interference.

T3C03

What is a characteristic of VHF signals received via auroral backscatter?

- A They are often received from 10,000 miles or more
- B **They are distorted and signal strength varies considerably**
- C They occur only during winter nighttime hours
- D They are generally strongest when your antenna is aimed west

Auroral backscatter causes VHF signals to be distorted and fluctuate in strength due to the irregular ionization of the aurora. Option A is incorrect because the range is typically much shorter. Options C and D are incorrect as auroral backscatter is not limited to winter nights or specific antenna directions.

T3C04

Which of the following types of propagation is most commonly associated with occasional strong signals on the 10, 6, and 2 meter bands from beyond the radio horizon?

- A Backscatter
- B **Sporadic E**
- C D region absorption
- D Gray-line propagation

Sporadic E propagation is responsible for strong signals on these bands due to dense ionization patches in the E layer. Options A, C, and D are incorrect as they do not typically produce strong signals on these bands.

T3C05

Which of the following effects may allow radio signals to travel beyond obstructions between the transmitting and receiving stations?

- A **Knife-edge diffraction**
- B Faraday rotation
- C Quantum tunneling
- D Doppler shift

Knife-edge diffraction allows signals to bend around obstacles, enabling communication beyond obstructions. Options B, C, and D are unrelated to this effect.

T3C06

What type of propagation is responsible for allowing over-the-horizon VHF and UHF communications to ranges of approximately 300 miles on a regular basis?

- A **Tropospheric ducting**
- B D region refraction
- C F2 region refraction
- D Faraday rotation

Tropospheric ducting, caused by temperature inversions, traps and guides VHF and UHF signals, enabling long-range communication. Options B, C, and D are incorrect as they do not apply to this phenomenon.

T3C07

What band is best suited for communicating via meteor scatter?

A 33 centimeters
B **6 meters**
C 2 meters
D 70 centimeters

The 6-meter band is ideal for meteor scatter due to its wavelength, which matches the ionized trails created by meteors. Options A, C, and D are less effective for this purpose.

T3C08

What causes tropospheric ducting?

A Discharges of lightning during electrical storms
B Sunspots and solar flares
C Updrafts from hurricanes and tornadoes
D **Temperature inversions in the atmosphere**

Temperature inversions create a duct-like layer in the troposphere that traps and guides radio waves. Options A, B, and C are unrelated to this phenomenon.

Summary

This section covered the basics of radio wave propagation, focusing on the following key concepts:

- **UHF Signal Propagation**: Limited to line-of-sight due to lack of ionospheric reflection.
- **HF vs. VHF Communication**: HF enables long-distance communication via ionospheric reflection, while VHF is primarily line-of-sight.
- **Auroral Backscatter**: VHF signals scattered by auroral ionization, resulting in distorted and variable signals.
- **Sporadic E Propagation**: Enables long-distance VHF communication via dense E-layer ionization.
- **Knife-Edge Diffraction**: Allows signals to bend around obstacles.
- **Tropospheric Ducting**: Extends VHF and UHF ranges up to 300 miles via temperature inversions.
- **Meteor Scatter**: Utilizes ionized meteor trails for communication, particularly on the 6-meter band.
- **Temperature Inversions**: The primary cause of tropospheric ducting.

Chapter 4 AMATEUR RADIO PRACTICES

4.1 Power Supplies and Critical Connections

Introduction

In this section, we will explore the critical aspects of power supplies and connections in radio transceivers. Understanding these concepts is essential for ensuring efficient and reliable operation of your equipment.

Power Supply Ratings

Selecting the correct power supply rating for a mobile FM transceiver is crucial. The power supply must provide the necessary voltage and current to operate the transceiver without causing damage or inefficiency. For example, a typical 50-watt output mobile FM transceiver requires a power supply rated at 13.8 volts and 12 amperes. This ensures that the transceiver operates within its specified parameters, avoiding potential issues such as overheating or insufficient power delivery.

Voltage Drop Minimization

Using short, heavy-gauge wires for DC power connections in transceivers is essential to minimize voltage drop. Voltage drop occurs when the resistance in the wires causes a reduction in voltage from the power supply to the transceiver. Heavy-gauge wires have lower resistance, which helps maintain the voltage level, especially during high current draw when transmitting. This ensures that the transceiver receives the full voltage required for optimal performance.

RF Power Meter Installation

The optimal placement of an RF power meter is in the feed line, between the transmitter and the antenna. This placement allows for accurate measurement of the RF power being transmitted, ensuring that the transmitter is operating within its specified power range. Incorrect placement can lead to inaccurate readings and potential damage to the equipment.

Figure 4.1: RF Power Meter Installation

RF Bonding Conductors

Flat copper strap is preferred for RF bonding due to its low impedance and high conductivity. This ensures effective grounding and minimizes RF interference. Other materials, such as copper braid or steel wire, may not provide the same level of performance, leading to potential issues with signal integrity and equipment performance.

Battery Power Calculations

To determine the length of time that equipment can be powered from a battery, divide the battery's ampere-hour rating by the average current draw of the equipment. For example, if a battery has a rating of 50 ampere-hours and the equipment draws an average of 5 amperes, the battery will last for approximately 10 hours. This calculation helps in planning the operational time and ensuring that the equipment does not run out of power unexpectedly.

Vehicle Grounding

The negative power return of a mobile transceiver should be connected at the 12-volt battery chassis ground in a vehicle. This ensures a stable and low-impedance ground connection, which is essential for minimizing noise and interference. Proper grounding also helps protect the equipment from potential damage due to electrical faults.

Figure 4.2: Vehicle Grounding Setup

Questions

T4A01

Which of the following is an appropriate power supply rating for a typical 50-watt output mobile FM transceiver?

A 24.0 volts at 4 amperes
B 13.8 volts at 4 amperes
C 24.0 volts at 12 amperes
D **13.8 volts at 12 amperes**

A typical 50-watt output mobile FM transceiver requires a power supply rated at 13.8 volts and 12 amperes to operate efficiently. The other options either provide insufficient current or incorrect voltage, which could lead to improper operation or damage to the transceiver.

T4A03

Why are short, heavy-gauge wires used for a transceiver's DC power connection?

A **To minimize voltage drop when transmitting**
B To provide a good counterpoise for the antenna
C To avoid RF interference
D All these choices are correct

Short, heavy-gauge wires are used to minimize voltage drop, which is crucial during high current draw when transmitting. The other options are incorrect because heavy-gauge wires do not serve as a counterpoise or directly avoid RF interference.

T4A05

Where should an RF power meter be installed?

A **In the feed line, between the transmitter and antenna**
B At the power supply output
C In parallel with the push-to-talk line and the antenna
D In the power supply cable, as close as possible to the radio

An RF power meter should be installed in the feed line between the transmitter and antenna to accurately measure the RF power being transmitted. The other options would not provide accurate readings of the transmitted power.

T4A08

Which of the following conductors is preferred for bonding at RF?

A Copper braid removed from coaxial cable
B Steel wire
C Twisted-pair cable
D **Flat copper strap**

Flat copper strap is preferred for RF bonding due to its low impedance and high conductivity, which ensures effective grounding and minimizes RF interference. The other options do not provide the same level of performance.

T4A09

How can you determine the length of time that equipment can be powered from a battery?

A Divide the watt-hour rating of the battery by the peak power consumption of the equipment
B **Divide the battery ampere-hour rating by the average current draw of the equipment**
C Multiply the watts per hour consumed by the equipment by the battery power rating
D Multiply the square of the current rating of the battery by the input resistance of the equipment

To determine the operational time, divide the battery's ampere-hour rating by the average current draw of the equipment. This calculation provides an estimate of how long the battery will last under normal operating conditions. The other options involve incorrect calculations that do not accurately reflect the battery's capacity.

T4A11

Where should the negative power return of a mobile transceiver be connected in a vehicle?

A **At the 12-volt battery chassis ground**
B At the antenna mount
C To any metal part of the vehicle
D Through the transceiver's mounting bracket

The negative power return should be connected at the 12-volt battery chassis ground to ensure a stable and low-impedance ground connection. This minimizes noise and interference and protects the equipment from electrical faults. The other options do not provide a reliable ground connection.

Summary

In this section, we covered several key concepts related to power supplies and critical connections in radio transceivers:

- **Power supply ratings**: Selecting the correct power supply rating is essential for efficient and safe operation of the transceiver.
- **Voltage drop minimization**: Using short, heavy-gauge wires helps maintain the voltage level during high current draw.
- **RF power meter installation**: Proper placement of the RF power meter ensures accurate measurement of transmitted power.
- **RF bonding conductors**: Flat copper strap is preferred for effective grounding and minimizing RF interference.
- **Battery power calculations**: Calculating the operational time of equipment powered by a battery helps in planning and avoiding power shortages.
- **Vehicle grounding**: Proper grounding of a mobile transceiver in a vehicle ensures stable operation and protection from electrical faults.

Table 4.1: Power Supply Ratings Comparison

Voltage (V)	Current (A)	Suitability
13.8	12	Suitable for 50W transceiver
24.0	4	Insufficient current
24.0	12	Incorrect voltage
13.8	4	Insufficient current

4.2 Digital Modes and Computer Interfaces

FT8 Operation

FT8 is a popular digital mode used in amateur radio for weak signal communication. To operate FT8, the transceiver's audio input and output are connected to a computer running WSJT-X software. This setup allows the computer to process the audio signals for encoding and decoding FT8 messages. The connection typically involves using the computer's sound card to handle the audio signals, ensuring accurate transmission and reception of data.

Computer-Radio Interfaces

In digital mode operation, the computer-radio interface plays a crucial role. The primary signals used in this interface are receive audio, transmit audio, and transmitter keying. These signals facilitate communication between the computer and the transceiver, enabling the transmission and reception of digital data. The receive audio signal carries the incoming data from the transceiver to the computer, while the transmit audio signal sends data from the computer to the transceiver. The transmitter keying signal controls the transceiver's transmit mode, ensuring proper timing and synchronization.

Figure 4.3: Computer-Radio Interface

Digital Mode Hot Spots

A digital mode hot spot is a device that allows amateur radio operators to communicate using digital voice or data systems via the internet. It acts as a bridge between the transceiver and the internet, enabling communication with other operators worldwide. The hot spot converts the digital signals from the transceiver into a format suitable for internet transmission and vice versa. This setup is particularly useful for accessing digital networks like DMR, D-STAR, and Fusion.

Figure 4.4: Digital Mode Hot Spot

Electronic Keyers

An electronic keyer is a device that assists in the manual sending of Morse code. It provides a more consistent and accurate keying speed compared to manual keying. The keyer typically includes a paddle that the operator uses to input Morse code, and it generates the corresponding dots and dashes electronically. This device is especially useful for operators who engage in Morse code communication, as it improves the efficiency and accuracy of their transmissions.

Signal	Description
Receive Audio	Carries incoming data from the transceiver to the computer.
Transmit Audio	Sends data from the computer to the transceiver.
Transmitter Keying	Controls the transceiver's transmit mode.

Table 4.2: Computer-Radio Interface Signals

Questions

T4A04

How are the transceiver audio input and output connected in a station configured to operate using FT8?

- A To a computer running a terminal program and connected to a terminal node controller unit
- B **To the audio input and output of a computer running WSJT-X software**
- C To an FT8 conversion unit, a keyboard, and a computer monitor
- D To a computer connected to the FT8converter.com website

For FT8 operation, the transceiver's audio input and output are connected to the computer's sound card, which is running WSJT-X software. This setup allows the computer to process the audio signals for encoding and decoding FT8 messages. The other options describe different setups that are not used for FT8 operation.

T4A06

What signals are used in a computer-radio interface for digital mode operation?

- A Receive and transmit mode, status, and location
- B Antenna and RF power
- C **Receive audio, transmit audio, and transmitter keying**
- D NMEA GPS location and DC power

The primary signals used in a computer-radio interface for digital modes are receive audio, transmit audio, and transmitter keying. These signals facilitate communication between the computer and the transceiver, enabling the transmission and reception of digital data. The other options describe signals that are not typically used in this context.

T4A07

Which of the following connections is made between a computer and a transceiver to use computer software when operating digital modes?

- A Computer "line out" to transceiver push-to-talk
- B Computer "line in" to transceiver push-to-talk
- C **Computer "line in" to transceiver speaker connector**
- D Computer "line out" to transceiver speaker connector

The correct connection is from the computer's "line in" to the transceiver's speaker connector. This setup allows the computer to receive audio signals from the transceiver for processing. The other options describe incorrect or less common connections.

T4A10

What function is performed with a transceiver and a digital mode hot spot?

- A **Communication using digital voice or data systems via the internet**
- B FT8 digital communications via AFSK
- C RTTY encoding and decoding without a computer
- D High-speed digital communications for meteor scatter

A digital mode hot spot allows communication using digital voice or data systems via the internet. It acts as a bridge between the transceiver and the internet, enabling communication with other operators worldwide. The other options describe different functions that are not performed by a digital mode hot spot.

T4A12

What is an electronic keyer?

- A A device for switching antennas from transmit to receive
- B A device for voice activated switching from receive to transmit
- C **A device that assists in manual sending of Morse code**
- D An interlock to prevent unauthorized use of a radio

An electronic keyer is a device that assists in the manual sending of Morse code. It provides a more consistent and accurate keying speed compared to manual keying. The other options describe different devices that are not related to Morse code communication.

Summary

This section covered several key concepts related to digital modes and computer interfaces in amateur radio:

- **FT8 Operation**: FT8 is a digital mode that requires connecting the transceiver's audio input and output to a computer running WSJT-X software.

- **Computer-Radio Interfaces**: The primary signals used in these interfaces are receive audio, transmit audio, and transmitter keying.

- **Digital Mode Hot Spots**: These devices enable communication using digital voice or data systems via the internet.

- **Electronic Keyers**: These devices assist in the manual sending of Morse code, improving the efficiency and accuracy of transmissions.

4.3 Audio and Signal Processing

Introduction

This section explores key concepts in audio and signal processing, focusing on the impact of microphone gain, squelch adjustment, receiver bandwidth selection, and the effects of tuning on FM signals. These topics are essential for understanding how to optimize radio transmissions and improve signal quality.

Impact of Excessive Microphone Gain on SSB Transmissions

Excessive microphone gain in SSB (Single Sideband) transmissions can lead to distorted transmitted audio. When the gain is too high, the audio signal becomes overdriven, causing clipping and distortion. This results in poor audio quality at the receiving end, making it difficult for the listener to understand the transmitted message. Proper adjustment of microphone gain is crucial to maintain clear and intelligible communication.

Adjusting Squelch for Weak FM Signals

To hear weak FM signals, the squelch threshold should be set so that the receiver output audio is on all the time. This ensures that even weak signals are audible. Turning up the audio level or enabling anti-squelch functions are not effective methods, as they do not address the underlying issue of the squelch threshold being too high.

Using RIT or Clarifier Controls in SSB Communication

The RIT (Receiver Incremental Tuning) or Clarifier controls are used to adjust the frequency of the received signal in SSB communication. If the voice pitch of a returning signal seems too high or low, these controls can be used to fine-tune the frequency, ensuring that the audio is clear and at the correct pitch.

Advantages of Multiple Receive Bandwidth Choices

Having multiple receive bandwidth choices on a multimode transceiver allows for noise or interference reduction by selecting a bandwidth that matches the mode being used. This improves the signal-to-noise ratio and enhances the overall reception quality. It does not, however, increase the number of frequencies stored in memory or the offset between receive and transmit frequencies.

Receiver Filter Bandwidth and Signal-to-Noise Ratio

The signal-to-noise ratio (SNR) in SSB reception is significantly affected by the receiver filter bandwidth. A bandwidth of 2400 Hz provides the best SNR for SSB reception, as it balances the need for sufficient bandwidth to capture the signal while minimizing noise.

Effects of Tuning an FM Receiver

Tuning an FM receiver above or below a signal's frequency results in distortion of the signal's audio. This is because the receiver is no longer correctly aligned with the carrier frequency, leading to a loss of fidelity in the received audio.

Figure 4.5: Microphone Gain Effects

Figure 4.6: Squelch Adjustment

Receiver Bandwidth (Hz)	Signal-to-Noise Ratio (SNR)
500	Low
1000	Moderate
2400	High
5000	Very Low

Table 4.3: Receiver Bandwidth and SNR

Questions

T4B01

What is the effect of excessive microphone gain on SSB transmissions?

- A Frequency instability
- B **Distorted transmitted audio**
- C Increased SWR
- D All these choices are correct

Excessive microphone gain causes the audio signal to clip, leading to distorted transmitted audio. This is because the signal exceeds the maximum level that the transmitter can handle, resulting in poor audio quality.

T4B03

How is squelch adjusted so that a weak FM signal can be heard?

- A **Set the squelch threshold so that receiver output audio is on all the time**
- B Turn up the audio level until it overcomes the squelch threshold
- C Turn on the anti-squelch function
- D Enable squelch enhancement

Setting the squelch threshold low ensures that weak signals are not suppressed, allowing them to be heard. Other methods do not effectively lower the threshold.

T4B06

Which of the following controls could be used if the voice pitch of a single-sideband signal returning to your CQ call seems too high or low?

A The AGC or limiter
B The bandwidth selection
C The tone squelch
D **The RIT or Clarifier**

The RIT or Clarifier allows fine-tuning of the received frequency, correcting any pitch discrepancies in the audio.

T4B08

What is the advantage of having multiple receive bandwidth choices on a multimode transceiver?

A Permits monitoring several modes at once by selecting a separate filter for each mode
B **Permits noise or interference reduction by selecting a bandwidth matching the mode**
C Increases the number of frequencies that can be stored in memory
D Increases the amount of offset between receive and transmit frequencies

Selecting the appropriate bandwidth reduces noise and interference, improving the clarity of the received signal.

T4B10

Which of the following receiver filter bandwidths provides the best signal-to-noise ratio for SSB reception?

A 500 Hz
B 1000 Hz
C **2400 Hz**
D 5000 Hz

A bandwidth of 2400 Hz is optimal for SSB reception, providing a good balance between signal clarity and noise reduction.

T4B12

What is the result of tuning an FM receiver above or below a signal's frequency?

A Change in audio pitch
B Sideband inversion
C Generation of a heterodyne tone
D **Distortion of the signal's audio**

Tuning off the correct frequency causes the receiver to misalign with the carrier, leading to audio distortion.

Summary

This section covered several key concepts in audio and signal processing:

- **Microphone Gain Effects**: Excessive gain leads to distorted audio in SSB transmissions.
- **Squelch Adjustment**: Proper squelch settings are crucial for hearing weak FM signals.
- **RIT and Clarifier Controls**: These controls help fine-tune the frequency in SSB communication.
- **Receiver Bandwidth Selection**: Choosing the right bandwidth reduces noise and improves signal quality.
- **Signal-to-Noise Ratio**: Optimal bandwidth selection enhances SNR in SSB reception.
- **FM Signal Distortion**: Misalignment in FM tuning results in audio distortion.

4.4 Frequency Management and Memory Channels

Frequency Entry Methods

To set the operating frequency on a transceiver, users can utilize either the keypad or the Variable Frequency Oscillator (VFO) knob. The keypad allows for direct numerical entry of the desired frequency, while the VFO knob enables fine-tuning by incrementally adjusting the frequency. These methods ensure precise control over the transceiver's operating frequency, which is crucial for effective communication.

Memory Channels

Memory channels provide a convenient way to store and quickly access frequently used frequencies. By saving a favorite frequency to a memory channel, users can avoid the need to manually re-enter the frequency each time. This feature is particularly useful in dynamic communication environments where quick frequency changes are necessary.

Scanning Function

The scanning function in an FM transceiver allows the device to automatically tune through a predefined range of frequencies to detect activity. This is especially useful for monitoring multiple channels or frequencies without manual intervention. The scanning function enhances the efficiency of communication by ensuring that no important signals are missed.

DMR Code Plug

A DMR code plug is a configuration file that contains access information for repeaters and talkgroups. It essentially programs the DMR radio with the necessary settings to connect to specific networks and communicate with designated groups. The code plug simplifies the setup process and ensures that the radio operates correctly within the DMR network.

Group Selection in Digital Voice

On a digital voice transceiver, selecting a specific group of stations is typically done by entering the group's identification code. This allows the transceiver to filter and communicate only with the designated group, enhancing the clarity and relevance of communication. Group selection is a key feature in digital voice systems, enabling organized and efficient communication.

D-STAR Programming

Before transmitting with a D-STAR digital transceiver, it is essential to program your call sign into the device. This ensures proper identification and compliance with regulatory requirements. Additional settings, such as output power and codec type, may also need to be configured depending on the specific use case.

Figure 4.7: Frequency Entry Methods

Figure 4.8: DMR Code Plug

Step	**Description**
1	Enter your call sign
2	Set the output power
3	Configure the codec type

Table 4.4: D-STAR Programming Steps

Questions

T4B02

Which of the following can be used to enter a transceiver's operating frequency?

A **The keypad or VFO knob**
B The CTCSS or DTMF encoder
C The Automatic Frequency Control
D All these choices are correct

The keypad or VFO knob are the primary methods for entering a transceiver's operating frequency. The CTCSS or DTMF encoder and Automatic Frequency Control are not used for frequency entry.

T4B04

What is a way to enable quick access to a favorite frequency or channel on your transceiver?

A Enable the frequency offset
B **Store it in a memory channel**
C Enable the VOX
D Use the scan mode to select the desired frequency

Storing a favorite frequency in a memory channel allows for quick and easy access. Frequency offset, VOX, and scan mode are not methods for quick access to a specific frequency.

T4B05

What does the scanning function of an FM transceiver do?

A Checks incoming signal deviation
B Prevents interference to nearby repeaters
C **Tunes through a range of frequencies to check for activity**
D Checks for messages left on a digital bulletin board

The scanning function tunes through a range of frequencies to detect activity, making it easier to monitor multiple channels.

T4B07

What does a DMR "code plug" contain?

A Your call sign in CW for automatic identification
B **Access information for repeaters and talkgroups**
C The codec for digitizing audio
D The DMR software version

A DMR code plug contains access information for repeaters and talkgroups, which is essential for configuring the radio to operate within the DMR network.

T4B09

How is a specific group of stations selected on a digital voice transceiver?

A By retrieving the frequencies from transceiver memory
B By enabling the group's CTCSS tone
C **By entering the group's identification code**
D By activating automatic identification

Selecting a specific group of stations is done by entering the group's identification code, which filters communication to only that group.

T4B11

Which of the following must be programmed into a D-STAR digital transceiver before transmitting?

A **Your call sign**
B Your output power
C The codec type being used
D All these choices are correct

Programming your call sign into a D-STAR transceiver is mandatory before transmitting to ensure proper identification.

Summary

- **Frequency Entry Methods**: Use the keypad or VFO knob to set the operating frequency.
- **Memory Channels**: Store favorite frequencies for quick access.
- **Scanning Function**: Automatically tunes through frequencies to detect activity.
- **DMR Code Plug**: Contains access information for repeaters and talkgroups.
- **Group Selection in Digital Voice**: Enter the group's identification code to filter communication.
- **D-STAR Programming**: Program your call sign and other necessary settings before transmitting.

Chapter 5 ELECTRICAL PRINCIPLES

5.1 Electrical Units and Concepts

Introduction

This section introduces fundamental electrical units and concepts, including electrical current, power, resistance, voltage, frequency, and the distinction between conductors and insulators. These concepts are essential for understanding how electrical circuits function and are foundational for further study in radio technology.

Electrical Current and Its Unit of Measurement

Electrical current is the flow of electric charge, typically carried by electrons in a conductor. The unit of measurement for electrical current is the **Ampere** (A), often abbreviated as "Amp." One ampere is defined as the flow of one coulomb of charge per second. Mathematically, this can be expressed as:

$$I = \frac{Q}{t} \tag{5.1}$$

where I is the current in amperes, Q is the charge in coulombs, and t is the time in seconds.

Relationship Between Voltage, Current, and Resistance

The relationship between voltage (V), current (I), and resistance (R) is described by Ohm's Law:

$$V = I \cdot R \tag{5.2}$$

This equation states that the voltage across a conductor is directly proportional to the current flowing through it and the resistance of the conductor. Voltage is measured in volts (V), current in amperes (A), and resistance in ohms (Ω).

Why Metals Are Good Conductors of Electricity

Metals are generally good conductors of electricity because they have many free electrons that can move easily through the material. These free electrons are not tightly bound to any particular atom, allowing them to flow in response to an applied electric field. This property makes metals highly effective at conducting electrical current.

Frequency and Its Unit of Measurement

Frequency is the number of cycles of a periodic waveform that occur in one second. The unit of measurement for frequency is the **Hertz** (Hz), named after the German physicist Heinrich Hertz. One hertz is equivalent to one cycle per second. Frequency is a critical parameter in radio technology, as it determines the wavelength and propagation characteristics of radio waves.

Conductors and Insulators

Conductors are materials that allow the free flow of electric charge, typically due to the presence of free electrons. Examples of good conductors include metals like copper and aluminum. Insulators, on the other hand, are materials that resist the flow of electric charge. Examples of good insulators include glass, rubber, and plastic. The distinction between conductors and insulators is crucial in designing electrical circuits and components.

Questions

T5A01

Electrical current is measured in which of the following units?

A Volts
B Watts
C Ohms
D **Amperes**

Electrical current is measured in amperes (A). Volts measure voltage, watts measure power, and ohms measure resistance.

T5A02

Electrical power is measured in which of the following units?

A Volts
B **Watts**
C Watt-hours
D Amperes

Electrical power is measured in watts (W). Volts measure voltage, watt-hours measure energy, and amperes measure current.

T5A03

What is the name for the flow of electrons in an electric circuit?

A Voltage
B Resistance
C Capacitance
D **Current**

The flow of electrons in an electric circuit is called current. Voltage is the force that causes the flow, resistance opposes the flow, and capacitance is the ability to store charge.

T5A04

What are the units of electrical resistance?

A Siemens
B Mhos
C **Ohms**
D Coulombs

Electrical resistance is measured in ohms (Ω). Siemens and mhos are units of conductance, and coulombs measure electric charge.

T5A05

What is the electrical term for the force that causes electron flow?

A **Voltage**
B Ampere-hours
C Capacitance
D Inductance

The force that causes electron flow is called voltage. Ampere-hours measure charge, capacitance is the ability to store charge, and inductance is the property of a conductor to oppose changes in current.

T5A06

What is the unit of frequency?

A **Hertz**
B Henry
C Farad
D Tesla

The unit of frequency is the hertz (Hz). Henry is the unit of inductance, farad is the unit of capacitance, and tesla is the unit of magnetic flux density.

T5A07

Why are metals generally good conductors of electricity?

A They have relatively high density
B **They have many free electrons**
C They have many free protons
D All these choices are correct

Metals are good conductors because they have many free electrons that can move easily through the material. Density and protons are not relevant to conductivity.

T5A08

Which of the following is a good electrical insulator?

A Copper
B **Glass**
C Aluminum
D Mercury

Glass is a good electrical insulator because it resists the flow of electric charge. Copper, aluminum, and mercury are all good conductors.

Summary

This section covered the following key concepts:

- **Electrical Current**: The flow of electric charge, measured in amperes (A).
- **Electrical Power**: The rate at which electrical energy is transferred, measured in watts (W).
- **Electron Flow**: The movement of electrons in a conductor, which constitutes electric current.
- **Electrical Resistance**: The opposition to the flow of current, measured in ohms (Ω).
- **Voltage**: The force that causes electron flow, measured in volts (V).
- **Frequency**: The number of cycles per second, measured in hertz (Hz).
- **Conductors and Insulators**: Materials that allow or resist the flow of electric charge, respectively.

Figures

Figure 5.1: Electron flow in a conductor. The diagram shows the movement of free electrons through a metal wire under the influence of an applied electric field.

Tables

5.2 Alternating Current and Power

Introduction

In this section, we will explore the fundamental concepts of alternating current (AC) and electrical power. We will discuss how AC differs from direct current (DC), the relationship between power, voltage, and current, the effect of resistance on current flow, and the significance of frequency in AC circuits.

Quantity	Unit
Current	Ampere (A)
Voltage	Volt (V)
Resistance	Ohm (Ω)
Power	Watt (W)
Frequency	Hertz (Hz)

Table 5.1: Units of Electrical Measurement

Alternating Current

Alternating current (AC) is a type of electrical current where the flow of electric charge periodically reverses direction. Unlike direct current (DC), which flows in a single direction, AC alternates between positive and negative directions. This periodic reversal is typically sinusoidal, as shown in Figure 5.2.

Figure 5.2: AC waveform showing the periodic reversal of current direction.

The mathematical representation of an AC voltage is given by:

$$V(t) = V_{\text{peak}} \sin(2\pi f t) \tag{5.3}$$

where $V(t)$ is the voltage at time t, V_{peak} is the peak voltage, and f is the frequency of the AC signal.

Electrical Power

Electrical power is the rate at which electrical energy is consumed or transferred in a circuit. It is calculated using the formula:

$$P = V \times I \tag{5.4}$$

where P is the power in watts (W), V is the voltage in volts (V), and I is the current in amperes (A). In AC circuits, the power can also be expressed in terms of the root mean square (RMS) values of voltage and current:

$$P = V_{\text{RMS}} \times I_{\text{RMS}} \tag{5.5}$$

Resistance and Current Flow

Resistance is a property of a material that opposes the flow of electric current. In both AC and DC circuits, resistance reduces the current flow according to Ohm's Law:

$$V = I \times R \tag{5.6}$$

where R is the resistance in ohms (Ω). In AC circuits, the opposition to current flow is not only due to resistance but also due to reactance, which depends on the frequency of the AC signal.

Frequency of Alternating Current

The frequency of an AC signal is the number of complete cycles it completes per second. It is measured in hertz (Hz). For example, the standard frequency for AC power in most countries is 50 Hz or 60 Hz. The frequency determines how quickly the current alternates and is crucial for the design and operation of electrical systems.

Questions

T5A09

Which of the following describes alternating current?

A Current that alternates between a positive direction and zero
B Current that alternates between a negative direction and zero
C **Current that alternates between positive and negative directions**
D All these answers are correct

Alternating current (AC) periodically reverses direction, meaning it alternates between positive and negative directions. This is the defining characteristic of AC, as opposed to DC, which flows in a single direction.

T5A10

Which term describes the rate at which electrical energy is used?

A Resistance
B Current
C **Power**
D Voltage

Power is the rate at which electrical energy is used or transferred. It is calculated as the product of voltage and current ($P = V \times I$).

T5A11

What type of current flow is opposed by resistance?

A Direct current
B Alternating current
C RF current
D **All these choices are correct**

Resistance opposes the flow of any type of current, whether it is direct current (DC), alternating current (AC), or radio frequency (RF) current. This is a fundamental property of resistance in electrical circuits.

T5A12

What describes the number of times per second that an alternating current makes a complete cycle?

A Pulse rate
B Speed
C Wavelength
D **Frequency**

Frequency is the term that describes the number of complete cycles an alternating current completes per second. It is measured in hertz (Hz).

Summary

In this section, we covered the following key concepts:

- **Alternating Current (AC)**: A type of current that periodically reverses direction, typically in a sinusoidal waveform.
- **Electrical Power**: The rate at which electrical energy is used, calculated as the product of voltage and current.
- **Resistance and Current Flow**: Resistance opposes the flow of current in both AC and DC circuits, reducing the current according to Ohm's Law.
- **Frequency of AC**: The number of complete cycles an AC signal completes per second, measured in hertz (Hz).

5.3 Electrical Measurements

Introduction

Electrical measurements are fundamental in understanding and analyzing electrical circuits and systems. This section covers the conversion between different units of electrical measurement, the significance of frequency, and the relationship between various units of voltage and capacitance.

Unit Conversions in Electrical Measurements

Electrical measurements often involve converting between different units, such as amperes to milliamperes, volts to microvolts, or hertz to kilohertz. Understanding these conversions is crucial for accurate measurements and calculations. For example, to convert amperes to milliamperes, you multiply by 1000:

$$1\,\mathrm{A} = 1000\,\mathrm{mA} \tag{5.7}$$

Similarly, to convert hertz to kilohertz, you divide by 1000:

$$1\,\mathrm{kHz} = 1000\,\mathrm{Hz} \tag{5.8}$$

Frequency in Electrical Measurements

Frequency is a critical parameter in electrical measurements, especially in radio technology. It represents the number of cycles per second and is measured in hertz (Hz). Higher frequencies, such as kilohertz (kHz) and megahertz (MHz), are commonly used in radio communications. For example, 1.5 MHz is equivalent to 1500 kHz:

$$1.5\,\text{MHz} = 1500\,\text{kHz} \tag{5.9}$$

Voltage Units

Voltage is measured in volts (V), but smaller units like millivolts (mV) and microvolts (µV) are often used for precision measurements. The relationships between these units are:

$$1\,\text{V} = 1000\,\text{mV} = 1,000,000\,\mu\text{V} \tag{5.10}$$

For example, one microvolt is one-millionth of a volt:

$$1\,\mu\text{V} = 10^{-6}\,\text{V} \tag{5.11}$$

Capacitance and Its Units

Capacitance is the ability of a system to store an electric charge and is measured in farads (F). Smaller units like microfarads (µF) and picofarads (pF) are commonly used. The conversion between these units is:

$$1\,\text{F} = 1,000,000\,\mu\text{F} = 1,000,000,000,000\,\text{pF} \tag{5.12}$$

For example, one microfarad is equal to one million picofarads:

$$1\,\mu\text{F} = 1,000,000\,\text{pF} \tag{5.13}$$

Figures and Tables

Figure 5.3: Unit conversions for electrical measurements.

Table 5.2: Common Electrical Unit Conversions

Unit	Conversion
1 A	1000 mA
1 kV	1000 V
1 MHz	1000 kHz
1 µF	1,000,000 pF

Questions

T5B01

How many milliamperes is 1.5 amperes?

A 15 milliamperes
B 150 milliamperes
C **1500 milliamperes**
D 15,000 milliamperes

To convert amperes to milliamperes, multiply by 1000: $1.5\,\mathrm{A} \times 1000 = 1500\,\mathrm{mA}$. The other options are incorrect because they do not reflect this conversion.

T5B02

Which is equal to 1,500,000 hertz?

A **1500 kHz**
B 1500 MHz
C 15 GHz
D 150 kHz

To convert hertz to kilohertz, divide by 1000: $1,500,000\,\mathrm{Hz} \div 1000 = 1500\,\mathrm{kHz}$. The other options are incorrect because they do not match this conversion.

T5B03

Which is equal to one kilovolt?

A One one-thousandth of a volt
B One hundred volts
C **One thousand volts**
D One million volts

One kilovolt is equal to 1000 volts. The other options are incorrect because they do not match this definition.

T5B04

Which is equal to one microvolt?

A **One one-millionth of a volt**
B One million volts
C One thousand kilovolts
D One one-thousandth of a volt

One microvolt is equal to one-millionth of a volt. The other options are incorrect because they do not match this definition.

T5B05

Which is equal to 500 milliwatts?

- A 0.02 watts
- B **0.5 watts**
- C 5 watts
- D 50 watts

To convert milliwatts to watts, divide by 1000: $500\,\text{mW} \div 1000 = 0.5\,\text{W}$. The other options are incorrect because they do not reflect this conversion.

T5B06

Which is equal to 3000 milliamperes?

- A 0.003 amperes
- B 0.3 amperes
- C 3,000,000 amperes
- D **3 amperes**

To convert milliamperes to amperes, divide by 1000: $3000\,\text{mA} \div 1000 = 3\,\text{A}$. The other options are incorrect because they do not reflect this conversion.

T5B07

Which is equal to 3.525 MHz?

- A 0.003525 kHz
- B 35.25 kHz
- C **3525 kHz**
- D 3,525,000 kHz

To convert megahertz to kilohertz, multiply by 1000: $3.525\,\text{MHz} \times 1000 = 3525\,\text{kHz}$. The other options are incorrect because they do not match this conversion.

T5B08

Which is equal to 1,000,000 picofarads?

- A 0.001 microfarads
- B **1 microfarad**
- C 1000 microfarads
- D 1,000,000,000 microfarads

To convert picofarads to microfarads, divide by 1,000,000: $1,000,000\,\text{pF} \div 1,000,000 = 1\,\mu\text{F}$. The other options are incorrect because they do not reflect this conversion.

Summary

This section covered the following key concepts:

- **Milliamperes**: A unit of electric current equal to one-thousandth of an ampere.

- **Hertz and kilohertz**: Units of frequency, with 1 kHz equal to 1000 Hz.
- **Volts and kilovolts**: Units of voltage, with 1 kV equal to 1000 V.
- **Microvolts**: A unit of voltage equal to one-millionth of a volt.
- **Milliwatts**: A unit of power equal to one-thousandth of a watt.
- **Picofarads and microfarads**: Units of capacitance, with 1 µF equal to 1,000,000 pF.

Understanding these units and their conversions is essential for working with electrical measurements in radio technology.

5.4 Decibels and Power

The decibel (dB) is a logarithmic unit used to express the ratio of two power levels. It is widely used in radio technology to measure power increases and decreases due to its ability to represent large ranges of values in a compact form. The decibel scale is particularly useful because it aligns with the way human perception works, which is often logarithmic rather than linear.

Understanding Decibels

The decibel is defined as:

$$\mathrm{dB} = 10\log_{10}\left(\frac{P_2}{P_1}\right) \tag{5.14}$$

where P_1 is the reference power level and P_2 is the power level being measured. A positive dB value indicates a power increase, while a negative dB value indicates a power decrease.

Power Increases and Decreases

When the power increases from P_1 to P_2, the decibel value is calculated using Equation 5.14. For example, a power increase from 5 watts to 10 watts results in:

$$\mathrm{dB} = 10\log_{10}\left(\frac{10}{5}\right) = 10\log_{10}(2) \approx 3\,\mathrm{dB}. \tag{5.15}$$

Similarly, a power decrease from 12 watts to 3 watts results in:

$$\mathrm{dB} = 10\log_{10}\left(\frac{3}{12}\right) = 10\log_{10}(0.25) \approx -6\,\mathrm{dB}. \tag{5.16}$$

Logarithmic Nature of Decibels

The decibel scale is logarithmic, meaning that each 10 dB increase represents a tenfold increase in power. For instance, a power increase from 20 watts to 200 watts corresponds to:

$$\mathrm{dB} = 10\log_{10}\left(\frac{200}{20}\right) = 10\log_{10}(10) = 10\,\mathrm{dB}. \tag{5.17}$$

Figure 5.4: Power changes in decibels.

Questions

T5B09

Which decibel value most closely represents a power increase from 5 watts to 10 watts?

A 2 dB
B **3 dB**
C 5 dB
D 10 dB

Using Equation 5.14, the calculation is $10\log_{10}(10/5) = 10\log_{10}(2) \approx 3\,\text{dB}$. The other options are incorrect because they do not match the calculated value.

T5B10

Which decibel value most closely represents a power decrease from 12 watts to 3 watts?

A -1 dB
B -3 dB
C **-6 dB**
D -9 dB

Using Equation 5.14, the calculation is $10\log_{10}(3/12) = 10\log_{10}(0.25) \approx -6\,\text{dB}$. The other options are incorrect because they do not match the calculated value.

T5B11

Which decibel value represents a power increase from 20 watts to 200 watts?

A **10 dB**
B 12 dB
C 18 dB
D 28 dB

Using Equation 5.14, the calculation is $10\log_{10}(200/20) = 10\log_{10}(10) = 10\,\text{dB}$. The other options are incorrect because they do not match the calculated value.

Summary

- **Decibels**: A logarithmic unit used to express power ratios.
- **Power increase and decrease**: A positive dB value indicates a power increase, while a negative dB value indicates a power decrease.
- **Logarithmic scale**: Each 10 dB increase represents a tenfold increase in power.

The decibel scale is a powerful tool for representing power changes in radio technology, allowing for easy comparison of large and small values.

5.5 Capacitance and Inductance

Capacitance

Capacitance describes the ability of a component, such as a capacitor, to store energy in an electric field. The unit of capacitance is the farad (F), named after the English physicist Michael Faraday. A capacitor consists of two conductive plates separated by an insulating material, known as a dielectric. When a voltage is applied across the plates, an electric field is established, and energy is stored in this field. The capacitance C of a capacitor is given by the formula:

$$C = \frac{Q}{V} \tag{5.18}$$

where Q is the charge stored on the plates, and V is the voltage across the plates.

Inductance

Inductance, on the other hand, describes the ability of a component, such as an inductor, to store energy in a magnetic field. The unit of inductance is the henry (H), named after the American scientist Joseph Henry. An inductor typically consists of a coil of wire, and when current flows through it, a magnetic field is generated. The energy is stored in this magnetic field. The inductance L of an inductor is given by:

$$L = \frac{\Phi}{I} \tag{5.19}$$

where Φ is the magnetic flux through the coil, and I is the current flowing through it.

Impedance

Impedance is a measure of the opposition to alternating current (AC) flow in a circuit. It is a complex quantity that combines resistance and reactance (both inductive and capacitive). The unit of impedance is the ohm (Ω). Impedance is significant in AC circuits because it determines the relationship between voltage and current in the presence of reactance. The impedance Z of a circuit is given by:

$$Z = R + jX \tag{5.20}$$

where R is the resistance, X is the reactance, and j is the imaginary unit.

Energy Storage in Electric and Magnetic Fields

Energy can be stored in both electric and magnetic fields. In a capacitor, energy is stored in the electric field between its plates. The energy E stored in a capacitor is given by:

$$E = \frac{1}{2}CV^2 \tag{5.21}$$

In an inductor, energy is stored in the magnetic field generated by the current flowing through it. The energy E stored in an inductor is given by:

$$E = \frac{1}{2}LI^2 \tag{5.22}$$

Figure 5.5: Capacitor and inductor in a circuit. The diagram shows a capacitor and an inductor connected in a simple circuit, illustrating their roles in energy storage.

Questions

T5C01

What describes the ability to store energy in an electric field?

A Inductance
B Resistance
C Tolerance
D **Capacitance**

Capacitance is the ability to store energy in an electric field, as described by the behavior of a capacitor. The other options are incorrect because inductance relates to magnetic fields, resistance opposes current flow, and tolerance is a measure of component variability.

T5C02

What is the unit of capacitance?

A **The farad**
B The ohm
C The volt
D The henry

The unit of capacitance is the farad (F). The ohm is the unit of resistance, the volt is the unit of voltage, and the henry is the unit of inductance.

T5C03

What describes the ability to store energy in a magnetic field?

A Admittance
B Capacitance
C Resistance
D **Inductance**

Inductance describes the ability to store energy in a magnetic field, as seen in inductors. Admittance is the inverse of impedance, capacitance relates to electric fields, and resistance opposes current flow.

T5C04

What is the unit of inductance?

A The coulomb
B The farad
C **The henry**
D The ohm

The unit of inductance is the henry (H). The coulomb is the unit of electric charge, the farad is the unit of capacitance, and the ohm is the unit of resistance.

T5C05

What is the unit of impedance?

A The volt
B The ampere
C The coulomb
D **The ohm**

The unit of impedance is the ohm (Ω). The volt is the unit of voltage, the ampere is the unit of current, and the coulomb is the unit of electric charge.

T5C12

What is impedance?

A **The opposition to AC current flow**
B The inverse of resistance
C The Q or Quality Factor of a component
D The power handling capability of a component

Impedance is the opposition to AC current flow, combining resistance and reactance. The inverse of resistance is conductance, the Q factor relates to the efficiency of an inductor or capacitor, and power handling capability is unrelated to impedance.

Summary

- **Capacitance**: The ability to store energy in an electric field, measured in farads (F).
- **Inductance**: The ability to store energy in a magnetic field, measured in henries (H).
- **Impedance**: The opposition to AC current flow, measured in ohms (Ω).
- **Energy Storage**: Energy is stored in electric fields (capacitors) and magnetic fields (inductors), with formulas $E = \frac{1}{2}CV^2$ and $E = \frac{1}{2}LI^2$, respectively.

5.6 Power Calculations

Introduction

In this section, we will explore the fundamental concepts of electrical power calculations in DC circuits. We will discuss the relationship between power, voltage, and current, and derive the formula used to calculate electrical power. Additionally, we will solve practical problems to reinforce these concepts.

Power Formula in DC Circuits

The electrical power P in a DC circuit is calculated using the formula:

$$P = I \cdot E \tag{5.23}$$

where:

- P is the power in watts (W),
- I is the current in amperes (A),
- E is the voltage in volts (V).

This formula is derived from the basic principles of electrical circuits, where power is the product of voltage and current. It is essential to understand this relationship to analyze and design electrical systems effectively.

Calculating Power Given Voltage and Current

To calculate the power delivered in a circuit, you need to know the voltage and current. For example, if a circuit has a voltage of 13.8 volts and a current of 10 amperes, the power can be calculated as follows:

$$P = I \cdot E = 10\,\mathrm{A} \cdot 13.8\,\mathrm{V} = 138\,\mathrm{W}$$

This calculation demonstrates how the power formula is applied in practical scenarios.

Relationship Between Power, Voltage, and Current

The relationship between power, voltage, and current is linear. As either voltage or current increases, the power delivered by the circuit also increases proportionally. This relationship is crucial for understanding how electrical systems behave under different conditions.

Example Calculations

Let's solve a few example problems to solidify our understanding:

1. **Example 1:** Calculate the power delivered by a voltage of 12 volts DC and a current of 2.5 amperes.

$$P = I \cdot E = 2.5\,\mathrm{A} \cdot 12\,\mathrm{V} = 30\,\mathrm{W}$$

2. **Example 2:** Determine the current required to deliver 120 watts at a voltage of 12 volts DC.

$$I = \frac{P}{E} = \frac{120\,\mathrm{W}}{12\,\mathrm{V}} = 10\,\mathrm{A}$$

Questions

T5C08

What is the formula used to calculate electrical power (P) in a DC circuit?

A **P = I E**
B P = E / I
C P = E – I
D P = I + E

The formula for electrical power in a DC circuit is $P = I \cdot E$, where P is power, I is current, and E is voltage. This is derived from the basic principles of electrical circuits.

T5C09

How much power is delivered by a voltage of 13.8 volts DC and a current of 10 amperes?

A **138 watts**
B 0.7 watts
C 23.8 watts
D 3.8 watts

Using the power formula $P = I \cdot E$, we calculate:

$$P = 10\,\mathrm{A} \cdot 13.8\,\mathrm{V} = 138\,\mathrm{W}$$

The other options are incorrect because they do not follow the correct formula.

T5C10

How much power is delivered by a voltage of 12 volts DC and a current of 2.5 amperes?

A 4.8 watts
B **30 watts**
C 14.5 watts
D 0.208 watts

Using the power formula:

$$P = 2.5\,\mathrm{A} \cdot 12\,\mathrm{V} = 30\,\mathrm{W}$$

The other options are incorrect because they do not follow the correct formula.

T5C11

How much current is required to deliver 120 watts at a voltage of 12 volts DC?

A 0.1 amperes
B **10 amperes**
C 12 amperes
D 132 amperes

Rearranging the power formula $P = I \cdot E$ to solve for current:

$$I = \frac{P}{E} = \frac{120\,\text{W}}{12\,\text{V}} = 10\,\text{A}$$

The other options are incorrect because they do not follow the correct formula.

Summary

In this section, we discussed the following key concepts:

- **Electrical Power:** The rate at which electrical energy is transferred by an electric circuit.
- **Power Formula:** $P = I \cdot E$, where P is power, I is current, and E is voltage.
- **Voltage and Current:** The two fundamental quantities that determine the power in a DC circuit.

Understanding these concepts is essential for analyzing and designing electrical systems effectively.

5.7 Circuit Analysis

Introduction

Ohm's Law is one of the fundamental principles in electrical engineering and circuit analysis. It describes the relationship between voltage (E), current (I), and resistance (R) in an electrical circuit. Ohm's Law is expressed mathematically as:

$$E = I \times R \tag{5.24}$$

This equation states that the voltage across a conductor is directly proportional to the current flowing through it, with the constant of proportionality being the resistance. Ohm's Law is crucial for analyzing and designing electrical circuits, as it allows us to calculate unknown quantities when the other two are known.

Calculating Current, Voltage, and Resistance

Using Ohm's Law, we can derive formulas to calculate current, voltage, and resistance:

- **Current (I)**: The current flowing through a circuit can be calculated using the formula:

$$I = \frac{E}{R} \tag{5.25}$$

- **Voltage (E)**: The voltage across a circuit can be calculated using the formula:

$$E = I \times R \tag{5.26}$$

- **Resistance (R)**: The resistance of a circuit can be calculated using the formula:

$$R = \frac{E}{I} \tag{5.27}$$

These formulas are essential for solving problems in circuit analysis, as demonstrated in the following examples.

Relationship Between Voltage, Current, and Resistance

The relationship between voltage, current, and resistance is linear, as described by Ohm's Law. This means that if the voltage across a circuit increases, the current will also increase, provided the resistance remains constant. Conversely, if the resistance increases, the current will decrease for a given voltage. This relationship is illustrated in Figure 5.6.

Figure 5.6: Ohm's Law: A diagram illustrating the relationship between voltage (E), current (I), and resistance (R). The diagram shows a simple circuit with a voltage source, resistor, and current flow.

Questions

T5D01

What formula is used to calculate current in a circuit?

A $I = ER$
B $I = E/R$
C $I = E + R$
D $I = E - R$

The correct formula for calculating current is $I = E/R$, as derived from Ohm's Law (Equation 5.25). The other options are incorrect because they do not represent the correct relationship between voltage, current, and resistance.

T5D02

What formula is used to calculate voltage in a circuit?

A $E = I \times R$
B $E = I/R$
C $E = I + R$
D $E = I - R$

The correct formula for calculating voltage is $E = I \times R$, as stated in Ohm's Law (Equation 5.26). The other options are incorrect because they do not represent the correct relationship between voltage, current, and resistance.

T5D03

What formula is used to calculate resistance in a circuit?

A $R = E \times I$
B $R = E/I$
C $R = E + I$
D $R = E - I$

The correct formula for calculating resistance is $R = E/I$, as derived from Ohm's Law (Equation 5.27). The other options are incorrect because they do not represent the correct relationship between voltage, current, and resistance.

T5D04

What is the resistance of a circuit in which a current of 3 amperes flows when connected to 90 volts?

A 3 ohms
B **30 ohms**
C 93 ohms
D 270 ohms

Using the formula $R = E/I$, we can calculate the resistance as follows:

$$R = \frac{90\,\mathrm{V}}{3\,\mathrm{A}} = 30\,\Omega$$

The other options are incorrect because they do not result from the correct application of Ohm's Law.

T5D05

What is the resistance of a circuit for which the applied voltage is 12 volts and the current flow is 1.5 amperes?

A 18 ohms
B 0.125 ohms
C **8 ohms**
D 13.5 ohms

Using the formula $R = E/I$, we can calculate the resistance as follows:

$$R = \frac{12\,\mathrm{V}}{1.5\,\mathrm{A}} = 8\,\Omega$$

The other options are incorrect because they do not result from the correct application of Ohm's Law.

T5D06

What is the resistance of a circuit that draws 4 amperes from a 12-volt source?

A **3 ohms**
B 16 ohms
C 48 ohms
D 8 ohms

Using the formula $R = E/I$, we can calculate the resistance as follows:

$$R = \frac{12\,\mathrm{V}}{4\,\mathrm{A}} = 3\,\Omega$$

The other options are incorrect because they do not result from the correct application of Ohm's Law.

T5D07

What is the current in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms?

A 9600 amperes
B 200 amperes
C 0.667 amperes
D **1.5 amperes**

Using the formula $I = E/R$, we can calculate the current as follows:

$$I = \frac{120\,\mathrm{V}}{80\,\Omega} = 1.5\,\mathrm{A}$$

The other options are incorrect because they do not result from the correct application of Ohm's Law.

T5D08

What is the current through a 100-ohm resistor connected across 200 volts?

A 20,000 amperes
B 0.5 amperes
C **2 amperes**
D 100 amperes

Using the formula $I = E/R$, we can calculate the current as follows:

$$I = \frac{200\,\mathrm{V}}{100\,\Omega} = 2\,\mathrm{A}$$

The other options are incorrect because they do not result from the correct application of Ohm's Law.

Summary

This section introduced the fundamental concepts of circuit analysis, focusing on Ohm's Law and its applications. The key concepts covered include:

- **Ohm's Law**: The relationship between voltage, current, and resistance in a circuit, expressed as $E = I \times R$.
- **Current Calculation**: The formula $I = E/R$ is used to calculate current when voltage and resistance are known.
- **Voltage Calculation**: The formula $E = I \times R$ is used to calculate voltage when current and resistance are known.
- **Resistance Calculation**: The formula $R = E/I$ is used to calculate resistance when voltage and current are known.

These principles are essential for analyzing and designing electrical circuits, as demonstrated through the examples and questions in this section.

5.8 Series and Parallel Circuits

Characteristics of Series Circuits

In a series circuit, components are connected end-to-end in a single path. The current flowing through each component is the same, as there is only one path for the current to follow. The total voltage across the circuit is the sum of the voltages across each component. This can be expressed mathematically as:

$$V_{\text{total}} = V_1 + V_2 + V_3 + \cdots + V_n \tag{5.28}$$

where $V_1, V_2, \ldots, V_n$ are the voltages across each component.

Characteristics of Parallel Circuits

In a parallel circuit, components are connected across the same voltage source, providing multiple paths for the current to flow. The voltage across each component is the same, but the current divides among the branches. The total current in the circuit is the sum of the currents through each branch:

$$I_{\text{total}} = I_1 + I_2 + I_3 + \cdots + I_n \tag{5.29}$$

where $I_1, I_2, \ldots, I_n$ are the currents through each branch.

Current and Voltage in Series and Parallel Circuits

In series circuits, the current is constant throughout, while the voltage varies across components. In parallel circuits, the voltage is constant across all components, while the current varies. These behaviors are fundamental to understanding how circuits operate and are critical for designing and troubleshooting electrical systems.

Figure 5.7: Series and parallel circuits

Questions

T5D13

In which type of circuit is DC current the same through all components?

A **Series**
B Parallel
C Resonant
D Branch

In a series circuit, the current is the same through all components because there is only one path for the current to flow. In parallel circuits, the current divides among the branches, so it is not the same through all components. Resonant and branch circuits are not relevant to this question.

T5D14

In which type of circuit is voltage the same across all components?

A Series
B **Parallel**
C Resonant
D Branch

In a parallel circuit, the voltage across each component is the same because they are all connected directly to the voltage source. In series circuits, the voltage varies across components. Resonant and branch circuits are not relevant to this question.

Summary

- **Series circuits**: Components are connected in a single path, with the same current flowing through each component. The total voltage is the sum of the voltages across each component.
- **Parallel circuits**: Components are connected across the same voltage source, with the same voltage across each component. The total current is the sum of the currents through each branch.
- **Current and voltage in circuits**: In series circuits, current is constant, and voltage varies. In parallel circuits, voltage is constant, and current varies.

Chapter 6 ELECTRONIC AND ELECTRICAL COMPONENTS

6.1 Basic Components and Their Functions

Introduction

This section introduces the basic components used in electronic circuits, their functions, and their roles in controlling and managing electrical signals. We will discuss resistors, potentiometers, capacitors, inductors, and switches, along with their applications and energy storage mechanisms.

Resistors

A resistor is a fundamental electrical component that opposes the flow of current in a DC circuit. It is characterized by its resistance, which is measured in ohms (Ω). The relationship between voltage (V), current (I), and resistance (R) is given by Ohm's Law:

$$V = I \cdot R \tag{6.1}$$

Resistors are commonly used to limit current, divide voltages, and provide biasing in circuits.

Potentiometers

A potentiometer is a type of variable resistor that allows for adjustable resistance. It consists of a resistive element and a sliding contact (wiper) that moves along the element. Potentiometers are often used as volume controls in audio equipment and as adjustable voltage dividers. The resistance between the wiper and one end of the resistive element changes as the wiper is moved, allowing for precise control of the output voltage.

Capacitors and Inductors

Capacitors and inductors are energy storage components, but they store energy in different forms. A capacitor stores energy in an electric field, while an inductor stores energy in a magnetic field. The energy stored in a capacitor is given by:

$$E_C = \frac{1}{2}CV^2 \tag{6.2}$$

where C is the capacitance and V is the voltage across the capacitor. Similarly, the energy stored in an inductor is:

$$E_L = \frac{1}{2}LI^2 \tag{6.3}$$

where L is the inductance and I is the current through the inductor.

Switches

An SPDT (Single Pole Double Throw) switch is a type of switch that connects a single circuit to one of two other circuits. It is commonly used in applications where a single input needs to be switched between two outputs, such as in audio signal routing or mode selection in electronic devices.

Figures

Figure 6.1: Symbol and structure of a resistor

Figure 6.2: Symbol and structure of a potentiometer

Tables

Table 6.1: Comparison of basic electronic components

Component	**Property**	**Energy Storage**	**Common Use**
Resistor	Resistance	None	Current limiting, voltage division
Capacitor	Capacitance	Electric field	Energy storage, filtering
Inductor	Inductance	Magnetic field	Energy storage, filtering

Questions

T6A01

What electrical component opposes the flow of current in a DC circuit?

A Inductor
B **Resistor**
C Inverter
D Transformer

A resistor opposes the flow of current in a DC circuit, as described by Ohm's Law. Inductors, inverters, and transformers do not primarily oppose current flow in the same way.

T6A02

What type of component is often used as an adjustable volume control?

A Fixed resistor
B Power resistor
C **Potentiometer**
D Transformer

A potentiometer is commonly used as an adjustable volume control because it allows for variable resistance, which adjusts the signal level.

T6A03

What electrical parameter is controlled by a potentiometer?

A Inductance
B **Resistance**
C Capacitance
D Field strength

A potentiometer controls resistance by adjusting the position of the wiper along the resistive element.

T6A04

What electrical component stores energy in an electric field?

A Varistor
B **Capacitor**
C Inductor
D Diode

A capacitor stores energy in an electric field, as opposed to an inductor, which stores energy in a magnetic field.

T6A05

What type of electrical component consists of conductive surfaces separated by an insulator?

A Resistor
B Potentiometer
C Oscillator
D **Capacitor**

A capacitor consists of two conductive plates separated by an insulating material (dielectric).

T6A06

What type of electrical component stores energy in a magnetic field?

A Varistor
B Capacitor
C **Inductor**
D Diode

An inductor stores energy in a magnetic field, as opposed to a capacitor, which stores energy in an electric field.

T6A07

What electrical component is typically constructed as a coil of wire?

A Switch
B Capacitor
C Diode
D **Inductor**

An inductor is typically constructed as a coil of wire, which generates a magnetic field when current flows through it.

T6A08

What is the function of an SPDT switch?

A A single circuit is opened or closed
B Two circuits are opened or closed
C **A single circuit is switched between one of two other circuits**
D Two circuits are each switched between one of two other circuits

An SPDT switch connects a single circuit to one of two other circuits, making it useful for routing signals or selecting modes.

Summary

This section covered the basic components used in electronic circuits:

- **Resistors**: Oppose current flow and are used for current limiting and voltage division.
- **Potentiometers**: Adjustable resistors used for volume control and voltage adjustment.
- **Capacitors**: Store energy in an electric field and are used for energy storage and filtering.
- **Inductors**: Store energy in a magnetic field and are used for energy storage and filtering.
- **Switches**: Control the flow of current in circuits, with SPDT switches routing signals between two paths.

6.2 Semiconductor Components and Their Applications

Forward Voltage Drop in Diodes

The forward voltage drop in a diode is a critical parameter in circuit design. It refers to the voltage required to allow current to flow through the diode in the forward direction. Different types of diodes exhibit varying forward voltage drops. For example, a silicon diode typically has a forward voltage drop of around 0.7V, while a Schottky diode may have a lower drop of approximately 0.3V. This characteristic is significant because it determines the minimum voltage required for the diode to conduct and influences the efficiency of the circuit.

Transistors as Electronic Switches

Transistors are versatile semiconductor devices that can function as electronic switches or amplifiers. When used as a switch, a transistor can control the flow of current between its collector and emitter terminals based on the voltage applied to its base terminal. This property makes transistors essential in digital circuits, where they are used to implement logic gates and other switching functions. Additionally, transistors amplify weak signals by controlling a larger current with a smaller input signal, making them indispensable in analog circuits.

Field-Effect Transistors (FETs)

A Field-Effect Transistor (FET) is a type of transistor that relies on an electric field to control the flow of current. It consists of three terminals: the gate, drain, and source. The gate terminal controls the conductivity between the drain and source by modulating the electric field within the device. FETs are widely used in applications requiring high input impedance and low power consumption, such as in amplifiers and integrated circuits.

Light-Emitting Diodes (LEDs)

A Light-Emitting Diode (LED) is a semiconductor device that emits light when forward current passes through it. The light emission occurs due to the recombination of electrons and holes within the semiconductor material, releasing energy in the form of photons. LEDs are commonly used in displays, indicators, and lighting due to their efficiency, longevity, and compact size.

Figure 6.3: Symbol and structure of a diode.

Figure 6.4: Symbol and structure of a transistor.

Table 6.2: Comparison of diode types.

Diode Type	Forward Voltage Drop	Applications
Silicon Diode	0.7V	Rectification
Schottky Diode	0.3V	High-speed switching
Zener Diode	Varies	Voltage regulation

Questions

T6B01

Which is true about forward voltage drop in a diode?

A **It is lower in some diode types than in others**
B It is proportional to peak inverse voltage
C It indicates that the diode is defective
D It has no impact on the voltage delivered to the load

Different diode types, such as silicon and Schottky diodes, have different forward voltage drops. For example, a Schottky diode has a lower forward voltage drop compared to a silicon diode. This characteristic is inherent to the diode's design and does not indicate a defect. The forward voltage drop directly affects the voltage delivered to the load in a circuit.

T6B02

What electronic component allows current to flow in only one direction?

A Resistor
B Fuse
C **Diode**
D Driven element

A diode is designed to allow current to flow in only one direction, from the anode to the cathode. This property is due to the P-N junction within the diode, which permits current flow in the forward direction while blocking it in the reverse direction.

T6B03

Which of these components can be used as an electronic switch?

A Varistor
B Potentiometer
C **Transistor**
D Thermistor

A transistor can function as an electronic switch by controlling the flow of current between its collector and emitter terminals based on the voltage applied to its base terminal. This makes it a fundamental component in digital and analog circuits.

T6B04

Which of the following components can consist of three regions of semiconductor material?

A Alternator
B **Transistor**
C Triode
D Pentagrid converter

A transistor consists of three regions of semiconductor material: the emitter, base, and collector. These regions form the basis of its operation as an amplifier or switch.

T6B05

What type of transistor has a gate, drain, and source?

A Varistor
B **Field-effect**
C Tesla-effect
D Bipolar junction

A Field-Effect Transistor (FET) has three terminals: the gate, drain, and source. The gate controls the flow of current between the drain and source by modulating the electric field within the device.

T6B06

How is the cathode lead of a semiconductor diode often marked on the package?

A With the word ”cathode”
B **With a stripe**
C With the letter C
D With the letter K

The cathode lead of a semiconductor diode is typically marked with a stripe on the package. This marking helps identify the polarity of the diode during circuit assembly.

T6B07

What causes a light-emitting diode (LED) to emit light?

A **Forward current**
B Reverse current
C Capacitively-coupled RF signal
D Inductively-coupled RF signal

An LED emits light when forward current passes through it. This current causes electrons and holes to recombine within the semiconductor material, releasing energy in the form of photons.

T6B08

What does the abbreviation FET stand for?

A Frequency Emission Transmitter
B Fast Electron Transistor
C Free Electron Transmitter
D **Field Effect Transistor**

FET stands for Field-Effect Transistor, a type of transistor that uses an electric field to control the flow of current.

Summary

This section covered the fundamental semiconductor components and their applications:

- **Diodes**: Devices that allow current to flow in one direction, with varying forward voltage drops depending on the type.
- **Transistors**: Components that can act as electronic switches or amplifiers, consisting of three semiconductor regions.
- **Field-Effect Transistors (FETs)**: Transistors with gate, drain, and source terminals, used for high input impedance and low power consumption applications.
- **Light-Emitting Diodes (LEDs)**: Diodes that emit light when forward current passes through them, widely used in displays and lighting.

6.3 Circuit Design and Analysis

Introduction

Schematic diagrams are essential tools in circuit design, providing a visual representation of how components are interconnected. They use standardized symbols to represent components, making it easier to understand and analyze circuits. This section will explore the importance of schematic diagrams, how to identify components, and the process of analyzing circuits using these diagrams.

Schematic Diagrams

Schematic diagrams are the backbone of circuit design. They provide a clear and concise way to represent the connections between components in a circuit. By using standardized symbols, schematic diagrams allow engineers and technicians to quickly understand the structure and function of a circuit. For example, a resistor is represented by a zigzag line, while a transistor is represented by a combination of lines and arrows. These symbols are universally recognized, making schematic diagrams an invaluable tool for communication in the field of electronics.

Component Identification

Identifying components in a schematic diagram is a fundamental skill in circuit analysis. Each component is represented by a unique symbol, and understanding these symbols is crucial for interpreting the diagram. For instance, a resistor is typically represented by a zigzag line, while a capacitor is represented by two parallel lines. By familiarizing oneself with these symbols, one can quickly identify the components in a circuit and understand their roles. Figure 6.5 provides an example of a schematic diagram with labeled components.

Figure 6.5: Example schematic diagram with labeled components.

Circuit Analysis

Analyzing a circuit using a schematic diagram involves identifying the key components and understanding how they interact. This process typically begins with identifying the power sources, such as batteries or power supplies, and then tracing the flow of current through the circuit. By understanding the function of each component, one can predict the behavior of the circuit and diagnose any issues. Table 6.3 lists common schematic symbols and their corresponding components, which can be a useful reference during circuit analysis.

Symbol	**Component**
\zigzag	Resistor
\parallel lines	Capacitor
\arrow	Transistor
\circle	Battery

Table 6.3: Common schematic symbols and their corresponding components.

Questions

T6C01

What is the name of an electrical wiring diagram that uses standard component symbols?

A Bill of materials
B Connector pinout
C **Schematic**
D Flow chart

A schematic diagram is the correct term for an electrical wiring diagram that uses standard component symbols. It is a visual representation of the circuit, showing how components are connected.

T6C02

What is component 1 in figure T-1?

A **Resistor**
B Transistor
C Battery
D Connector

Component 1 in figure T-1 is a resistor. Resistors are commonly represented by a zigzag line in schematic diagrams.

T6C03

What is component 2 in figure T-1?

A Resistor
B **Transistor**
C Indicator lamp
D Connector

Component 2 in figure T-1 is a transistor. Transistors are typically represented by a combination of lines and arrows in schematic diagrams.

T6C04

What is component 3 in figure T-1?

A Resistor
B Transistor
C **Lamp**
D Ground symbol

Component 3 in figure T-1 is a lamp. Lamps are often represented by a circle with a cross inside in schematic diagrams.

T6C05

What is component 4 in figure T-1?

A Resistor
B Transistor
C Ground symbol
D **Battery**

Component 4 in figure T-1 is a battery. Batteries are typically represented by a pair of parallel lines, one longer than the other, in schematic diagrams.

T6C06

What is component 6 in figure T-2?

A Resistor
B **Capacitor**
C Regulator IC
D Transistor

Component 6 in figure T-2 is a capacitor. Capacitors are typically represented by two parallel lines in schematic diagrams.

T6C07

What is component 8 in figure T-2?

A Resistor
B Inductor
C Regulator IC
D **Light emitting diode**

Component 8 in figure T-2 is a light emitting diode (LED). LEDs are typically represented by a triangle with a line pointing outward and a small arrow indicating light emission.

T6C08

What is component 9 in figure T-2?

A Variable capacitor
B Variable inductor
C **Variable resistor**
D Variable transformer

Component 9 in figure T-2 is a variable resistor. Variable resistors are typically represented by a zigzag line with an arrow pointing to it, indicating adjustability.

Summary

This section covered the importance of schematic diagrams in circuit design, the identification of components, and the process of analyzing circuits. Key concepts include:

- **Schematic Diagrams**: Visual representations of circuits using standardized symbols.
- **Component Identification**: Recognizing components by their symbols in schematic diagrams.
- **Circuit Analysis**: Understanding the function and interaction of components in a circuit.

By mastering these concepts, one can effectively design and analyze electronic circuits.

6.4 Advanced Electronics and Core Technologies

Rectifiers

A rectifier is an electronic device that converts alternating current (AC) into direct current (DC). This is achieved by allowing current to flow in only one direction, effectively "rectifying" the AC signal. Rectifiers are commonly used in power supplies to provide a stable DC voltage for electronic devices. The simplest form of a rectifier is the diode, which allows current to pass in one direction while blocking it in the opposite direction. More complex rectifier circuits, such as the full-wave bridge rectifier, are used to improve efficiency and reduce ripple in the output DC signal.

Figure 6.6: Rectifier circuit operation. The diagram should show the input AC waveform, the rectifier diodes, and the resulting DC waveform with ripple.

Relays

A relay is an electrically-controlled switch that uses a small electrical signal to control a larger current or voltage. Relays are commonly used in applications where it is necessary to control a high-power circuit with a low-power signal, such as in automotive systems or industrial control systems. The basic operation of a relay involves an electromagnet that, when energized, moves a set of contacts to either open or close a circuit.

Figure 6.7: Relay structure and operation. The diagram should show the electromagnet, the movable armature, and the contacts in both the open and closed positions.

Shielded Wire

Shielded wire is used to prevent the coupling of unwanted signals to or from the wire. This is particularly important in environments where electromagnetic interference (EMI) is a concern, such as in radio frequency (RF) circuits or in data transmission lines. The shield, typically made of a conductive material like copper, surrounds the inner conductor and is grounded to absorb or reflect any interfering signals.

Regulators

A voltage regulator is a circuit that maintains a constant output voltage regardless of changes in input voltage or load conditions. This is essential in power supplies to ensure that electronic devices receive a stable voltage, which is critical for their proper operation. There are several types of voltage regulators, including linear regulators and switching regulators, each with its own advantages and disadvantages.

Type	Advantages	Applications
Linear Regulator	Simple, low noise	Low-power devices
Switching Regulator	High efficiency, compact	High-power devices

Table 6.4: Comparison of voltage regulators.

Questions

T6D01

Which of the following devices or circuits changes an alternating current into a varying direct current signal?

A Transformer
B **Rectifier**
C Amplifier
D Reflector

A rectifier is specifically designed to convert AC to DC by allowing current to flow in only one direction. Transformers change voltage levels, amplifiers increase signal strength, and reflectors are not related to electrical signal conversion.

T6D02

What is a relay?

A **An electrically-controlled switch**
B A current controlled amplifier
C An inverting amplifier
D A pass transistor

A relay is an electrically-controlled switch that uses a small electrical signal to control a larger current or voltage. It is not an amplifier or a transistor.

T6D03

Which of the following is a reason to use shielded wire?

A To decrease the resistance of DC power connections
B To increase the current carrying capability of the wire
C **To prevent coupling of unwanted signals to or from the wire**
D To couple the wire to other signals

Shielded wire is used to prevent electromagnetic interference (EMI) from affecting the signal carried by the wire. It does not decrease resistance or increase current capacity.

T6D04

Which of the following displays an electrical quantity as a numeric value?

A Potentiometer
B Transistor
C **Meter**
D Relay

A meter is designed to display electrical quantities such as voltage, current, or resistance as numeric values. Potentiometers, transistors, and relays do not display values.

T6D05

What type of circuit controls the amount of voltage from a power supply?

A **Regulator**
B Oscillator
C Filter
D Phase inverter

A voltage regulator maintains a constant output voltage regardless of changes in input voltage or load conditions. Oscillators, filters, and phase inverters do not control voltage levels.

T6D06

What component changes 120 V AC power to a lower AC voltage for other uses?

A Variable capacitor
B **Transformer**
C Transistor
D Diode

A transformer is used to step down (or step up) AC voltage levels. Variable capacitors, transistors, and diodes do not change AC voltage levels.

T6D07

Which of the following is commonly used as a visual indicator?

A **LED**
B FET
C Zener diode
D Bipolar transistor

An LED (Light Emitting Diode) is commonly used as a visual indicator due to its ability to emit light when current passes through it. FETs, Zener diodes, and bipolar transistors are not used for visual indication.

T6D08

Which of the following is combined with an inductor to make a resonant circuit?

A Resistor
B Zener diode
C Potentiometer
D **Capacitor**

A capacitor, when combined with an inductor, forms a resonant circuit that can oscillate at a specific frequency. Resistors, Zener diodes, and potentiometers do not form resonant circuits with inductors.

Summary

This section covered several key concepts in advanced electronics:

- **Rectifiers**: Devices that convert AC to DC, essential in power supplies.
- **Relays**: Electrically-controlled switches used to manage high-power circuits with low-power signals.
- **Shielded Wire**: Used to prevent electromagnetic interference in sensitive circuits.
- **Regulators**: Circuits that maintain a constant output voltage, crucial for stable power supply.
- **Resonant Circuits**: Circuits that combine inductors and capacitors to oscillate at specific frequencies, used in tuning and filtering applications.

Chapter 7 PRACTICAL CIRCUITS

7.1 Signal Essentials

Receiver Sensitivity

Receiver sensitivity refers to the ability of a receiver to detect weak signals. It is a critical parameter in radio communication, as it determines the minimum signal strength that can be reliably detected. High sensitivity allows a receiver to pick up distant or weak signals, which is essential for effective communication, especially in low-power or long-distance scenarios.

Transceiver Functionality

A transceiver is a device that combines both a transmitter and a receiver in a single unit. It allows for two-way communication by enabling the transmission and reception of signals. Key components of a transceiver include the transmitter, receiver, and often a mixer for frequency conversion. Figure 7.1 illustrates the block diagram of a basic transceiver.

Figure 7.1: Block diagram of a basic transceiver showing key components.

Frequency Conversion

Frequency conversion is the process of changing a signal from one frequency to another. This is typically achieved using a mixer, which combines the input signal with a local oscillator signal to produce sum and difference frequencies. The desired frequency is then filtered out. Figure 7.2 demonstrates this process.

Figure 7.2: Frequency conversion process using a mixer.

Signal Discrimination

Selectivity is the ability of a receiver to discriminate between multiple signals, particularly those that are close in frequency. High selectivity ensures that the receiver can isolate the desired signal from unwanted interference, which is crucial for clear communication.

Oscillator Circuits

An oscillator is a circuit that generates a signal at a specific frequency. It is a fundamental component in both transmitters and receivers, providing the carrier signal for modulation and the local oscillator signal for frequency conversion.

Transverter Usage

A transverter is a device that converts the RF input and output of a transceiver to another frequency band. This allows the transceiver to operate on bands for which it was not originally designed, extending its versatility.

PTT Input Function

The PTT (Push-To-Talk) input on a transceiver is used to switch the device from receive mode to transmit mode when grounded. This is essential for half-duplex communication, where the same frequency is used for both transmission and reception.

Modulation Techniques

Modulation is the process of combining speech or data with an RF carrier signal. This allows the information to be transmitted over long distances. Common modulation techniques include AM (Amplitude Modulation), FM (Frequency Modulation), and SSB (Single Sideband). Table 7.1 provides a comparison of these techniques.

Modulation Type	**Bandwidth**	**Efficiency**	**Complexity**
AM	High	Low	Low
FM	Medium	Medium	Medium
SSB	Low	High	High

Table 7.1: Comparison of AM, FM, and SSB modulation techniques.

Questions

T7A01

Which term describes the ability of a receiver to detect the presence of a signal?

A Linearity
B **Sensitivity**
C Selectivity
D Total Harmonic Distortion

Sensitivity is the correct term, as it directly relates to the receiver's ability to detect weak signals. Linearity refers to the proportionality of input and output, selectivity refers to the ability to discriminate between signals, and total harmonic distortion is a measure of signal distortion.

T7A02

What is a transceiver?

- A **A device that combines a receiver and transmitter**
- B A device for matching feed line impedance to 50 ohms
- C A device for automatically sending and decoding Morse code
- D A device for converting receiver and transmitter frequencies to another band

A transceiver integrates both a transmitter and a receiver, enabling two-way communication. The other options describe different devices or functions, such as impedance matching or frequency conversion.

T7A03

Which of the following is used to convert a signal from one frequency to another?

- A Phase splitter
- B **Mixer**
- C Inverter
- D Amplifier

A mixer is used for frequency conversion by combining the input signal with a local oscillator signal. Phase splitters, inverters, and amplifiers serve different purposes in signal processing.

T7A04

Which term describes the ability of a receiver to discriminate between multiple signals?

- A Discrimination ratio
- B Sensitivity
- C **Selectivity**
- D Harmonic distortion

Selectivity is the correct term, as it refers to the receiver's ability to distinguish between signals close in frequency. Sensitivity relates to detecting weak signals, while harmonic distortion is a measure of signal quality.

T7A05

What is the name of a circuit that generates a signal at a specific frequency?

- A Reactance modulator
- B Phase modulator
- C Low-pass filter
- D **Oscillator**

An oscillator generates a signal at a specific frequency, making it essential for both transmitters and receivers. Reactance modulators, phase modulators, and low-pass filters serve different functions in signal processing.

T7A06

What device converts the RF input and output of a transceiver to another band?

A High-pass filter
B Low-pass filter
C **Transverter**
D Phase converter

A transverter is used to convert the RF input and output of a transceiver to another frequency band, allowing operation on different bands. High-pass and low-pass filters are used for signal filtering, while a phase converter changes the phase of a signal.

T7A07

What is the function of a transceiver's PTT input?

A Input for a key used to send CW
B **Switches transceiver from receive to transmit when grounded**
C Provides a transmit tuning tone when grounded
D Input for a preamplifier tuning tone

The PTT input switches the transceiver from receive to transmit mode when grounded, enabling half-duplex communication. The other options describe different functions not related to the PTT input.

T7A08

Which of the following describes combining speech with an RF carrier signal?

A Impedance matching
B Oscillation
C **Modulation**
D Low-pass filtering

Modulation is the process of combining speech or data with an RF carrier signal, enabling the transmission of information. Impedance matching, oscillation, and low-pass filtering are unrelated to this process.

Summary

This section covered essential concepts in radio communication, including:

- **Receiver Sensitivity**: The ability to detect weak signals.
- **Transceiver Functionality**: A device combining a transmitter and receiver.
- **Frequency Conversion**: The process of changing signal frequency using a mixer.
- **Signal Discrimination**: The ability to distinguish between signals close in frequency.
- **Oscillator Circuits**: Circuits that generate specific frequencies.

- **Transverter Usage**: Devices that convert RF signals to another band.
- **PTT Input Function**: Switches a transceiver from receive to transmit mode.
- **Modulation Techniques**: Methods for combining speech or data with an RF carrier.

7.2 Radio Troubleshooting Essentials

Over-deviation in FM Transceivers

Over-deviation in FM transceivers occurs when the frequency deviation exceeds the allowed limits, causing distortion and potential interference with adjacent channels. This can be addressed by adjusting the microphone gain or speaking farther away from the microphone to reduce the input signal level.

RF Interference

RF interference in broadcast receivers is often caused by strong signals outside the AM or FM band that the receiver cannot reject. This can lead to unintentional reception of amateur radio transmissions. Proper filtering and shielding can mitigate this issue.

Harmonics and Spurious Emissions

Harmonics and spurious emissions are unwanted signals generated by transmitters that can cause interference. These signals are often multiples of the fundamental frequency and can be reduced by using filters and ensuring proper transmitter operation.

RF Feedback

RF feedback occurs when RF current flows on the shield of a microphone cable, causing distorted audio. This can be mitigated by using ferrite chokes, which absorb the RF energy and prevent it from affecting the audio signal.

Band-reject Filters

Band-reject filters are used to block specific frequencies that cause interference. For example, they can be installed at the antenna input of a receiver to block strong amateur signals that cause fundamental overload.

Interference Resolution

When a neighbor reports interference from your amateur station, the first step is to ensure your station is functioning properly and not causing interference to your own equipment. If the issue persists, work with your neighbor to identify and resolve the problem.

Cable TV Interference

Cable TV interference caused by amateur radio transmissions can be resolved by ensuring your station meets good amateur practice standards and using appropriate filters to block interfering signals.

Figure 7.3: Illustration of RF interference paths and mitigation techniques.

Figure 7.4: Ferrite choke installed on a cable to reduce RF feedback.

Interference Source	**Solution**
Over-deviation in FM transceivers	Adjust microphone gain or distance
RF interference in broadcast receivers	Use filters and shielding
Harmonics and spurious emissions	Use filters and ensure proper transmitter operation
RF feedback	Install ferrite chokes
Fundamental overload	Use band-reject filters

Table 7.2: Table listing common RF interference sources and their solutions.

Questions

T7B01

What can you do if you are told your FM handheld or mobile transceiver is over-deviating?

- A Talk louder into the microphone
- B Let the transceiver cool off
- C Change to a higher power level
- D **Talk farther away from the microphone**

Over-deviation occurs when the input signal is too strong, causing excessive frequency deviation. Speaking farther from the microphone reduces the input level, addressing the issue. Other options do not directly address the root cause.

T7B02

What would cause a broadcast AM or FM radio to receive an amateur radio transmission unintentionally?

- A **The receiver is unable to reject strong signals outside the AM or FM band**
- B The microphone gain of the transmitter is turned up too high
- C The audio amplifier of the transmitter is overloaded
- D The deviation of an FM transmitter is set too low

Broadcast receivers may lack the filtering to reject strong signals outside their intended band, leading to unintentional reception of amateur transmissions. The other options are unrelated to this issue.

T7B03

Which of the following can cause radio frequency interference?

- A Fundamental overload
- B Harmonics
- C Spurious emissions
- D **All these choices are correct**

Fundamental overload, harmonics, and spurious emissions are all potential sources of RF interference. Each can disrupt communication if not properly managed.

T7B04

Which of the following could you use to cure distorted audio caused by RF current on the shield of a microphone cable?

- A Band-pass filter
- B Low-pass filter
- C Preamplifier
- D **Ferrite choke**

Ferrite chokes absorb RF energy on the cable shield, preventing it from causing audio distortion. Filters and preamplifiers do not address this specific issue.

T7B05

How can fundamental overload of a non-amateur radio or TV receiver by an amateur signal be reduced or eliminated?

- A **Block the amateur signal with a filter at the antenna input of the affected receiver**
- B Block the interfering signal with a filter on the amateur transmitter
- C Switch the transmitter from FM to SSB
- D Switch the transmitter to a narrow-band mode

Installing a filter at the receiver's antenna input blocks the interfering amateur signal. Filters on the transmitter or mode changes do not directly address receiver overload.

T7B06

Which of the following actions should you take if a neighbor tells you that your station's transmissions are interfering with their radio or TV reception?

- A **Make sure that your station is functioning properly and that it does not cause interference to your own radio or television when it is tuned to the same channel**
- B Immediately turn off your transmitter and contact the nearest FCC office for assistance
- C Install a harmonic doubler on the output of your transmitter and tune it until the interference is eliminated
- D All these choices are correct

The first step is to verify your station's operation and ensure it is not causing interference to your own equipment. This helps identify if the issue is with your station or the neighbor's equipment.

T7B07

Which of the following can reduce overload of a VHF transceiver by a nearby commercial FM station?

- A Installing an RF preamplifier
- B Using double-shielded coaxial cable
- C Installing bypass capacitors on the microphone cable
- D **Installing a band-reject filter**

A band-reject filter blocks the specific frequency of the commercial FM station, reducing overload. Preamplifiers and shielding do not address this issue.

T7B08

What should you do if something in a neighbor's home is causing harmful interference to your amateur station?

- A Work with your neighbor to identify the offending device
- B Politely inform your neighbor that FCC rules prohibit the use of devices that cause interference
- C Make sure your station meets the standards of good amateur practice
- D **All these choices are correct**

All the listed actions are appropriate steps to resolve interference caused by a neighbor's device. Cooperation and adherence to FCC rules are key.

Summary

- **Over-deviation in FM Transceivers**: Adjust microphone gain or distance to reduce input signal level.
- **RF Interference**: Caused by strong signals outside the intended band; mitigated with filters and shielding.

- **Harmonics and Spurious Emissions**: Unwanted signals that cause interference; reduced with proper filtering.

- **RF Feedback**: Distorted audio caused by RF current on microphone cables; mitigated with ferrite chokes.

- **Band-reject Filters**: Block specific frequencies to reduce interference.

- **Interference Resolution**: Verify station operation and work with neighbors to resolve issues.

- **Cable TV Interference**: Ensure proper station operation and use filters to block interfering signals.

7.3 Test Equipment and Antenna Basics

Purpose and Construction of a Dummy Load

A dummy load is a device used to simulate an antenna's electrical characteristics without radiating radio frequency (RF) energy. It is primarily used to prevent transmitting signals over the air when testing or tuning a transmitter. A dummy load typically consists of a non-inductive resistor mounted on a heat sink to dissipate the power as heat. This ensures that the transmitter can be tested safely without causing interference.

Antenna Resonance and Antenna Analyzers

An antenna analyzer is a crucial tool for determining if an antenna is resonant at the desired operating frequency. Resonance occurs when the antenna's impedance is purely resistive, minimizing the standing wave ratio (SWR). By measuring the impedance and SWR, an antenna analyzer helps ensure optimal performance and efficiency of the antenna system.

Standing Wave Ratio (SWR) and Impedance Matching

SWR is a measure of how well the antenna's impedance matches the feed line's impedance. A perfect match is indicated by an SWR of 1:1, meaning all the power is transferred to the antenna without reflection. High SWR values indicate impedance mismatch, which can lead to power loss, heat generation, and potential damage to the transmitter. Impedance matching is critical for maximizing power transfer and minimizing reflections.

Coaxial Cable Issues and Prevention

Coaxial cables are prone to failure due to factors such as moisture ingress, UV degradation, and physical damage. Moisture in the cable can cause signal loss and corrosion, while UV exposure can degrade the outer jacket. Using UV-resistant jackets and proper sealing techniques can mitigate these issues. Regular inspection and maintenance are also essential to ensure the longevity of coaxial cables.

Directional Wattmeters and SWR Measurement

Directional wattmeters are used to measure SWR by comparing the forward and reflected power in a transmission line. These instruments provide valuable information about the efficiency of the antenna system and help identify impedance mismatches. A high SWR reading, such as 4:1, indicates a significant impedance mismatch, which can lead to power loss and potential damage to the transmitter.

Heat Dissipation in Dummy Loads and Feed Lines

Power lost in a feed line is converted into heat, which can cause the cable to degrade over time. Similarly, dummy loads dissipate the transmitter's power as heat, requiring robust heat sinks to prevent overheating. Proper heat management is essential to maintain the performance and reliability of both dummy loads and feed lines.

Figure 7.5: Dummy load connected to a transmitter for testing purposes.

Figure 7.6: Measurement of SWR using a directional wattmeter.

Table 7.3: Comparison of different types of coaxial cables.

Type	**Air Core**	**Foam**	**Solid Dielectric**
Impedance	50-75 Ω	50-75 Ω	50-75 Ω
Loss	Low	Medium	High
Flexibility	High	Medium	Low
Cost	High	Medium	Low

Questions

T7C01

What is the primary purpose of a dummy load?

A **To prevent transmitting signals over the air when making tests**
B To prevent over-modulation of a transmitter
C To improve the efficiency of an antenna
D To improve the signal-to-noise ratio of a receiver

A dummy load is used to absorb the transmitter's power without radiating it, allowing safe testing and tuning. The other options are incorrect because a dummy load does not affect modulation, antenna efficiency, or signal-to-noise ratio.

T7C02

Which of the following is used to determine if an antenna is resonant at the desired operating frequency?

A A VTVM
B **An antenna analyzer**
C A Q meter
D A frequency counter

An antenna analyzer measures impedance and SWR to determine resonance. A VTVM measures voltage, a Q meter measures quality factor, and a frequency counter measures frequency, none of which directly indicate resonance.

T7C03

What does a dummy load consist of?

A A high-gain amplifier and a TR switch
B **A non-inductive resistor mounted on a heat sink**
C A low-voltage power supply and a DC relay
D A 50-ohm reactance used to terminate a transmission line

A dummy load is a non-inductive resistor that dissipates power as heat. The other options describe components unrelated to dummy loads.

Summary

This section covered the basics of test equipment and antennas, including the purpose and construction of dummy loads, the use of antenna analyzers, and the importance of SWR and impedance matching. Key concepts include:

- **Dummy Loads**: Non-inductive resistors used to absorb transmitter power during testing.
- **Antenna Resonance**: Achieved when the antenna's impedance is purely resistive, minimizing SWR.
- **SWR Measurement**: Indicates the efficiency of power transfer between the feed line and antenna.
- **Impedance Matching**: Ensures maximum power transfer and minimizes reflections.
- **Coaxial Cable Issues**: Moisture, UV degradation, and physical damage can lead to cable failure.
- **Heat Dissipation**: Power lost in feed lines and dummy loads is converted into heat.
- **Directional Wattmeters**: Used to measure SWR by comparing forward and reflected power.

- **Moisture in Cables**: Can cause signal loss and corrosion, mitigated by proper sealing and UV-resistant jackets.

7.4 Measuring Instruments in Electronics

Introduction

In this section, we will explore the various instruments used in electronics to measure electrical quantities such as voltage, current, and resistance. We will also discuss the proper usage of these instruments and the precautions necessary to avoid damage. Additionally, we will cover the types of solder used in electronics and how to identify and avoid common soldering issues.

Voltage Measurement

A voltmeter is an instrument used to measure electric potential, or voltage, across a component in a circuit. To measure voltage, the voltmeter must be connected in parallel with the component. This ensures that the voltmeter does not interfere with the current flow in the circuit. The voltage across the component is then displayed on the voltmeter's screen.

Current Measurement

To measure electric current, a multimeter must be connected in series with the component. This allows the current to flow through the multimeter, which then displays the measured current. It is crucial to ensure that the multimeter is set to the correct current measurement mode to avoid damaging the instrument.

Multimeter Usage

Multimeters are versatile instruments that can measure voltage, current, and resistance. However, improper use can lead to damage. For example, attempting to measure voltage while the multimeter is set to the resistance setting can cause damage. Always ensure that the multimeter is set to the correct measurement mode before use.

Solder Types

Different types of solder are used in electronics, each with specific applications. Acid-core solder should not be used in radio and electronic applications due to its corrosive nature. Rosin-core solder is preferred for electronics as it is non-corrosive and provides a reliable connection.

Cold Solder Joints

A cold solder joint occurs when the solder does not melt properly, resulting in a rough or lumpy surface. This type of joint is weak and can lead to circuit failures. To avoid cold solder joints, ensure that the soldering iron is at the correct temperature and that the solder flows smoothly onto the joint.

Capacitor Testing

An ohmmeter can be used to test capacitors. When testing a capacitor, the ohmmeter measures the resistance across the capacitor's terminals. A good capacitor will show a low resistance initially, which will increase as the capacitor charges. If the capacitor shows a constant low resistance, it may be shorted.

Precautions for Resistance Measurement

When measuring in-circuit resistance, ensure that the power to the circuit is turned off. Measuring resistance in a live circuit can damage the multimeter and provide inaccurate readings. Additionally, be aware of parallel components that may affect the resistance measurement.

Proper Use of a Multimeter

For accurate voltage and resistance measurements, always connect the multimeter in parallel for voltage and in series for current. Ensure that the multimeter is set to the correct measurement mode and range. Avoid using the resistance setting to measure voltage, as this can damage the multimeter.

Figure 7.7: Correct multimeter connections for measuring voltage and current.

Figure 7.8: Comparison of a cold solder joint and a proper solder joint.

Solder Type	**Composition**	**Application**
Acid-core	Acid flux	Plumbing (not for electronics)
Rosin-core	Rosin flux	Electronics
Lead-tin	Lead and tin	General-purpose soldering

Table 7.4: Table comparing acid-core, rosin-core, and lead-tin solder.

Questions

T7D01

Which instrument would you use to measure electric potential?

A An ammeter
B **A voltmeter**
C A wavemeter
D An ohmmeter

A voltmeter is specifically designed to measure electric potential, or voltage, across a component in a circuit. An ammeter measures current, a wavemeter measures wavelength, and an ohmmeter measures resistance.

T7D02

How is a voltmeter connected to a component to measure applied voltage?

A In series
B **In parallel**
C In quadrature
D In phase

A voltmeter must be connected in parallel with the component to measure the voltage across it without interfering with the current flow. Connecting it in series would disrupt the circuit.

T7D03

When configured to measure current, how is a multimeter connected to a component?

A **In series**
B In parallel
C In quadrature
D In phase

To measure current, the multimeter must be connected in series with the component so that the current flows through the multimeter. Connecting it in parallel would not measure the current correctly.

T7D04

Which instrument is used to measure electric current?

A An ohmmeter
B An electrometer
C A voltmeter
D **An ammeter**

An ammeter is specifically designed to measure electric current. An ohmmeter measures resistance, an electrometer measures electric charge, and a voltmeter measures voltage.

T7D06

Which of the following can damage a multimeter?

A Attempting to measure resistance using the voltage setting
B Failing to connect one of the probes to ground
C **Attempting to measure voltage when using the resistance setting**
D Not allowing it to warm up properly

Attempting to measure voltage while the multimeter is set to the resistance setting can cause damage due to the high current flow. Other options are less likely to cause immediate damage.

T7D07

Which of the following measurements are made using a multimeter?

A Signal strength and noise
B Impedance and reactance
C **Voltage and resistance**
D All these choices are correct

A multimeter can measure voltage and resistance, but not signal strength, noise, impedance, or reactance directly.

T7D08

Which of the following types of solder should not be used for radio and electronic applications?

A **Acid-core solder**
B Lead-tin solder
C Rosin-core solder
D Tin-copper solder

Acid-core solder is corrosive and should not be used in electronics. Rosin-core solder is preferred for electronic applications.

T7D09

What is the characteristic appearance of a cold tin-lead solder joint?

A Dark black spots
B A bright or shiny surface
C **A rough or lumpy surface**
D Excessive solder

A cold solder joint has a rough or lumpy surface due to improper melting of the solder. This results in a weak connection.

Summary

This section covered the essential measuring instruments used in electronics, including voltmeters, ammeters, and multimeters. We discussed the correct methods for connecting these instruments to measure voltage and current, as well as the precautions necessary to avoid damage. Additionally, we explored the different types of solder and their applications, and how to identify and avoid cold solder joints. Key concepts included:

- **Voltage Measurement**: Using a voltmeter connected in parallel.
- **Current Measurement**: Using an ammeter connected in series.
- **Multimeter Usage**: Proper settings and connections to avoid damage.
- **Solder Types**: Acid-core, rosin-core, and lead-tin solder.

- **Cold Solder Joints**: Characteristics and how to avoid them.
- **Capacitor Testing**: Using an ohmmeter to test capacitors.
- **Ohmmeter Precautions**: Ensuring the circuit is powered off before measuring resistance.

Chapter 8 SIGNALS AND EMISSIONS

8.1 Modulation Techniques

Introduction

Modulation techniques are fundamental to radio communication, enabling the transmission of information over long distances. This section explores the differences between Amplitude Modulation (AM), Frequency Modulation (FM), and Single Sideband (SSB) modulation. We will also discuss the bandwidth requirements for different types of signals and the advantages and disadvantages of SSB compared to FM. Finally, we will explain the concept of sideband selection in SSB communications.

Differences Between AM, FM, and SSB

Amplitude Modulation (AM) varies the amplitude of the carrier wave in proportion to the signal being transmitted. Frequency Modulation (FM), on the other hand, varies the frequency of the carrier wave. Single Sideband (SSB) is a form of AM that eliminates one sideband and the carrier, resulting in a more efficient use of bandwidth.

Figure 8.1: Comparison of AM, FM, and SSB waveforms.

Bandwidth Requirements

The bandwidth of a signal is a critical factor in radio communication. SSB signals typically require less bandwidth compared to AM and FM signals. For example, a typical SSB voice signal has an approximate bandwidth of 3 kHz, while FM voice signals can require up to 15 kHz. Continuous Wave (CW) signals, used in Morse code, have the narrowest bandwidth, often less than 1 kHz.

Figure 8.2: Bandwidth comparison of SSB, FM, and CW signals.

Modulation Type	**Bandwidth**
SSB	3 kHz
FM	15 kHz
CW	¡1 kHz

Table 8.1: Bandwidth of Different Modulation Types

Advantages and Disadvantages of SSB

SSB offers several advantages over FM, including narrower bandwidth and greater power efficiency. However, SSB signals can be more challenging to tune correctly and are more susceptible to interference. FM, while requiring more bandwidth, provides better signal quality and is easier to tune.

Sideband Selection in SSB Communications

In SSB communications, the choice of upper or lower sideband depends on the frequency band being used. For example, upper sideband is typically used for 10 meter HF, VHF, and UHF communications. This selection helps optimize the transmission for the specific frequency range.

Questions

T8A01

Which of the following is a form of amplitude modulation?

A Spread spectrum
B Packet radio
C **Single sideband**
D Phase shift keying (PSK)

SSB is a form of amplitude modulation that eliminates one sideband and the carrier. Spread spectrum and packet radio are not forms of amplitude modulation, and PSK is a type of phase modulation.

T8A02

What type of modulation is commonly used for VHF packet radio transmissions?

A **FM or PM**
B SSB
C AM
D PSK

FM or PM is commonly used for VHF packet radio transmissions due to its robustness and ease of tuning. SSB and AM are less commonly used for this purpose, and PSK is typically used for digital communications.

T8A03

Which type of voice mode is often used for long-distance (weak signal) contacts on the VHF and UHF bands?

A FM
B DRM
C **SSB**
D PM

SSB is often used for long-distance contacts on the VHF and UHF bands because it is more power-efficient and has a narrower bandwidth, making it better suited for weak signal conditions.

T8A04

Which type of modulation is commonly used for VHF and UHF voice repeaters?

A AM
B SSB
C PSK
D **FM or PM**

FM or PM is commonly used for VHF and UHF voice repeaters because it provides better signal quality and is easier to tune. AM and SSB are less commonly used for repeaters, and PSK is typically used for digital communications.

T8A05

Which of the following types of signal has the narrowest bandwidth?

A FM voice
B SSB voice
C **CW**
D Slow-scan TV

CW signals have the narrowest bandwidth, often less than 1 kHz, making them ideal for long-distance communication with minimal interference.

T8A06

Which sideband is normally used for 10 meter HF, VHF, and UHF single-sideband communications?

A **Upper sideband**
B Lower sideband
C Suppressed sideband
D Inverted sideband

Upper sideband is normally used for 10 meter HF, VHF, and UHF single-sideband communications. This choice optimizes the transmission for these frequency ranges.

T8A07

What is a characteristic of single sideband (SSB) compared to FM?

A SSB signals are easier to tune in correctly
B SSB signals are less susceptible to interference
C **SSB signals have narrower bandwidth**
D All these choices are correct

SSB signals have narrower bandwidth compared to FM, making them more efficient in terms of spectrum usage. However, they can be more challenging to tune and are more susceptible to interference.

T8A08

What is the approximate bandwidth of a typical single sideband (SSB) voice signal?

A 1 kHz
B **3 kHz**
C 6 kHz
D 15 kHz

A typical SSB voice signal has an approximate bandwidth of 3 kHz, making it more efficient than AM or FM signals in terms of bandwidth usage.

Summary

This section covered the key concepts of modulation techniques, including Amplitude Modulation (AM), Frequency Modulation (FM), and Single Sideband (SSB). We discussed the bandwidth requirements for different types of signals and the advantages and disadvantages of SSB compared to FM. Additionally, we explained the concept of sideband selection in SSB communications.

- **Amplitude Modulation (AM)**: Varies the amplitude of the carrier wave.
- **Frequency Modulation (FM)**: Varies the frequency of the carrier wave.
- **Single Sideband (SSB)**: A form of AM that eliminates one sideband and the carrier.
- **Bandwidth of Signals**: SSB signals typically require less bandwidth compared to AM and FM signals.
- **Sideband Selection**: Upper sideband is typically used for 10 meter HF, VHF, and UHF communications.

8.2 Satellite Communications

Introduction

Satellite communications play a crucial role in modern radio technology, enabling long-distance communication, data transmission, and global connectivity. This section explores key concepts such as satellite telemetry, Doppler shift, U/V mode, spin fading, and the characteristics of Low Earth Orbit (LEO) satellites.

Satellite Telemetry

Telemetry is essential for monitoring the health and status of satellites. It involves the transmission of data such as temperature, battery voltage, and system performance from the satellite to ground stations. This information is critical for ensuring the satellite operates correctly and for diagnosing any issues that may arise.

Doppler Shift

Doppler shift is a phenomenon observed in satellite communications where the frequency of the signal changes due to the relative motion between the satellite and the ground station. This effect is particularly pronounced in LEO satellites, which move rapidly relative to the Earth's surface. The Doppler shift can be calculated using the formula:

$$\Delta f = \frac{v \cdot f_0}{c} \tag{8.1}$$

where Δf is the frequency shift, v is the relative velocity, f_0 is the original frequency, and c is the speed of light.

U/V Mode

U/V mode refers to a common configuration in amateur radio satellites where the uplink is in the 70 centimeter band (UHF) and the downlink is in the 2 meter band (VHF). This mode allows for efficient communication and is widely used due to the availability of equipment and the favorable propagation characteristics of these frequency bands.

Spin Fading

Spin fading occurs when a satellite's rotation causes periodic variations in signal strength. This effect is due to the changing orientation of the satellite's antennas relative to the ground station. Spin fading can be mitigated by using diversity reception techniques or by tracking the satellite's orientation.

LEO Satellites

Low Earth Orbit (LEO) satellites are characterized by their relatively low altitude, typically between 160 and 2,000 kilometers above the Earth's surface. This proximity results in shorter communication delays and lower power requirements for transmission. Table 8.2 summarizes the key characteristics of LEO satellites.

Table 8.2: Characteristics of LEO Satellites

Characteristic	**Description**
Altitude	160 - 2,000 km
Orbital Period	90 - 120 minutes
Signal Delay	5 - 10 ms
Power Requirements	Low

Figures

Figure 8.3: Doppler shift in satellite communications. The diagram illustrates the change in frequency as the satellite moves relative to the ground station.

Figure 8.4: Effect of spin fading on satellite signals. The graph shows the periodic variation in signal strength due to the satellite's rotation.

Questions

T8B01

What telemetry information is typically transmitted by satellite beacons?

- A The signal strength of received signals
- B Time of day accurate to plus or minus 1/10 second
- C **Health and status of the satellite**
- D All these choices are correct

Satellite beacons transmit health and status information, which is crucial for monitoring the satellite's condition. This includes data on battery voltage, temperature, and system performance. The other options, while potentially useful, are not the primary purpose of satellite telemetry.

T8B02

What is the impact of using excessive effective radiated power on a satellite uplink?

- A Possibility of commanding the satellite to an improper mode
- B **Blocking access by other users**
- C Overloading the satellite batteries
- D Possibility of rebooting the satellite control computer

Using excessive power on a satellite uplink can block access for other users, as the strong signal may dominate the satellite's receiver. This is why it's important to use the minimum necessary power for communication.

T8B03

Which of the following are provided by satellite tracking programs?

- A Maps showing the real-time position of the satellite track over Earth
- B The time, azimuth, and elevation of the start, maximum altitude, and end of a pass
- C The apparent frequency of the satellite transmission, including effects of Doppler shift
- D **All these choices are correct**

Satellite tracking programs provide comprehensive information, including real-time position maps, pass details, and frequency adjustments for Doppler shift. All the listed options are correct.

T8B04

What mode of transmission is commonly used by amateur radio satellites?

- A SSB
- B FM
- C CW/data
- D **All these choices are correct**

Amateur radio satellites commonly use SSB, FM, and CW/data modes. Each mode has its advantages depending on the application and available equipment.

T8B05

What is a satellite beacon?

- A The primary transmit antenna on the satellite
- B An indicator light that shows where to point your antenna
- C A reflective surface on the satellite
- D **A transmission from a satellite that contains status information**

A satellite beacon is a transmission that provides status information about the satellite, such as its health and operational status. This is essential for monitoring and maintaining the satellite.

T8B06

Which of the following are inputs to a satellite tracking program?

- A The satellite transmitted power
- B **The Keplerian elements**
- C The last observed time of zero Doppler shift
- D All these choices are correct

Keplerian elements are the primary inputs to a satellite tracking program. These elements describe the satellite's orbit and are used to predict its position and movement.

T8B07

What is Doppler shift in reference to satellite communications?

- A A change in the satellite orbit
- B A mode where the satellite receives signals on one band and transmits on another
- C **An observed change in signal frequency caused by relative motion between the satellite and Earth station**
- D A special digital communications mode for some satellites

Doppler shift is the change in frequency observed due to the relative motion between the satellite and the ground station. This effect is particularly important in LEO satellites, where the relative velocity is high.

T8B08

What is meant by the statement that a satellite is operating in U/V mode?

A The satellite uplink is in the 15 meter band and the downlink is in the 10 meter band
B **The satellite uplink is in the 70 centimeter band and the downlink is in the 2 meter band**
C The satellite operates using ultraviolet frequencies
D The satellite frequencies are usually variable

U/V mode refers to a configuration where the uplink is in the 70 centimeter band (UHF) and the downlink is in the 2 meter band (VHF). This mode is commonly used in amateur radio satellites.

Summary

This section covered several key concepts in satellite communications:

- **Satellite Telemetry**: The transmission of health and status information from the satellite to ground stations.
- **Doppler Shift**: The change in signal frequency due to relative motion between the satellite and the ground station.
- **U/V Mode**: A common configuration where the uplink is in the 70 cm band and the downlink is in the 2 m band.
- **Spin Fading**: Periodic variations in signal strength caused by the satellite's rotation.
- **LEO Satellites**: Satellites in low Earth orbit, characterized by low altitude and short orbital periods.

8.3 Radio Operations

Radio Direction Finding

Radio direction finding (RDF) is a technique used to locate the source of a radio signal. This method is particularly useful for identifying sources of noise interference or jamming. The process involves using a directional antenna to determine the bearing of the signal. By taking multiple bearings from different locations, the source of the signal can be triangulated. RDF is widely used in amateur radio for activities such as fox hunting, where participants locate hidden transmitters.

Contesting

Contesting is a popular activity in amateur radio where operators attempt to contact as many stations as possible within a specified period. This activity tests the operator's ability to make quick and efficient contacts, often under challenging conditions. Contesting helps improve operating skills and can be a fun way to engage with the amateur radio community.

Grid Locator

A grid locator is a letter-number designator assigned to a geographic location. It is used in amateur radio to provide a concise way to describe a station's location. The grid locator system divides the Earth into a grid of squares, each identified by a unique combination of letters and numbers. This system is particularly useful for activities like contesting and DXing, where precise location information is important.

VoIP and IRLP

Voice Over Internet Protocol (VoIP) is a method of delivering voice communications over the internet using digital techniques. In amateur radio, VoIP is used to connect stations over the internet, allowing for long-distance communication without the need for traditional radio waves. The Internet Radio Linking Project (IRLP) is a technique that connects amateur radio systems, such as repeaters, via the internet using VoIP. This allows operators to communicate with others around the world through their local repeater.

Figure 8.5: Setup for radio direction finding. The diagram shows a directional antenna and the process of triangulating the signal source.

Figure 8.6: Grid locator mapping. The graph illustrates the relationship between grid locators and geographic locations.

Feature	**VoIP**	**IRLP**
Communication Method	Digital voice over internet	Connects repeaters via internet
Usage	Long-distance communication	Linking repeaters globally

Table 8.3: Comparison of VoIP and IRLP

Questions

T8C01

Which of the following methods is used to locate sources of noise interference or jamming?

A Echolocation
B Doppler radar
C **Radio direction finding**
D Phase locking

Radio direction finding is the correct method for locating sources of noise interference or jamming. Echolocation and Doppler radar are not applicable in this context, and phase locking is unrelated to locating interference sources.

T8C02

Which of these items would be useful for a hidden transmitter hunt?

- A Calibrated SWR meter
- B **A directional antenna**
- C A calibrated noise bridge
- D All these choices are correct

A directional antenna is essential for a hidden transmitter hunt as it helps in pinpointing the location of the transmitter. The other items listed are not directly useful for this activity.

T8C03

What operating activity involves contacting as many stations as possible during a specified period?

- A Simulated emergency exercises
- B Net operations
- C Public service events
- D **Contesting**

Contesting is the activity where operators aim to contact as many stations as possible within a specified time frame. The other options involve different types of amateur radio operations.

T8C04

Which of the following is good procedure when contacting another station in a contest?

- A Sign only the last two letters of your call if there are many other stations calling
- B Contact the station twice to be sure that you are in his log
- C **Send only the minimum information needed for proper identification and the contest exchange**
- D All these choices are correct

In contesting, it is important to send only the minimum information required for identification and the contest exchange to ensure efficient communication. The other options are not considered good practice.

T8C05

What is a grid locator?

- A **A letter-number designator assigned to a geographic location**
- B A letter-number designator assigned to an azimuth and elevation
- C An instrument for neutralizing a final amplifier
- D An instrument for radio direction finding

A grid locator is a letter-number designator used to specify a geographic location. It is not related to azimuth, elevation, or any type of instrument.

T8C06

How is over the air access to IRLP nodes accomplished?

- A By obtaining a password that is sent via voice to the node
- B **By using DTMF signals**
- C By entering the proper internet password
- D By using CTCSS tone codes

Over the air access to IRLP nodes is typically accomplished using DTMF (Dual-Tone Multi-Frequency) signals. This method allows operators to control the node remotely.

T8C07

What is Voice Over Internet Protocol (VoIP)?

- A A set of rules specifying how to identify your station when linked over the internet to another station
- B A technique employed to "spot" DX stations via the internet
- C A technique for measuring the modulation quality of a transmitter using remote sites monitored via the internet
- D **A method of delivering voice communications over the internet using digital techniques**

VoIP is a method of delivering voice communications over the internet using digital techniques. It is not related to identifying stations, spotting DX stations, or measuring modulation quality.

T8C08

What is the Internet Radio Linking Project (IRLP)?

- A **A technique to connect amateur radio systems, such as repeaters, via the internet using Voice Over Internet Protocol (VoIP)**
- B A system for providing access to websites via amateur radio
- C A system for informing amateurs in real time of the frequency of active DX stations
- D A technique for measuring signal strength of an amateur transmitter via the internet

IRLP is a technique that connects amateur radio systems, such as repeaters, via the internet using VoIP. It is not related to accessing websites, informing about DX stations, or measuring signal strength.

Summary

- **Radio Direction Finding**: A technique used to locate the source of a radio signal, often used in activities like fox hunting.
- **Contesting**: An amateur radio activity where operators attempt to contact as many stations as possible within a specified period.
- **Grid Locator**: A letter-number designator assigned to a geographic location, used in activities like contesting and DXing.
- **VoIP**: A method of delivering voice communications over the internet using digital techniques.
- **IRLP**: A technique that connects amateur radio systems, such as repeaters, via the internet using VoIP.

8.4 Digital Communications

Digital Modes in Amateur Radio

Digital communication modes have become increasingly popular in amateur radio due to their efficiency and versatility. Some of the most commonly used digital modes include DMR (Digital Mobile Radio), APRS (Automatic Packet Reporting System), and PSK (Phase Shift Keying). Each of these modes serves different purposes and operates on distinct principles.

DMR and Talkgroups

DMR is a digital voice mode that allows for efficient use of radio spectrum by time-multiplexing two digital voice signals on a single 12.5 kHz repeater channel. A key feature of DMR is the use of *talkgroups*, which enable groups of users to share a channel at different times without hearing other users on the same channel. This is particularly useful for organizing communications among users with common interests or objectives.

Figure 8.7: Structure of a DMR talkgroup. The diagram illustrates how multiple users are grouped into talkgroups, allowing for efficient channel sharing.

APRS Applications

APRS is a digital communication mode that enables the transmission of various types of data, including GPS position data, text messages, and weather information. It is widely used for real-time tactical digital communications, often in conjunction with a map showing the locations of stations. This makes APRS particularly useful for emergency communications and tracking.

Figure 8.8: Data flow in an APRS network. The graph shows how data is transmitted and received across an APRS network, including GPS data and text messages.

ARQ Transmission and Error Correction

ARQ (Automatic Repeat Request) is a protocol used in digital communications to ensure data integrity. When an error is detected in a transmitted packet, the receiver requests a retransmission of the corrupted data. This process is crucial for maintaining reliable communication, especially in environments with high noise or interference.

Comparison of Digital Modes

Table 8.4 summarizes the key features of the digital modes discussed in this section.

Table 8.4: Comparison of Digital Modes

Mode	Key Feature	Application
DMR	Time-multiplexing of voice signals	Efficient spectrum usage
APRS	Transmission of GPS and text data	Real-time tracking and messaging
PSK	Phase modulation for data transmission	Low-bandwidth data transfer
ARQ	Error detection and correction	Reliable data transmission

Questions

T8D01

Which of the following is a digital communications mode?

A Packet radio
B IEEE 802.11
C FT8
D **All these choices are correct**

Packet radio, IEEE 802.11, and FT8 are all examples of digital communication modes. Packet radio is used for data transmission, IEEE 802.11 is a standard for wireless networking, and FT8 is a popular digital mode for weak signal communication.

T8D02

What is a “talkgroup” on a DMR repeater?

A A group of operators sharing common interests
B **A way for groups of users to share a channel at different times without hearing other users on the channel**
C A protocol that increases the signal-to-noise ratio when multiple repeaters are linked together
D A net that meets at a specified time

A talkgroup in DMR is a method for organizing users into groups that share a channel without interfering with other groups. This allows for efficient use of the repeater channel.

T8D03

What kind of data can be transmitted by APRS?

A GPS position data
B Text messages
C Weather data
D **All these choices are correct**

APRS can transmit various types of data, including GPS position data, text messages, and weather information. This versatility makes it a valuable tool for amateur radio operators.

Summary

This section introduced several key concepts in digital communications, including:

- **Digital Modes**: Techniques like DMR, APRS, and PSK that enable efficient and reliable data transmission.
- **DMR**: A digital voice mode that uses talkgroups to organize users and optimize channel usage.
- **APRS**: A system for transmitting GPS, text, and weather data, often used for real-time tracking and messaging.
- **PSK**: A modulation technique for low-bandwidth data transfer.
- **ARQ Transmission**: A protocol for error detection and correction, ensuring reliable communication.

Chapter 9 ANTENNAS AND FEED LINES

9.1 Antenna Basics

Beam Antenna

A beam antenna is designed to concentrate signals in one direction, providing increased gain and directivity compared to omnidirectional antennas. This directional property makes beam antennas particularly useful for long-distance communication, as they can focus energy in a specific direction, reducing interference from other directions. The directional properties of a beam antenna are illustrated in Figure 9.1.

Figure 9.1: Directional properties of a beam antenna. The diagram shows how the antenna concentrates signals in one direction, reducing radiation in other directions.

Antenna Loading

Antenna loading refers to the process of electrically lengthening an antenna by inserting inductors or capacitors into its radiating elements. This technique is often used to make an antenna resonant at a desired frequency, especially when physical constraints limit the antenna's size. The process of antenna loading is depicted in Figure 9.2.

Figure 9.2: Antenna loading process. The diagram shows inductors inserted into the radiating elements to electrically lengthen the antenna.

Polarization

Polarization refers to the orientation of the electric field of the radio wave relative to the Earth's surface. A simple dipole antenna oriented parallel to the Earth's surface is horizontally polarized, while one oriented perpendicular to the surface is vertically polarized. The polarization of an antenna affects how well it can transmit and receive signals, especially over long distances.

Antenna Efficiency

Short, flexible antennas, such as those supplied with handheld transceivers, are often less efficient than full-sized antennas. This is because their reduced size limits their ability to radiate energy effectively, resulting in lower signal strength and range. Full-sized antennas, such as quarter-wave antennas, are more efficient due to their larger radiating elements.

Resonant Frequency

The resonant frequency of a dipole antenna can be altered by changing its physical length or by adding inductive or capacitive loading. Shortening the antenna increases its resonant frequency, while lengthening it decreases the frequency. This relationship is crucial for tuning antennas to specific frequencies.

Antenna Gain

Different types of antennas offer varying levels of gain. For example, a Yagi antenna typically provides higher gain compared to isotropic or J-pole antennas. Table 9.1 compares the gain of different antenna types.

Antenna Type	**Gain (dBi)**
Isotropic	0
J-pole	2-3
5/8 wave vertical	3-4
Yagi	7-10

Table 9.1: Comparison of Antenna Gain. The table shows the typical gain values for different types of antennas.

Shielding Effect

Using a handheld VHF transceiver with a flexible antenna inside a vehicle can reduce signal strength due to the shielding effect of the vehicle's metal body. This shielding blocks or reflects radio waves, reducing the antenna's effectiveness.

Antenna Length Calculations

The length of a quarter-wavelength vertical antenna for a given frequency can be calculated using the formula:

$$L = \frac{300}{4f} \tag{9.1}$$

where L is the length in meters and f is the frequency in MHz. For example, for a frequency of 146 MHz, the length of a quarter-wavelength antenna is approximately 19 inches.

Questions

T9A01

What is a beam antenna?

A An antenna built from aluminum I-beams
B An omnidirectional antenna invented by Clarence Beam
C **An antenna that concentrates signals in one direction**
D An antenna that reverses the phase of received signals

A beam antenna is designed to concentrate signals in one direction, providing increased gain and directivity. This makes it ideal for long-distance communication. The other options are incorrect because they describe either a physical construction or a non-existent antenna type.

T9A02

Which of the following describes a type of antenna loading?

A **Electrically lengthening by inserting inductors in radiating elements**
B Inserting a resistor in the radiating portion of the antenna to make it resonant
C Installing a spring in the base of a mobile vertical antenna to make it more flexible
D Strengthening the radiating elements of a beam antenna to better resist wind damage

Antenna loading involves electrically lengthening the antenna by adding inductors or capacitors. This technique is used to make the antenna resonant at a desired frequency. The other options describe mechanical modifications or incorrect electrical changes.

T9A03

Which of the following describes a simple dipole oriented parallel to Earth's surface?

A A ground-wave antenna
B **A horizontally polarized antenna**
C A travelling-wave antenna
D A vertically polarized antenna

A dipole antenna oriented parallel to the Earth's surface is horizontally polarized. This orientation affects how the antenna transmits and receives signals. The other options describe different types of antennas or polarizations.

T9A04

What is a disadvantage of the short, flexible antenna supplied with most handheld radio transceivers, compared to a full-sized quarter-wave antenna?

A **It has low efficiency**
B It transmits only circularly polarized signals
C It is mechanically fragile
D All these choices are correct

Short, flexible antennas are less efficient than full-sized antennas because their smaller size limits their ability to radiate energy effectively. The other options are incorrect because they describe either a non-existent polarization or a mechanical property that is not a primary disadvantage.

T9A05

Which of the following increases the resonant frequency of a dipole antenna?

A Lengthening it
B Inserting coils in series with radiating wires
C **Shortening it**
D Adding capacitive loading to the ends of the radiating wires

Shortening a dipole antenna increases its resonant frequency. This is because the resonant frequency is inversely proportional to the antenna's length. The other options either decrease the resonant frequency or do not directly affect it.

T9A06

Which of the following types of antenna offers the greatest gain?

A 5/8 wave vertical
B Isotropic
C J pole
D **Yagi**

A Yagi antenna typically offers the greatest gain among the listed options. This is due to its directional properties and multiple elements. The other options either have lower gain or are omnidirectional.

T9A07

What is a disadvantage of using a handheld VHF transceiver with a flexible antenna inside a vehicle?

A **Signal strength is reduced due to the shielding effect of the vehicle**
B The bandwidth of the antenna will decrease, increasing SWR
C The SWR might decrease, decreasing the signal strength
D All these choices are correct

The primary disadvantage is the reduction in signal strength due to the vehicle's metal body shielding the antenna. The other options are incorrect because they describe effects that are not directly caused by the shielding.

T9A08

What is the approximate length, in inches, of a quarter-wavelength vertical antenna for 146 MHz?

A 112
B 50
C **19**
D 12

Using the formula $L = \frac{300}{4f}$, where $f = 146$ MHz, the length is approximately 19 inches. The other options are incorrect because they do not match the calculated length.

Summary

This section covered the fundamental concepts of antenna technology, including beam antennas, antenna loading, polarization, efficiency, resonant frequency, gain, shielding effects, and antenna length calculations. Understanding these concepts is crucial for designing and optimizing antennas for various communication needs.

- **Beam antenna**: Concentrates signals in one direction for increased gain and directivity.
- **Antenna loading**: Electrically lengthens an antenna using inductors or capacitors to achieve resonance.
- **Polarization**: The orientation of the electric field relative to the Earth's surface, affecting signal transmission.
- **Antenna efficiency**: Larger antennas are generally more efficient than smaller ones.
- **Resonant frequency**: Can be altered by changing the antenna's length or adding loading elements.
- **Antenna gain**: Yagi antennas offer higher gain compared to isotropic or J-pole antennas.
- **Shielding effect**: Metal structures can reduce signal strength by blocking or reflecting radio waves.
- **Antenna length calculations**: The length of a quarter-wavelength antenna can be calculated using the formula $L = \frac{300}{4f}$.

9.2 Antenna Characteristics

Half-Wavelength Dipole Antenna

The length of a half-wavelength dipole antenna can be calculated using the formula:

$$L = \frac{492}{f} \tag{9.2}$$

where L is the length in feet and f is the frequency in MHz. For a 6-meter dipole antenna, the frequency is approximately 50 MHz. Plugging this into the formula:

$$L = \frac{492}{50} \approx 9.84 \text{ feet} \tag{9.3}$$

Converting feet to inches (1 foot = 12 inches):

$$L \approx 9.84 \times 12 \approx 118 \text{ inches} \tag{9.4}$$

This is close to the approximate length of 112 inches, as given in the question.

Radiation Pattern of a Half-Wave Dipole Antenna

A half-wave dipole antenna radiates most strongly in a direction broadside to the antenna. This means the signal is strongest perpendicular to the axis of the antenna. The radiation pattern is typically depicted as a figure-eight shape, with nulls at the ends of the antenna. For a visual representation, refer to Figure 9.3.

Figure 9.3: Radiation pattern of a half-wave dipole antenna.

Antenna Gain

Antenna gain is defined as the increase in signal strength in a specified direction compared to a reference antenna, typically an isotropic radiator or a dipole. It is a measure of how effectively the antenna directs energy in a particular direction. Higher gain antennas are useful for long-distance communication as they concentrate the signal in a specific direction, increasing the effective radiated power.

Advantages of a 5/8 Wavelength Whip Antenna

A 5/8 wavelength whip antenna offers more gain compared to a 1/4-wavelength antenna, making it more efficient for VHF or UHF mobile service. This increased gain results in better signal transmission and reception, especially in mobile applications where space and antenna size are limited.

Questions

T9A09

What is the approximate length, in inches, of a half-wavelength 6 meter dipole antenna?

A 6
B 50
C **112**
D 236

The correct length is approximately 112 inches, as calculated using the formula for a half-wavelength dipole antenna. Option A is too short, and options B and D are incorrect based on the calculation.

T9A10

In which direction does a half-wave dipole antenna radiate the strongest signal?

A Equally in all directions
B Off the ends of the antenna
C In the direction of the feed line
D **Broadside to the antenna**

A half-wave dipole antenna radiates most strongly broadside to the antenna, as shown in Figure 9.3. Options A, B, and C are incorrect because they do not describe the correct radiation pattern.

T9A11

What is antenna gain?

A The additional power that is added to the transmitter power
B The additional power that is required in the antenna when transmitting on a higher frequency
C **The increase in signal strength in a specified direction compared to a reference antenna**
D The increase in impedance on receive or transmit compared to a reference antenna

Antenna gain is the increase in signal strength in a specified direction compared to a reference antenna. Options A, B, and D are incorrect because they do not accurately define antenna gain.

T9A12

What is an advantage of a 5/8 wavelength whip antenna for VHF or UHF mobile service?

A **It has more gain than a 1/4-wavelength antenna**
B It radiates at a very high angle
C It eliminates distortion caused by reflected signals
D It has 10 times the power gain of a 1/4 wavelength whip

A 5/8 wavelength whip antenna has more gain than a 1/4-wavelength antenna, making it more efficient for mobile applications. Options B, C, and D are incorrect because they do not describe the primary advantage of this antenna.

Summary

This section covered the following key concepts:

- **Half-wavelength dipole**: A dipole antenna with a length equal to half the wavelength of the operating frequency. Its length can be calculated using $L = \frac{492}{f}$.

- **Radiation pattern**: The directional distribution of radiation from an antenna. A half-wave dipole has a figure-eight pattern with maximum radiation broadside to the antenna.
- **Antenna gain**: The increase in signal strength in a specific direction compared to a reference antenna. It is crucial for long-distance communication.
- **Whip antenna advantages**: A 5/8 wavelength whip antenna offers higher gain compared to a 1/4-wavelength antenna, making it suitable for VHF/UHF mobile applications.

9.3 Feed Line Basics

Benefits of Low SWR

A low Standing Wave Ratio (SWR) is crucial in antenna systems as it minimizes signal loss. When the SWR is low, more power is effectively transferred from the transmitter to the antenna, reducing the amount of power reflected back to the transmitter. This is particularly important in maintaining the efficiency of the communication system. The relationship between SWR and signal loss can be visualized in Figure 9.4.

Common Impedance of Coaxial Cables

In amateur radio, the most common impedance for coaxial cables is 50 ohms. This impedance is chosen because it provides a good balance between power handling and signal loss. Coaxial cables with this impedance are widely available and compatible with most amateur radio equipment.

Why Coaxial Cable is Common

Coaxial cable is the most common feed line for amateur radio antenna systems due to its ease of use and minimal installation requirements. While it may not have the lowest loss or the highest power handling capability compared to other types of feed lines, its practicality and widespread availability make it the preferred choice for many amateur radio operators.

Function of an Antenna Tuner

An antenna tuner, also known as an antenna coupler, primarily functions to match the impedance of the antenna system to the output impedance of the transceiver. This matching ensures maximum power transfer and minimizes reflections, which can lead to signal loss and potential damage to the transmitter.

Effect of Frequency on Coaxial Cable

As the frequency of a signal in coaxial cable increases, the signal loss also increases. This is due to the skin effect and dielectric losses, which become more pronounced at higher frequencies. The relationship between frequency and loss is an important consideration when designing systems for high-frequency operation.

Comparison of RF Connector Types

Different RF connector types are suitable for various frequency ranges. For instance, Type N connectors are preferred for frequencies above 400 MHz due to their superior performance and lower loss at these frequencies. A comparison of different RF connector types is illustrated in Figure 9.5.

Characteristics of PL-259 Connectors

PL-259 type coax connectors are commonly used at HF and VHF frequencies. They are not typically used for microwave operation due to their higher loss at those frequencies. However, they are robust and easy to use, making them a popular choice for many amateur radio applications.

Sources of Loss in Coaxial Feed Lines

Loss in coaxial feed lines can be attributed to several factors, including water intrusion into connectors, high SWR, and the use of multiple connectors in the line. Each of these factors can significantly impact the performance of the feed line, leading to increased signal loss.

Table 9.2: Comparison of Coaxial Cable Loss

Cable Type	**Impedance (Ohms)**	**Loss (dB/100ft)**
RG-58	50	6.0
RG-8	50	3.5
LMR-400	50	1.3

Figure 9.4: Effect of SWR on signal loss

Figure 9.5: Comparison of RF connector types

Questions

T9B01

What is a benefit of low SWR?

- A Reduced television interference
- B **Reduced signal loss**
- C Less antenna wear
- D All these choices are correct

Low SWR ensures that more power is transferred from the transmitter to the antenna, reducing signal loss. This is crucial for maintaining the efficiency of the communication system.

T9B02

What is the most common impedance of coaxial cables used in amateur radio?

A 8 ohms
B **50 ohms**
C 600 ohms
D 12 ohms

50 ohms is the standard impedance for coaxial cables in amateur radio, providing a balance between power handling and signal loss.

T9B03

Why is coaxial cable the most common feed line for amateur radio antenna systems?

A **It is easy to use and requires few special installation considerations**
B It has less loss than any other type of feed line
C It can handle more power than any other type of feed line
D It is less expensive than any other type of feed line

Coaxial cable is preferred due to its ease of use and minimal installation requirements, despite not having the lowest loss or highest power handling capability.

T9B04

What is the major function of an antenna tuner (antenna coupler)?

A **It matches the antenna system impedance to the transceiver's output impedance**
B It helps a receiver automatically tune in weak stations
C It allows an antenna to be used on both transmit and receive
D It automatically selects the proper antenna for the frequency band being used

The primary function of an antenna tuner is to match the impedance of the antenna system to the transceiver's output impedance, ensuring maximum power transfer.

T9B05

What happens as the frequency of a signal in coaxial cable is increased?

A The characteristic impedance decreases
B The loss decreases
C The characteristic impedance increases
D **The loss increases**

As frequency increases, the loss in coaxial cable also increases due to the skin effect and dielectric losses.

T9B06

Which of the following RF connector types is most suitable for frequencies above 400 MHz?

A UHF (PL-259/SO-239)
B **Type N**
C RS-213
D DB-25

Type N connectors are preferred for frequencies above 400 MHz due to their lower loss and better performance at these frequencies.

T9B07

Which of the following is true of PL-259 type coax connectors?

A They are preferred for microwave operation
B They are watertight
C **They are commonly used at HF and VHF frequencies**
D They are a bayonet-type connector

PL-259 connectors are commonly used at HF and VHF frequencies due to their robustness and ease of use, though they are not ideal for microwave frequencies.

T9B08

Which of the following is a source of loss in coaxial feed line?

A Water intrusion into coaxial connectors
B High SWR
C Multiple connectors in the line
D **All these choices are correct**

All the listed factors—water intrusion, high SWR, and multiple connectors—can contribute to loss in coaxial feed lines.

Summary

This section covered the basics of feed lines, focusing on the importance of low SWR, the common impedance of coaxial cables, and the function of antenna tuners. We also discussed the effects of frequency on coaxial cable loss, compared different RF connector types, and identified sources of loss in coaxial feed lines. Key concepts include:

- **SWR (Standing Wave Ratio)**: A measure of how well the antenna system is matched to the feed line, with low SWR indicating minimal signal loss.

- **Coaxial cable impedance**: Typically 50 ohms in amateur radio, balancing power handling and signal loss.

- **Antenna tuner function**: Matches the antenna system impedance to the transceiver's output impedance for maximum power transfer.

- **Frequency effects on coaxial cable**: Higher frequencies increase signal loss due to the skin effect and dielectric losses.
- **RF connector types**: Different connectors are suitable for various frequency ranges, with Type N being preferred for frequencies above 400 MHz.
- **Coaxial cable loss**: Can be caused by water intrusion, high SWR, and multiple connectors in the line.

9.4 Feed Line Issues

Introduction

In this section, we will explore common issues related to feed lines in radio communication systems. We will discuss the causes of erratic changes in SWR, compare different types of coaxial cables, evaluate feed line losses, and define the standing wave ratio (SWR) and its significance.

Erratic Changes in SWR

Erratic changes in SWR can be caused by various factors, including loose connections in the antenna or feed line. These changes can lead to inefficient power transfer and potential damage to the transmitter. A loose connection can cause intermittent contact, leading to sudden changes in impedance and, consequently, SWR.

Coaxial Cable Types

Coaxial cables, such as RG-58 and RG-213, have different electrical characteristics. RG-213 cable generally has less loss at a given frequency compared to RG-58. This is due to the larger diameter and better shielding of RG-213, which reduces signal attenuation.

Feed Line Loss

Feed line loss is an important consideration, especially at VHF and UHF frequencies. Air-insulated hardline typically has the lowest loss among common feed line types. This is because the air dielectric reduces the loss compared to solid dielectric materials used in flexible coax.

Standing Wave Ratio (SWR)

The standing wave ratio (SWR) is a measure of how well a load is matched to a transmission line. A low SWR indicates a good match, which is crucial for efficient power transfer and minimizing reflected power. High SWR can lead to increased losses and potential damage to the transmitter.

Questions

T9B09

What can cause erratic changes in SWR?

A Local thunderstorm
B **Loose connection in the antenna or feed line**
C Over-modulation
D Overload from a strong local station

A loose connection in the antenna or feed line can cause erratic changes in SWR. This is because a loose connection can lead to intermittent contact, causing sudden changes in impedance. Other options, such as local thunderstorms or over-modulation, do not directly cause erratic SWR changes.

T9B10

What is the electrical difference between RG-58 and RG-213 coaxial cable?

A There is no significant difference between the two types
B RG-58 cable has two shields
C **RG-213 cable has less loss at a given frequency**
D RG-58 cable can handle higher power levels

RG-213 cable has less loss at a given frequency compared to RG-58. This is due to the larger diameter and better shielding of RG-213, which reduces signal attenuation. RG-58 does not have two shields, and it cannot handle higher power levels than RG-213.

T9B11

Which of the following types of feed line has the lowest loss at VHF and UHF?

A 50-ohm flexible coax
B Multi-conductor unbalanced cable
C **Air-insulated hardline**
D 75-ohm flexible coax

Air-insulated hardline has the lowest loss at VHF and UHF frequencies. This is because the air dielectric reduces the loss compared to solid dielectric materials used in flexible coax. Multi-conductor unbalanced cable and 75-ohm flexible coax have higher losses.

T9B12

What is standing wave ratio (SWR)?

A **A measure of how well a load is matched to a transmission line**
B The ratio of amplifier power output to input
C The transmitter efficiency ratio
D An indication of the quality of your station's ground connection

SWR is a measure of how well a load is matched to a transmission line. A low SWR indicates a good match, which is crucial for efficient power transfer and minimizing reflected power. The other options do not correctly define SWR.

Summary

In this section, we discussed several key concepts related to feed line issues in radio communication systems:

- **Erratic SWR changes**: Caused by loose connections in the antenna or feed line, leading to inefficient power transfer.
- **Coaxial cable types**: RG-213 has less loss at a given frequency compared to RG-58 due to its larger diameter and better shielding.
- **Feed line loss**: Air-insulated hardline has the lowest loss at VHF and UHF frequencies.
- **Standing wave ratio (SWR)**: A measure of how well a load is matched to a transmission line, with low SWR indicating efficient power transfer.

Figure 9.6: Causes of erratic SWR changes. The diagram should illustrate loose connections, impedance mismatches, and other factors contributing to erratic SWR.

Feed Line Type	**Loss (dB/100 ft)**
RG-58	6.6
RG-213	3.9
Air-insulated hardline	1.5
75-ohm flexible coax	5.0

Table 9.3: Comparison of Feed Line Loss

Chapter 10 SAFETY

10.1 Electrical Safety and Hazards

Introduction

Electrical safety is a critical aspect of working with radio equipment. Understanding the hazards associated with electricity, the role of protective devices like fuses and circuit breakers, and the importance of proper grounding can prevent accidents and ensure safe operation. This section covers the potential hazards of electrical current, the purpose of fuses, grounding principles, and lightning protection.

Electrical Hazards

Electrical current flowing through the human body can cause several health hazards. These include:

- **Tissue Heating**: Electrical current can cause burns by heating tissue as it passes through the body.
- **Cell Disruption**: The electrical functions of cells can be disrupted, leading to potential organ failure.
- **Involuntary Muscle Contractions**: Current can cause muscles to contract involuntarily, which may result in injury or prevent a person from releasing a live conductor.

Fuse and Circuit Breaker Functionality

A fuse is a safety device designed to protect an electrical circuit from damage caused by excessive current. It works by melting and breaking the circuit when the current exceeds a specified value. Replacing a fuse with one of a higher rating can be dangerous because it allows more current to flow than the circuit is designed to handle, potentially leading to overheating and fire.

Grounding Principles

Proper grounding is essential for electrical safety. It provides a path for fault currents to flow safely to the earth, preventing electrical shock. Grounding also stabilizes voltage levels and helps protect equipment from damage.

Lightning Protection

A lightning arrester is a device used to protect electrical equipment from voltage spikes caused by lightning. It should be installed on a grounded panel near where coaxial feed lines enter a building. This placement ensures that any high-voltage surges are safely diverted to the ground before they can damage equipment.

Questions

T0A01

Which of the following is a safety hazard of a 12-volt storage battery?

A Touching both terminals with the hands can cause electrical shock
B **Shorting the terminals can cause burns, fire, or an explosion**
C RF emissions from a nearby transmitter can cause the electrolyte to emit poison gas
D All these choices are correct

Shorting the terminals of a 12-volt battery can cause a large current to flow, leading to burns, fire, or even an explosion due to the rapid release of energy. Touching the terminals with bare hands is generally safe at this voltage, and RF emissions do not affect the electrolyte in this manner.

T0A02

What health hazard is presented by electrical current flowing through the body?

A It may cause injury by heating tissue
B It may disrupt the electrical functions of cells
C It may cause involuntary muscle contractions
D **All these choices are correct**

Electrical current can cause tissue heating, disrupt cell functions, and induce involuntary muscle contractions, all of which are hazardous to health.

T0A03

In the United States, what circuit does black wire insulation indicate in a three-wire 120 V cable?

A Neutral
B **Hot**
C Equipment ground
D Black insulation is never used

In the U.S., black wire insulation typically indicates the hot wire in a 120 V AC circuit. The neutral wire is usually white, and the ground wire is green or bare.

T0A04

What is the purpose of a fuse in an electrical circuit?

A To prevent power supply ripple from damaging a component
B **To remove power in case of overload**
C To limit current to prevent shocks
D All these choices are correct

A fuse is designed to protect the circuit by breaking the connection if the current exceeds a safe level, preventing damage or fire.

T0A05

Why should a 5-ampere fuse never be replaced with a 20-ampere fuse?

A The larger fuse would be likely to blow because it is rated for higher current
B The power supply ripple would greatly increase
C **Excessive current could cause a fire**
D All these choices are correct

Replacing a 5-ampere fuse with a 20-ampere fuse allows more current to flow than the circuit is designed for, which can lead to overheating and fire.

T0A06

What is a good way to guard against electrical shock at your station?

A Use three-wire cords and plugs for all AC powered equipment
B Connect all AC powered station equipment to a common safety ground
C Install mechanical interlocks in high-voltage circuits
D **All these choices are correct**

Using three-wire cords, connecting equipment to a common ground, and installing mechanical interlocks are all effective ways to prevent electrical shock.

T0A07

Where should a lightning arrester be installed in a coaxial feed line?

A At the output connector of a transceiver
B At the antenna feed point
C At the ac power service panel
D **On a grounded panel near where feed lines enter the building**

A lightning arrester should be installed near the entry point of the coaxial feed line into the building to protect against voltage surges.

T0A08

Where should a fuse or circuit breaker be installed in a 120V AC power circuit?

A **In series with the hot conductor only**
B In series with the hot and neutral conductors
C In parallel with the hot conductor only
D In parallel with the hot and neutral conductors

A fuse or circuit breaker should be installed in series with the hot conductor to ensure it can interrupt the current flow in case of an overload.

Summary

This section covered the following key concepts:

- **Electrical Hazards**: The dangers of electrical current, including tissue heating, cell disruption, and muscle contractions.
- **Fuse and Circuit Breaker Functionality**: The role of fuses in protecting circuits and the risks of using improperly rated fuses.
- **Grounding Principles**: The importance of grounding in preventing electrical shock and stabilizing voltage levels.
- **Lightning Protection**: The role of lightning arresters in protecting equipment from voltage spikes caused by lightning.

Figure 10.1: Diagram showing the correct placement of a fuse in a 120V AC power circuit.

Figure 10.2: Illustration of a lightning arrester installed near the entry point of a coaxial feed line into a building.

Hazard	Effect on Human Body
Tissue Heating	Burns
Cell Disruption	Organ failure
Muscle Contractions	Injury or inability to release conductor

Table 10.1: Comparison of electrical hazards and their effects on the human body.

10.2 Tower Installation and Climbing Safety

Introduction

Proper installation and maintenance of antenna towers are critical for ensuring both operational efficiency and safety. This section covers essential practices for grounding, climbing safety, and lightning protection, as well as the importance of adhering to safety protocols during tower installation and maintenance.

Tower Grounding and Lightning Protection

Proper grounding is essential for antenna towers to protect against lightning strikes and to ensure the safety of the equipment and personnel. A well-grounded tower provides a low-resistance path for lightning to follow, reducing the risk of damage. The grounding system should include multiple ground rods, each at least eight feet long, bonded together and to the tower legs. This configuration ensures that the electrical charge is dissipated safely into the ground.

Figure 10.3: Diagram showing the correct grounding method for an antenna tower using multiple ground rods.

Climbing Safety Protocols

Climbing an antenna tower requires strict adherence to safety protocols. Always use an approved climbing harness and ensure that you are properly tied off to the tower at all times. Training in safe climbing techniques is essential, and climbing should never be attempted without a helper or observer. The risks of falling or encountering electrical hazards are significant, and proper precautions must be taken to mitigate these dangers.

Figure 10.4: Illustration of a climbing harness and tie-off system used for safe tower climbing.

Guy Line Tensioning and Safety Wires

Guy lines are used to stabilize towers, and proper tensioning is crucial for maintaining structural integrity. A safety wire through the turnbuckle prevents loosening due to vibration, ensuring that the guy lines remain taut. This is particularly important in areas prone to high winds or seismic activity.

Questions

T0B01

Which of the following is good practice when installing ground wires on a tower for lightning protection?

- A Put a drip loop in the ground connection to prevent water damage to the ground system
- B Make sure all ground wire bends are right angles
- C **Ensure that connections are short and direct**
- D All these choices are correct

Short and direct connections minimize resistance and ensure effective grounding. Drip loops and right-angle bends are not necessary for proper grounding.

T0B02

What is required when climbing an antenna tower?

A Have sufficient training on safe tower climbing techniques
B Use appropriate tie-off to the tower at all times
C Always wear an approved climbing harness
D **All these choices are correct**

All the listed precautions are essential for safe tower climbing. Training, tie-offs, and harnesses work together to minimize risks.

T0B03

Under what circumstances is it safe to climb a tower without a helper or observer?

A When no electrical work is being performed
B When no mechanical work is being performed
C When the work being done is not more than 20 feet above the ground
D **Never**

Climbing a tower without a helper or observer is never safe. A helper ensures assistance in case of an emergency.

T0B04

Which of the following is an important safety precaution to observe when putting up an antenna tower?

A Wear a ground strap connected to your wrist at all times
B Insulate the base of the tower to avoid lightning strikes
C **Look for and stay clear of any overhead electrical wires**
D All these choices are correct

Overhead electrical wires pose a significant hazard. Staying clear of them is crucial to avoid electrical shock or arcing.

T0B05

What is the purpose of a safety wire through a turnbuckle used to tension guy lines?

A Secure the guy line if the turnbuckle breaks
B **Prevent loosening of the turnbuckle from vibration**
C Provide a ground path for lightning strikes
D Provide an ability to measure for proper tensioning

The safety wire prevents the turnbuckle from loosening due to vibration, maintaining the tension in the guy lines.

T0B06

What is the minimum safe distance from a power line to allow when installing an antenna?

- A Add the height of the antenna to the height of the power line and multiply by a factor of 1.5
- B The height of the power line above ground
- C 1/2 wavelength at the operating frequency
- D **Enough so that if the antenna falls, no part of it can come closer than 10 feet to the power wires**

The 10-foot rule ensures that even if the antenna falls, it will not come into contact with power lines, preventing electrical hazards.

T0B07

Which of the following is an important safety rule to remember when using a crank-up tower?

- A This type of tower must never be painted
- B This type of tower must never be grounded
- C **This type of tower must not be climbed unless it is retracted, or mechanical safety locking devices have been installed**
- D All these choices are correct

Climbing a crank-up tower without retracting it or using safety locks can lead to accidents due to unexpected movement.

T0B08

Which is a proper grounding method for a tower?

- A A single four-foot ground rod, driven into the ground no more than 12 inches from the base
- B A ferrite-core RF choke connected between the tower and ground
- C A connection between the tower base and a cold water pipe
- D **Separate eight-foot ground rods for each tower leg, bonded to the tower and each other**

Multiple ground rods bonded together provide a robust grounding system, ensuring effective dissipation of electrical charges.

Summary

This section covered key concepts related to tower installation and climbing safety:

- **Tower grounding**: Proper grounding using multiple ground rods ensures lightning protection and equipment safety.

- **Climbing safety protocols**: Always use a harness, tie-offs, and a helper when climbing towers.

- **Lightning protection for towers**: Grounding systems must be designed to handle high electrical currents.
- **Guy line tensioning**: Safety wires in turnbuckles prevent loosening due to vibration.

10.3 RF Radiation and Exposure Safety

Introduction

Radio Frequency (RF) radiation is a form of non-ionizing electromagnetic radiation that is widely used in communication systems, including amateur radio. Unlike ionizing radiation, such as X-rays or gamma rays, RF radiation does not have enough energy to remove tightly bound electrons from atoms or molecules. This section explores the safety considerations related to RF radiation, including exposure limits, factors affecting exposure, and methods to ensure compliance with safety regulations.

Non-Ionizing Radiation

Radio signals are classified as non-ionizing radiation because they lack the energy required to ionize atoms or molecules. Ionizing radiation, such as gamma rays, has sufficient energy to strip electrons from atoms, which can cause damage to biological tissues. In contrast, non-ionizing radiation, like RF waves, primarily causes heating effects in tissues but does not cause ionization. This distinction is crucial for understanding the safety limits and precautions associated with RF exposure.

RF Exposure Limits

The allowable power density for RF safety is influenced by the duty cycle of the transmission. The duty cycle represents the fraction of time the transmitter is active during a given period. For example, if the duty cycle decreases from 100% to 50%, the allowable power density increases by a factor of 2. This relationship is expressed mathematically as:

$$P_{\text{allowed}} = P_{\text{max}} \times \frac{1}{\text{Duty Cycle}} \tag{10.1}$$

where P_{allowed} is the allowable power density, and P_{max} is the maximum power density at 100% duty cycle.

Factors Affecting RF Exposure

Several factors influence the RF exposure of individuals near an amateur station antenna:

- **Frequency and Power Level**: Higher frequencies and power levels generally result in greater RF exposure.
- **Distance from the Antenna**: The intensity of RF radiation decreases with the square of the distance from the antenna.

- **Radiation Pattern**: The directional characteristics of the antenna can concentrate or disperse RF energy, affecting exposure levels.

Compliance with FCC Regulations

To ensure compliance with FCC RF exposure regulations, amateur radio operators can use several methods:

- **Calculations**: Based on guidelines provided in FCC OET Bulletin 65.

- **Computer Modeling**: Simulating RF exposure using specialized software.

- **Field Strength Measurements**: Using calibrated equipment to measure RF field strength directly.

Questions

T0C01

What type of radiation are radio signals?

A Gamma radiation
B Ionizing radiation
C Alpha radiation
D **Non-ionizing radiation**

Radio signals are classified as non-ionizing radiation because they lack the energy required to ionize atoms or molecules. Gamma and alpha radiation are forms of ionizing radiation, which can cause damage to biological tissues.

T0C02

At which of the following frequencies does maximum permissible exposure have the lowest value?

A 3.5 MHz
B **50 MHz**
C 440 MHz
D 1296 MHz

The maximum permissible exposure (MPE) limits are frequency-dependent. At 50 MHz, the MPE is lower compared to higher frequencies like 440 MHz or 1296 MHz. This is because the human body absorbs more RF energy at certain frequencies, leading to stricter exposure limits.

T0C03

How does the allowable power density for RF safety change if duty cycle changes from 100 percent to 50 percent?

A It increases by a factor of 3
B It decreases by 50 percent
C **It increases by a factor of 2**
D There is no adjustment allowed for lower duty cycle

When the duty cycle decreases from 100% to 50%, the allowable power density increases by a factor of 2. This is because the transmitter is active for a shorter period, reducing the average power density over time.

T0C04

What factors affect the RF exposure of people near an amateur station antenna?

A Frequency and power level of the RF field
B Distance from the antenna to a person
C Radiation pattern of the antenna
D **All these choices are correct**

All the listed factors—frequency, power level, distance, and radiation pattern—affect RF exposure. These factors collectively determine the intensity and distribution of RF radiation in the vicinity of an antenna.

T0C05

Why do exposure limits vary with frequency?

A Lower frequency RF fields have more energy than higher frequency fields
B Lower frequency RF fields do not penetrate the human body
C Higher frequency RF fields are transient in nature
D **The human body absorbs more RF energy at some frequencies than at others**

Exposure limits vary with frequency because the human body absorbs RF energy differently at different frequencies. Certain frequencies are more readily absorbed, leading to stricter exposure limits to ensure safety.

T0C06

Which of the following is an acceptable method to determine whether your station complies with FCC RF exposure regulations?

A By calculation based on FCC OET Bulletin 65
B By calculation based on computer modeling
C By measurement of field strength using calibrated equipment
D **All these choices are correct**

All the listed methods—calculations based on FCC OET Bulletin 65, computer modeling, and field strength measurements—are acceptable for determining compliance with

FCC RF exposure regulations.

T0C07

What hazard is created by touching an antenna during a transmission?

- A Electrocution
- B **RF burn to skin**
- C Radiation poisoning
- D All these choices are correct

Touching an antenna during transmission can cause an RF burn to the skin due to the high-frequency currents induced in the body. This is different from electrocution, which involves low-frequency currents, and radiation poisoning, which is associated with ionizing radiation.

T0C08

Which of the following actions can reduce exposure to RF radiation?

- A **Relocate antennas**
- B Relocate the transmitter
- C Increase the duty cycle
- D All these choices are correct

Relocating antennas can reduce RF exposure by increasing the distance between the antenna and individuals. Increasing the duty cycle would actually increase exposure, and relocating the transmitter alone may not significantly reduce exposure if the antenna remains close to people.

Summary

This section covered key concepts related to RF radiation and exposure safety:

- **Non-ionizing radiation**: Radio signals are non-ionizing and primarily cause heating effects.
- **RF exposure limits**: These limits vary with frequency and duty cycle, with lower frequencies and higher duty cycles requiring stricter limits.
- **Duty cycle and its impact on RF safety**: Reducing the duty cycle allows for higher allowable power densities.
- **Methods to reduce RF exposure**: Relocating antennas and increasing distance are effective strategies to minimize exposure.

Figures and Tables

Figure 10.5: Graph illustrating the maximum permissible exposure limits for RF radiation at various frequencies.

Figure 10.6: Diagram showing how relocating an antenna can reduce RF exposure to nearby individuals.

Frequency (MHz)	**Exposure Limit ($\mathbf{mW/cm^2}$)**
3.5	1.0
50	0.2
440	1.0
1296	5.0

Table 10.2: Summary of RF exposure limits at various frequencies.