Contents

Chapter 1 COMMISSION RULES

1.1 Introduction to the Amateur Radio Service

Basis and Purpose of the Amateur Radio Service

The Amateur Radio Service, as defined by the Federal Communications Commission (FCC), serves several key purposes. One of its primary goals is to advance skills in the technical and communication phases of the radio art. This includes fostering experimentation, innovation, and the development of new technologies within the amateur radio community. Additionally, the service aims to provide a pool of trained operators who can assist in emergency communications, thereby contributing to public safety.

Role of the FCC

The FCC is the regulatory authority responsible for overseeing and enforcing the rules governing the Amateur Radio Service in the United States. The FCC ensures that amateur radio operators adhere to the regulations outlined in Part 97 of the FCC rules, which cover everything from licensing to operational standards. The FCC also maintains the Universal Licensing System (ULS), a database that contains all current amateur radio licenses.

Phonetic Alphabet Usage

The use of a phonetic alphabet is encouraged by the FCC for station identification in the Amateur Radio Service. This practice enhances clarity and reduces the likelihood of miscommunication, especially in noisy or challenging conditions. While not mandatory, the phonetic alphabet is particularly useful during emergency communications and when contacting foreign stations.

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 this database is the definitive proof that the FCC has issued the license.

Definitions of Beacon and Space Station

According to FCC Part 97, 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 crucial for understanding the operational scope and limitations of amateur radio activities.

Figure 1.1: FCC Regulatory Structure

Term	**Definition**
Beacon	An amateur station transmitting communications for observing propagatio
Space Station	An amateur station located more than 50 km above Earth's surface.
License Documentation	The license appears 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 correct answer is **C**. The Basis and Purpose of the Amateur Radio Service includes advancing skills in the technical and communication phases of the radio art. This is explicitly stated in FCC Part 97.

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 correct answer is **C**. The Federal Communications Commission (FCC) is the agency responsible for regulating and enforcing the rules for the Amateur Radio Service in the United States.

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 correct answer is **B**. The FCC encourages the use of a phonetic alphabet for station identification to enhance clarity and reduce miscommunication.

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

The correct answer is **A**. An individual may hold only one operator/primary station license grant at any given time.

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 correct answer is **C**. The appearance of the license in the FCC ULS database is the definitive proof that the FCC has issued the license.

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**

The correct answer is **D**. According to FCC Part 97, a beacon is an amateur station that transmits communications for the purposes of observing propagation or related experimental activities.

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

The correct answer is **C**. According to FCC Part 97, a space station is an amateur station located more than 50 km above Earth's surface.

Summary

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

- **Purpose of the Amateur Radio Service**: Advancing technical and communication skills, fostering innovation, and contributing to public safety.
- **Regulatory authority of the FCC**: The FCC oversees and enforces amateur radio rules, maintaining the ULS database for license documentation.
- **Phonetic alphabet usage**: Encouraged by the FCC for clarity in station identification.
- **License grants and documentation**: Only one license grant per person, documented in the FCC ULS database.
- **Definitions of beacon and space station**: A beacon is for propagation observation, while a space station is an amateur station 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 radio 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 operate as repeaters 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. Additionally, they can operate on the 6-meter band, which includes frequencies such as 52.525 MHz, and the 2-meter band, which includes 146.52 MHz. These bands are commonly used for local and regional communication.

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. No additional approval from NASA or other entities is required for this activity.

Amateur Band Segments and Their Usage

Amateur radio bands are divided into segments, each with specific uses. For example, the 6-meter band (50-54 MHz) is often used for local and regional communication, while the 2-meter band (144-148 MHz) is popular for both local and satellite communication. The 219-220 MHz segment of the 1.25-meter band is reserved for fixed digital message forwarding systems, ensuring efficient use of this spectrum for specific applications.

Figure 1.2: Amateur Radio Frequency Allocation

Band	**Frequency Range**
6 meters	50-54 MHz
2 meters	144-148 MHz
1.25 meters	219-220 MHz
10 meters	28.300-28.500 MHz

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

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

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

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

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

T1B04

Which amateur band includes 146.52 MHz?

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

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**

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

Summary

This section covered the role of frequency coordinators, who are selected by local amateur operators to manage frequency allocations for repeaters and auxiliary stations. Technician licensees have access to specific frequency ranges, including the 6-meter, 2-meter, and 10-meter bands, with certain segments reserved for phone operation. Communication with the International Space Station (ISS) is permitted for Technician class or higher licensees on VHF bands. Key amateur band segments, such as the 6-meter and 2-meter bands, have specific uses, and the 219-220 MHz segment is reserved for fixed digital message forwarding systems.

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 bands and modes.

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 or tenure, is eligible to apply for a vanity call sign. The process involves submitting an application to the FCC, which is then reviewed and approved if the requested call sign is available and meets regulatory requirements. 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 exchanging messages of a personal character and participating in international contests. However, communications for business purposes or those that would be permitted by an international broadcast station are prohibited.

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 to maintain operating privileges.

Table 1.3: Amateur Radio License Classes and Privileges

License Class	**Privileges**	**Renewal Term**
Technician	Entry-level privileges, limited frequency access	10 years
General	Expanded frequency access, including HF bands	10 years
Amateur Extra	Full access to all amateur bands and modes	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 correct answer is **D**. The FCC currently offers 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**

The correct answer is **D**. Any licensed amateur, regardless of license class or tenure, is eligible to 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

The correct answer is **A**. FCC-licensed amateur radio stations are permitted to make international communications that are incidental to the purposes of the Amateur Radio Service, including personal messages.

Summary

This section covered the current license classes available from the FCC, the rules for selecting a vanity call sign, the types of international communications permitted, and the importance of maintaining accurate contact information with the FCC. Key concepts include:

- **License classes and availability**: Technician, General, and Amateur Extra classes are currently available, each with specific operating privileges.
- **Vanity call sign rules**: Any licensed amateur can apply for a vanity call sign.
- **International communications**: Permitted communications are incidental to the Amateur Radio Service and include personal messages.
- **License renewal and revocation**: Accurate contact information must be maintained, and licenses are typically valid for ten years.

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 ethical standards.

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 related to radio frequency usage.

One-Way Transmissions

One-way transmissions by amateur stations are generally prohibited, particularly 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 to this rule, such as transmissions for international Morse code practice or telecommand signals for controlling space stations or radio-controlled craft.

Encoded Messages and Music Transmissions

Encoded messages, which obscure their meaning, are only permitted when transmitting control commands to space stations or radio control craft. This ensures that the primary purpose of amateur radio—facilitating communication and experimentation—is not compromised. Similarly, music transmissions using phone emissions are only allowed when incidental to an authorized retransmission of manned spacecraft communications.

Equipment Sales and Notifications

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 the amateur radio service from being used as a commercial platform while allowing for the occasional exchange of equipment among enthusiasts.

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)

The correct answer is **A**. According to FCC regulations, amateur radio stations are prohibited from communicating with countries that have notified the ITU of their objection to such communications. This ensures compliance with international agreements and respects the regulatory decisions 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

The correct answer is **B**. One-way transmissions are prohibited when they constitute broadcasting, which is defined as transmissions intended for reception by the general public. However, exceptions exist for specific purposes such as Morse code practice or telecommand signals.

Summary

This section covered the key operating rules and restrictions for amateur radio stations, including:

- **Prohibited Communications**: Amateur stations must avoid communications with countries that have notified the ITU of their objections.
- **One-Way Transmissions**: Broadcasting is generally prohibited, with exceptions for specific purposes like Morse code practice.
- **Encoded Messages**: Messages encoded to obscure their meaning are only allowed for control commands to space stations or radio-controlled craft.
- **Music Transmission**: Music transmissions are permitted only when incidental to authorized retransmissions of manned spacecraft communications.
- **Equipment Sales**: Notifications about equipment for sale or trade are allowed, provided they are not made on a regular basis.

Figures and Tables

Figure 1.4: One-Way Transmission Rules

Rule Type	Description
Prohibited Communications	Communications with countries that have notified the ITU of objectio
One-Way Transmissions	Prohibited for broadcasting, allowed for Morse code practice and telec

Table 1.4: Prohibited Communications and One-Way Transmission Rules

1.5 Control Operator Responsibilities

Introduction

This section discusses the responsibilities and requirements of control operators in amateur radio stations. It covers the rules governing control operators, their privileges, and the specific considerations for operating through amateur satellites or space stations. Additionally, it defines the concept of a control point and explains how transmitting frequency privileges are determined.

Control Operator Rules and Responsibilities

The control operator is a licensed amateur radio operator responsible for ensuring that the station operates in compliance with FCC regulations. The station licensee must designate the control operator, and this individual is accountable for the proper operation of the station. Even if the control operator is not the station licensee, both parties share responsibility for ensuring compliance with regulations.

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 or class requirements beyond the operator's existing privileges. This flexibility allows a wide range of licensed amateurs to participate in satellite communications.

Transmitting Frequency Privileges

The transmitting frequency privileges of an amateur station are determined by the class of the control operator's license. For example, a Technician class licensee cannot operate in Amateur Extra Class band segments, regardless of the station's configuration or the presence of higher-class licensees.

Control Point Definition

The control point is the location where the control operator performs their duties. This is distinct from the physical location of the transmitting apparatus or antenna. The control point is crucial for ensuring that the station operates within legal and technical limits.

Figure 1.5: Control Operator Responsibilities

Table 1.5: Control Operator Responsibilities and Privileges

Responsibility	**Privilege**
Ensure FCC compliance	Operate within license class limits
Designate control operator	Transmit on authorized frequencies
Share responsibility with licensee	Participate in satellite operations

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 present during transmission. This is a fundamental rule outlined in FCC Part 97. Automatic control, such as in repeaters, still requires a control operator to ensure compliance.

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**

The control operator for satellite operations must only be authorized to transmit on the satellite's uplink frequency. No additional certifications or class restrictions apply.

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, as per FCC regulations.

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 control operator's license class determines the transmitting frequency privileges of the station.

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 where the control operator performs their duties, not necessarily where the equipment is located.

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 operate in Amateur Extra Class band segments, as their privileges are limited to their license class.

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 share responsibility for the station's proper operation.

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, as it operates without direct human intervention during transmission.

Summary

This section covered the following key concepts:

- **Control operator requirements**: The control operator must ensure FCC compliance and is designated by the station licensee.
- **Satellite and space station operations**: Any licensed amateur authorized to transmit on the satellite's uplink frequency can be the control operator.
- **Transmitting frequency privileges**: The control operator's license class determines the station's transmitting frequency privileges.
- **Control point definition**: The control point is where the control operator performs their duties, distinct from the physical location of the equipment.

1.6 Station Identification and Third-Party Communications

Station Identification Rules

The Federal Communications Commission (FCC) mandates specific rules for station identification to ensure proper operation and accountability in amateur radio communications. Station identification involves transmitting the FCC-assigned call sign at regular intervals. This is crucial for maintaining transparency and compliance with regulations.

When using tactical call signs, such as "Race Headquarters," the FCC requires that the station's assigned call sign be transmitted at the end of each communication and every ten minutes during a communication. This ensures that the station's identity is clear, even when using temporary or situational identifiers.

Third-Party Communications

Third-party communications refer to messages transmitted by a licensed control operator on behalf of another person. The control operator is responsible for ensuring that all transmissions comply with FCC regulations. For third-party communications to a foreign station, the foreign station must be in a country with which the U.S. has a third-party agreement. The control operator must also handle the station identification during such communications.

Language Restrictions

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

Self-Assigned Indicators

Self-assigned indicators, such as "KL7CC/W3," are acceptable in phone transmissions. These indicators can be used to provide additional context or information about the station's operation, but they must not obscure the FCC-assigned call sign.

Figure 1.6: 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 call sign transmissions.

Rule	**Description**
Station Identification	Transmit FCC-assigned call sign at the end of each communication a
Tactical Call Signs	Use assigned call sign with tactical identifiers; identify at required int
Third-Party Communications	Control operator must handle identification; foreign station must be i
Language Restrictions	Identification in phone sub-bands must be in English.
Self-Assigned Indicators	Acceptable in phone transmissions; must not obscure FCC-assigned c

Table 1.6: 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 FCC inspection at any time upon request by an FCC representative. This ensures compliance with FCC regulations and allows for immediate verification of proper operation.

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 of the station.

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 communications.

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 a station transmitting phone signals, the call sign must be sent using a CW (Morse code) or phone emission. This ensures proper identification regardless of the transmission mode.

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 phone transmissions. These indicators provide additional context without obscuring the FCC-assigned call sign.

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. The control operator is responsible for station identification.

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 complies with FCC regulations.

Summary

This section covered the following key concepts:

- **Station identification requirements**: The FCC mandates that stations transmit their assigned call sign at specific intervals, especially when using tactical call signs.
- **Tactical call signs**: These are temporary identifiers used in specific situations, but the FCC-assigned call sign must still be transmitted at required intervals.
- **Third-party communications**: These involve a control operator transmitting messages on behalf of another person, with specific restrictions for foreign stations.
- **Language restrictions**: Station identification in phone sub-bands must be in English to ensure clarity and consistency.

Chapter 2 OPERATING PROCEDURES

2.1 Repeater and Communication Basics

Repeater Frequency Offsets

Repeater frequency offsets are a critical aspect of amateur radio operations. They refer to the difference between a repeater's transmit and receive frequencies. This offset allows the repeater to receive signals on one frequency and retransmit them on another, ensuring that the original signal does not interfere with the retransmitted signal. This is particularly important in maintaining clear and reliable communication over long distances.

Simplex Operations

The national calling frequency for FM simplex operations in the 2 meter band is **146.520 MHz**. This frequency is widely recognized and used by amateur radio operators for initiating communications without the need for a repeater. It serves as a common meeting point for operators to establish contact before moving to other frequencies for further communication.

Calling Procedures

The procedural signal **CQ** is used to call any station and is a standard method for initiating communications in amateur radio. When an operator transmits "CQ," they are essentially announcing their availability to communicate with any station that hears the call. This is particularly useful in making initial contact with other operators, especially in contests or during emergency situations.

Repeater Terminology

The term **repeater offset** refers to the difference between a repeater's transmit and receive frequencies. This offset is essential for the repeater to function correctly, as it allows the repeater to receive a signal on one frequency and retransmit it on another without causing interference. This separation of frequencies ensures that the repeater can amplify and retransmit signals effectively, extending the range of communication.

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

T2A01

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

1. Plus or minus 5 MHz
2. **Plus or minus 600 kHz**
3. Plus or minus 500 kHz
4. Plus or minus 1 MHz

Explanation: The correct answer is **B**, which states that the common repeater frequency offset in the 2 meter band is ± 600 kHz. This offset is standard for 2 meter repeaters to avoid interference between the input and output frequencies. The other options are incorrect because they do not match the standard offset for the 2 meter band.

T2A02

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

1. **146.520 MHz**
2. 145.000 MHz
3. 432.100 MHz
4. 446.000 MHz

Explanation: The correct answer is **A**, which is 146.520 MHz. This frequency is widely recognized as the national calling frequency for FM simplex operations in the 2 meter band. The other frequencies listed are either not standard calling frequencies or belong to different bands.

T2A03

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

1. **Plus or minus 5 MHz**
2. Plus or minus 600 kHz
3. Plus or minus 500 kHz
4. Plus or minus 1 MHz

Explanation: The correct answer is **A**, which states that the common repeater frequency offset in the 70 cm band is ± 5 MHz. This offset is standard for 70 cm repeaters to ensure clear communication. The other options are incorrect because they do not match the standard offset 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?

1. Say "break, break," then say the station's call sign
2. **Say the station's call sign, then identify with your call sign**
3. Say "CQ" three times, then the other station's call sign
4. Wait for the station to call CQ, then answer

Explanation: The correct answer is **B**, which involves saying the station's call sign followed by your own call sign. This is the standard procedure for calling a specific station on a repeater. The other options are either incorrect or not standard procedures.

T2A05

How should you respond to a station calling CQ?

1. Transmit "CQ" followed by the other station's call sign
2. Transmit your call sign followed by the other station's call sign
3. **Transmit the other station's call sign followed by your call sign**
4. Transmit a signal report followed by your call sign

Explanation: The correct answer is **C**, which involves transmitting the other station's call sign followed by your own call sign. This is the standard procedure for responding to a CQ 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?

1. **Identify the transmitting station**
2. Conduct tests only between 10 p.m. and 6 a.m. local time
3. Notify the FCC of the transmissions
4. All these choices are correct

Explanation: The correct answer is **A**, which states that identifying the transmitting station is required during on-the-air test transmissions. This is a regulatory requirement to ensure accountability. The other options are either incorrect or not required by regulation.

T2A07

What is meant by "repeater offset"?

1. **The difference between a repeater's transmit and receive frequencies**
2. The repeater has a time delay to prevent interference
3. The repeater station identification is done on a separate frequency
4. The number of simultaneous transmit frequencies used by a repeater

Explanation: The correct answer is **A**, which defines "repeater offset" as the difference between a repeater's transmit and receive frequencies. This is the standard definition and is crucial for understanding how repeaters operate. The other options are incorrect or do not accurately define the term.

T2A08

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

1. Call on the quarter hour
2. Test transmission, no reply expected
3. Only the called station should transmit
4. **Calling any station**

Explanation: The correct answer is **D**, which states that "CQ" means calling any station. This is the standard meaning of the procedural signal and is used to initiate communications with any available station. The other options are incorrect or do not accurately describe the meaning of "CQ."

2.2 Radio Operating Essentials

Band Plans

A band plan is a voluntary guideline for using different modes or activities within an amateur band. It helps to organize the use of frequencies, 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 radio spectrum.

Simplex vs. Duplex

Simplex communication refers to a mode where transmission and reception occur on the same frequency. This is commonly used in direct, point-to-point communication. Duplex communication, on the other hand, involves two frequencies: one for transmitting and another for receiving. This mode is often used in repeater systems to extend the range of communication.

Figure 2.2: Simplex vs. Duplex Communication

Table 2.2: Simplex vs. Duplex Communication

Mode	**Description**
Simplex	Transmission and reception on the same frequency
Duplex	Transmission and reception on separate 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 manage communication.

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.

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 repeaters in the network. This setup extends the coverage area and enables communication over a much larger geographic region. Linked repeater networks are particularly useful in emergency situations where wide-area communication is essential.

Multiple Choice Questions

T2A09

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

1. **A.** “CQ CQ” followed by the repeater’s call sign
2. **B.** The station’s call sign followed by the word “monitoring”
3. **C.** The repeater call sign followed by the station’s call sign
4. **D.** “QSY” followed by your call sign

Explanation: The correct answer is **B**. When a station is listening on 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 ready to receive calls. Option A is incorrect because “CQ CQ” is a general call for any station, not specific to repeaters. Option C is incorrect because it reverses the order of the call signs. Option D is incorrect because “QSY” is used to indicate a change in frequency, not to indicate that a station is monitoring.

T2A10

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

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

Explanation: The correct answer is **A**. A band plan is a voluntary guideline that helps amateur radio operators organize the use of frequencies within a band, ensuring that different modes and activities can coexist without interference. Option B is incorrect because a band plan is not a list of operating schedules. Option C is incorrect because it refers to net frequencies, which are specific to organized nets, not the entire band. Option D is incorrect because a band plan is not specific to a single club but is a community-wide guideline.

T2A11

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

1. **A.** Full duplex
2. **B.** Diplex
3. **C.** Simplex
4. **D.** Multiplex

Explanation: The correct answer is **C**. Simplex communication involves transmitting and receiving on the same frequency. Option A is incorrect because full duplex involves simultaneous transmission and reception on separate frequencies. Option B is incorrect because diplex refers to the use of a single antenna for two different frequencies, not the communication mode. Option D is incorrect because multiplex refers to combining multiple signals into one, not the communication mode.

T2A12

What should you do before calling CQ?

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

Explanation: The correct answer is **D**. Before calling CQ, you should listen to ensure the frequency is not in use, ask if the frequency is in use, and ensure you are authorized to use that frequency. All these steps are important to avoid interference and ensure proper operation.

T2B01

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

1. **A.** To reduce power output
2. **B.** To increase power output
3. **C.** To listen on a repeater's input frequency
4. **D.** To listen on a repeater's output frequency

Explanation: The correct answer is **C**. The "reverse" function on a VHF/UHF transceiver is used to listen on a repeater's input frequency, allowing you to hear what is being transmitted to the repeater. Option A is incorrect because the reverse function does not affect power output. Option B is incorrect for the same reason. Option D is incorrect because the reverse function does not listen on the repeater's output frequency.

T2B02

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

1. **A.** Carrier squelch
2. **B.** Tone burst
3. **C.** DTMF
4. **D.** CTCSS

Explanation: The correct answer is **D**. CTCSS (Continuous Tone-Coded Squelch System) uses a sub-audible tone to open the squelch of a receiver. Option A is incorrect because carrier squelch does not use a tone. Option B is incorrect because tone burst is a different method of signaling. Option C is incorrect because DTMF is used for remote control, not squelch control.

T2B03

Which of the following describes a linked repeater network?

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

Explanation: The correct answer is **A**. A linked repeater network involves multiple repeaters that transmit signals received by one repeater across the entire network. Option B is incorrect because it describes a single repeater with multiple receivers, not a network. Option C is incorrect because it refers to multiple repeaters with the same control operator, not necessarily linked. Option D is incorrect because APRS is a different system used for tracking and messaging, not for linking repeaters.

T2B04

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

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

Explanation: The correct answer is **D**. All the listed reasons (improper transceiver offset, wrong CTCSS tone, and wrong DCS code) could prevent you from accessing a repeater even if you can hear its output. Each of these factors is critical for proper repeater operation.

2.3 Advanced Operating Techniques

FM Transmission Distortion

FM transmission distortion on voice peaks can occur when the input signal exceeds the modulation limits of the transmitter. This typically happens when the operator speaks too loudly, causing the audio signal to clip. To avoid this, ensure that your microphone gain is properly adjusted and avoid speaking too close to the microphone.

DTMF Signaling

DTMF (Dual-Tone Multi-Frequency) signaling uses pairs of audio tones to represent digits and symbols. This type of signaling is commonly used in amateur radio for remote control of repeaters, accessing voicemail systems, and other automated functions. Each key on a DTMF keypad generates a unique pair of tones, which can be easily decoded by the receiving equipment.

Joining a Digital Repeater Talkgroup

To join a digital repeater's talkgroup, you need to program your radio with the group's ID or code. This allows your radio to communicate with other radios in the same talkgroup. The process typically involves selecting the appropriate talkgroup from a list and entering the corresponding ID into your radio's settings.

Figure 2.3: Joining a Digital Repeater Talkgroup

Managing Frequency Interference

When two stations transmitting on the same frequency interfere with each other, they should negotiate continued use of the frequency. This can involve agreeing on a time-sharing arrangement or selecting a different frequency. The Q signals QRM and QSY are used to indicate interference and a change in frequency, respectively.

Q Signal	**Meaning**
QRM	Interference from other stations
QSY	Changing frequency

Table 2.3: Common Q Signals

T2B05

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

1. Your repeater offset is inverted
2. You need to talk louder
3. **You are talking too loudly**
4. Your transmit power is too high

Explanation: Distortion on voice peaks in FM transmission is typically caused by over-modulation, which occurs when the input signal is too strong. This can be avoided by adjusting the microphone gain and speaking at a normal volume.

T2B06

What type of signaling uses pairs of audio tones?

1. **DTMF**
2. CTCSS
3. GPRS
4. D-STAR

Explanation: DTMF (Dual-Tone Multi-Frequency) signaling uses pairs of audio tones to represent digits and symbols. This is commonly used in amateur radio for remote control of repeaters and accessing automated systems.

T2B07

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

1. Register your radio with the local FCC office
2. Join the repeater owner's club
3. **Program your radio with the group's ID or code**
4. Sign your call after the courtesy tone

Explanation: To join a digital repeater's talkgroup, you need to program your radio with the group's ID or code. This allows your radio to communicate with other radios in the same talkgroup.

T2B08

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

1. **The stations should negotiate continued use of the frequency**
2. Both stations should choose another frequency to avoid conflict
3. Interference is inevitable, so no action is required
4. Use subaudible tones so both stations can share the frequency

Explanation: When two stations interfere on the same frequency, they should negotiate to resolve the issue. This can involve time-sharing or selecting a different frequency to avoid conflict.

T2B09

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

1. **So stations within range of each other can communicate without tying up a repeater**
2. For contest operation
3. For working DX only
4. So stations with simple transmitters can access the repeater without automated offset

Explanation: Simplex channels are designated in the VHF/UHF band plans to allow direct communication between stations within range, without the need for 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?

1. **QRM**
2. QRN
3. QTH
4. QSB

Explanation: The Q signal QRM indicates that you are receiving interference from other stations. This is commonly used to report interference during communication.

T2B11

Which Q signal indicates that you are changing frequency?

1. QRU
2. **QSY**
3. QSL
4. QRZ

Explanation: The Q signal QSY indicates that you are changing frequency. This is used to inform other stations of a frequency change during communication.

T2B12

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

1. **Must match the repeater color code for access**
2. Defines the frequency pair to use
3. Identifies the codec used
4. Defines the minimum signal level required for access

Explanation: The color code in DMR repeater systems is used to ensure that your radio matches the repeater's color code for access. This helps in managing access and preventing unauthorized use of the repeater.

2.4 Emergency Operations and Traffic Handling

FCC Rules in Emergencies

FCC rules play a crucial role in regulating amateur radio operations, even during emergencies. These rules ensure that communication remains orderly and effective, especially when amateur radio operators are providing critical support during disasters. The FCC rules apply to all amateur radio operations, including those conducted under emergency conditions. This ensures that all communications are conducted within the legal framework, maintaining the integrity and reliability of the amateur radio service.

Duties of a Net Control Station

During an emergency net, the Net Control Station (NCS) is responsible for managing communications between stations. The NCS calls the net to order, directs communications, and ensures that messages are passed efficiently and accurately. The NCS also ensures that all stations checking into the net are properly licensed and that the net operates smoothly. This role is critical in maintaining order and ensuring that emergency communications are handled effectively.

Importance of Phonetic Alphabet

Clear communication is essential in emergency situations, especially when dealing with unusual or complex words. The use of a standard phonetic alphabet helps ensure that messages are received correctly. By spelling out words using a phonetic alphabet, operators can avoid misunderstandings and ensure that critical information is accurately conveyed.

Characteristics of Good Traffic Handling

Good traffic handling involves passing messages exactly as received, without alteration. This ensures that the original intent and content of the message are preserved. It is also important to transmit only when directed by the net control station, unless reporting an emergency. This helps maintain order and prevents unnecessary interruptions during critical communications.

Figure 2.4: Traffic Handling Process

T2C01

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

1. When operating a RACES station
2. When operating under special FEMA rules
3. When operating under special ARES rules
4. **FCC rules always apply**

Table 2.4: Phonetic Alphabet

Letter	Phonetic Word
A	Alpha
B	Bravo
C	Charlie
D	Delta
E	Echo
F	Foxtrot
G	Golf
H	Hotel
I	India
J	Juliet
K	Kilo
L	Lima
M	Mike
N	November
O	Oscar
P	Papa
Q	Quebec
R	Romeo
S	Sierra
T	Tango
U	Uniform
V	Victor
W	Whiskey
X	X-ray
Y	Yankee
Z	Zulu

Explanation: FCC rules always apply to the operation of an amateur station, regardless of the situation. This ensures that all communications are conducted within the legal framework, maintaining the integrity and reliability of the amateur radio service.

T2C02

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

1. Choose the regular net meeting time and frequency
2. Ensure that all stations checking into the net are properly licensed for operation on the net frequency
3. **Call the net to order and direct communications between stations checking in**
4. All these choices are correct

Explanation: The primary duty of a Net Control Station is to call the net to order and direct communications between stations checking in. While ensuring proper licensing is important, it is not the primary duty of the NCS.

T2C03

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

1. Send the words by voice and Morse code
2. Speak very loudly into the microphone
3. **Spell the words using a standard phonetic alphabet**
4. All these choices are correct

Explanation: Using a standard phonetic alphabet ensures that unusual words are spelled out clearly, reducing the chance of misunderstanding. Speaking loudly or using Morse code does not guarantee clarity.

T2C04

What is RACES?

1. An emergency organization combining amateur radio and citizens band operators and frequencies
2. An international radio experimentation society
3. A radio contest held in a short period, sometimes called a "sprint"
4. **An FCC part 97 amateur radio service for civil defense communications during national emergencies**

Explanation: RACES is an FCC part 97 amateur radio service specifically designed for civil defense communications during national emergencies. It is not a contest or an international society.

T2C05

What does the term "traffic" refer to in net operation?

1. **Messages exchanged by net stations**
2. The number of stations checking in and out of a net
3. Operation by mobile or portable stations
4. Requests to activate the net by a served agency

Explanation: In net operation, "traffic" refers to the messages exchanged by net stations. It does not refer to the number of stations or the type of operation.

T2C06

What is the Amateur Radio Emergency Service (ARES)?

1. **A group of licensed amateurs who have voluntarily registered their qualifications and equipment for communications duty in the public service**
2. A group of licensed amateurs who are members of the military and who voluntarily agreed to provide message handling services in the case of an emergency
3. A training program that provides licensing courses for those interested in obtaining an amateur license to use during emergencies
4. A training program that certifies amateur operators for membership in the Radio Amateur Civil Emergency Service

Explanation: ARES is a group of licensed amateurs who have voluntarily registered their qualifications and equipment for communications duty in the public service. It is not a training program or limited to military members.

T2C07

Which of the following is standard practice when you participate in a net?

1. When first responding to the net control station, transmit your call sign, name, and address as in the FCC database
2. Record the time of each of your transmissions
3. **Unless you are reporting an emergency, transmit only when directed by the net control station**
4. All these choices are correct

Explanation: Standard practice in a net is to transmit only when directed by the net control station, unless you are reporting an emergency. This helps maintain order and prevents unnecessary interruptions.

T2C08

Which of the following is a characteristic of good traffic handling?

1. **Passing messages exactly as received**
2. Making decisions as to whether messages are worthy of relay or delivery
3. Ensuring that any newsworthy messages are relayed to the news media
4. All these choices are correct

Explanation: Good traffic handling involves passing messages exactly as received, without alteration. This ensures that the original intent and content of the message are preserved.

2.5 Message Handling and Radiograms

Frequency Privileges in Emergencies

Amateur station control operators are generally required to operate within the frequency privileges of their license class. However, there are specific circumstances where they are permitted to operate outside these privileges. These exceptions are strictly limited to situations involving the immediate safety of human life or the protection of property. This flexibility ensures that amateur radio operators can provide critical communication support during emergencies when other communication systems may be unavailable or overloaded.

Radiogram Preambles

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, the date and time of origination, and the call signs of the originating and handling stations. The preamble ensures that the message can be properly routed and accounted for throughout its transmission.

Table 2.5: Radiogram Preamble Components

Component	**Description**
Message Number	Unique identifier for the message
Date and Time	Origination date and time
Originating Station	Call sign of the station that created the message
Handling Station	Call sign of the station handling the message

Figure 2.5: Radiogram Preamble Structure

Message Tracking

In a radiogram header, the term "check" refers to the number of words or word equivalents in the text portion of the message. This count is crucial for ensuring the accuracy and completeness of the message during transmission and reception. It helps operators verify that the entire message has been received without omissions or errors.

Squelch Function

The squelch function in a receiver is designed to mute the audio output when no signal is present. This prevents the listener from hearing background noise or static, which can be distracting or annoying. When a signal is detected, the squelch opens, allowing the audio to be heard. This function is particularly useful in maintaining clear and effective communication.

T2C09

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

1. No
2. Yes, but only when part of a FEMA emergency plan
3. Yes, but only when part of a RACES emergency plan
4. **Yes, but only in situations involving the immediate safety of human life or protection of property**

Explanation: The correct answer is D. Amateur operators are allowed to operate outside their licensed frequency privileges only in situations where there is an immediate threat to human life or property. This exception is crucial for emergency communications. Options A, B, and C are incorrect because they either completely restrict such operations or limit them to specific emergency plans, which is not the case.

T2C10

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

1. The email address of the originating station
2. The address of the intended recipient
3. The telephone number of the addressee
4. **Information needed to track the message**

Explanation: The correct answer is D. The preamble contains information necessary for tracking the message, such as the message number, date and time of origination, and call signs of the originating and handling stations. Options A, B, and C are incorrect because they refer to details that are not typically included in the preamble.

T2C11

What is meant by “check” in a radiogram header?

1. **The number of words or word equivalents in the text portion of the message**
2. The call sign of the originating station
3. A list of stations that have relayed the message
4. A box on the message form that indicates that the message was received and/or relayed

Explanation: The correct answer is A. The ”check” refers to the count of words or word equivalents in the message text, which is essential for verifying the message’s completeness. Options B, C, and D are incorrect because they describe other elements of the radiogram that are not related to the ”check.”

T2B13

What is the purpose of a squelch function?

1. Reduce a CW transmitter's key clicks
2. **Mute the receiver audio when a signal is not present**
3. Eliminate parasitic oscillations in an RF amplifier
4. Reduce interference from impulse noise

Explanation: The correct answer is B. The squelch function mutes the receiver's audio output when no signal is present, preventing the listener from hearing background noise. Options A, C, and D are incorrect because they describe functions related to transmitters and amplifiers, not the receiver's squelch function.

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, diffractions, and scattering. This phenomenon can cause significant variations in VHF signal strength when the antenna is moved even a few feet. The signals arriving via different paths may interfere constructively or destructively, leading to signal reinforcement or cancellation, respectively. This is why VHF signals can vary greatly in strength over short distances.

Figure 3.1: Multipath propagation causing signal cancellation and reinforcement

Signal Absorption by Vegetation

Vegetation can significantly affect UHF and microwave signals by absorbing them. The water content in leaves and other plant materials absorbs the energy of these high-frequency signals, reducing their strength. This absorption effect is more pronounced at higher frequencies, such as UHF and microwave bands, compared to lower frequencies.

Figure 3.2: Effect of vegetation on UHF and microwave signals

Antenna Polarization

Antenna polarization is crucial in long-distance VHF and UHF communications. Horizontal polarization is typically used for long-distance CW (Continuous Wave) and SSB (Single Sideband) contacts because it minimizes ground wave interference and is less affected by reflections from the ground. Mismatched polarization between antennas at opposite ends of a radio link can lead to a significant reduction in received signal strength.

Overcoming Obstructions with Directional Antennas

When buildings or obstructions block the direct line-of-sight path in VHF or UHF communications, directional antennas can be used to find alternative paths. By reflecting signals off nearby structures or terrain, the signal can reach the repeater indirectly, overcoming the obstruction.

Picket Fencing

Picket fencing refers to the rapid flutter observed in mobile signals due to multipath propagation. As a mobile unit moves, the signal strength fluctuates rapidly due to the changing interference patterns caused by reflections from nearby objects. This effect is particularly noticeable in urban environments with many reflective surfaces.

Weather Effects on Signal Propagation

Weather conditions, particularly precipitation, can significantly affect microwave signal propagation. Rain, snow, and fog can absorb and scatter microwave signals, reducing their range and strength. The following table summarizes the effects of different weather conditions on signal propagation.

Weather Condition	**Effect on Signal Propagation**
Precipitation	Absorption and scattering, reducing signal range
High Winds	Minimal direct effect on signal propagation
Low Barometric Pressure	Minimal direct effect on signal propagation
Colder Temperatures	Minimal direct effect on signal propagation

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. This multipath effect can lead to rapid and unpredictable variations in signal strength, known as fading. Other factors, such as frequency shift due to Faraday rotation or interference from thunderstorms, can also contribute to irregular fading.

T3A01

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

1. The signal path encounters different concentrations of water vapor
2. VHF ionospheric propagation is very sensitive to path length
3. **Multipath propagation cancels or reinforces signals**
4. All these choices are correct

Explanation: Multipath propagation causes signals to arrive at the receiver via multiple paths, leading to constructive or destructive interference. This interference results in significant variations in signal strength over short distances. Options A and B are incorrect because water vapor concentration and ionospheric propagation are not primary factors in VHF signal variability over short distances.

T3A02

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

1. Knife-edge diffraction
2. **Absorption**
3. Amplification
4. Polarization rotation

Explanation: Vegetation absorbs UHF and microwave signals due to the water content in leaves and other plant materials. This absorption reduces signal strength. Knife-edge diffraction (A) and polarization rotation (D) are not primary effects of vegetation, and amplification (C) is incorrect as vegetation does not amplify signals.

T3A03

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

1. Right-hand circular
2. Left-hand circular
3. **Horizontal**
4. Vertical

Explanation: Horizontal polarization is typically used for long-distance VHF and UHF communications because it minimizes ground wave interference and is less affected by reflections from the ground. Circular polarization (A and B) and vertical polarization (D) are less common for long-distance communications.

T3A04

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

1. The modulation sidebands might become inverted
2. **Received signal strength is reduced**
3. Signals have an echo effect
4. Nothing significant will happen

Explanation: Mismatched polarization between antennas leads to a reduction in received signal strength because the antennas are not optimally aligned to receive the transmitted signal. Options A, C, and D are incorrect because mismatched polarization does not cause sideband inversion, echo effects, or have no significant impact.

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?

1. Change from vertical to horizontal polarization
2. **Try to find a path that reflects signals to the repeater**
3. Try the long path
4. Increase the antenna SWR

Explanation: Reflecting signals off nearby structures or terrain can provide an alternative path to the repeater, overcoming obstructions. Changing polarization (A) or increasing SWR (D) will not help, and the long path (C) is not a practical solution in this context.

T3A06

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

1. Alternating transmissions during a net operation
2. **Rapid flutter on mobile signals due to multipath propagation**
3. A type of ground system used with vertical antennas
4. Local vs long-distance communications

Explanation: Picket fencing refers to the rapid flutter observed in mobile signals due to multipath propagation. This effect is caused by the changing interference patterns as the mobile unit moves. Options A, C, and D are incorrect as they do not describe the phenomenon of picket fencing.

T3A07

What weather condition might decrease range at microwave frequencies?

1. High winds
2. Low barometric pressure
3. **Precipitation**
4. Colder temperatures

Explanation: Precipitation, such as rain, snow, and fog, absorbs and scatters microwave signals, reducing their range. High winds (A), low barometric pressure (B), and colder temperatures (D) have minimal direct effects on microwave signal propagation.

T3A08

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

1. Frequency shift due to Faraday rotation
2. Interference from thunderstorms
3. Intermodulation distortion
4. **Random combining of signals arriving via different paths**

Explanation: Irregular fading is often caused by the random combining of signals arriving via different paths due to multipath propagation. Faraday rotation (A), thunderstorms (B), and intermodulation distortion (C) are not primary causes of irregular fading in ionospheric signals.

3.2 Electromagnetic Essentials

Electric and Magnetic Fields

Electromagnetic waves consist of oscillating electric and magnetic fields. These fields are perpendicular to each other and to the direction of wave propagation. The electric field and magnetic field are at right angles, forming a transverse wave. This relationship is illustrated in Figure 3.3.

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

Wave Polarization

Wave polarization is defined by the orientation of the electric field. The polarization can be linear, circular, or elliptical, depending on how the electric field vector changes over time.

Components of a Radio Wave

A radio wave is composed of two primary components: the electric field and the magnetic field. These fields propagate together through space, carrying energy and information.

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

Wavelength and frequency are inversely related. As the frequency of a wave increases, its wavelength decreases, and vice versa. This relationship is shown in Figure 3.4.

Figure 3.4: Wavelength vs. frequency relationship.

Frequency to Wavelength Conversion

The wavelength (λ) in meters can be calculated from the frequency (f) in megahertz using the formula:

$$\lambda = \frac{300}{f}$$

This formula is useful for converting between frequency and wavelength in radio communications.

Amateur Radio Band Identification

Amateur radio bands are often identified by their approximate wavelength in meters. For example, the 2-meter band corresponds to a wavelength of approximately 2 meters, which is in the VHF range.

Frequency Ranges

Table 3.2 summarizes the frequency ranges for VHF, UHF, and HF bands.

Table 3.2: Frequency ranges for amateur radio bands.

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

Multiple Choice Questions

T3B01

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

1. They travel at different speeds
2. They are in parallel
3. They revolve in opposite directions
4. **They are at right angles**

Explanation: The electric and magnetic fields in an electromagnetic wave are 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?

1. **The orientation of the electric field**
2. The orientation of the magnetic field
3. The ratio of the energy in the magnetic field to the energy in the electric field
4. The ratio of the velocity to the wavelength

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

T3B03

What are the two components of a radio wave?

1. Impedance and reactance
2. Voltage and current
3. **Electric and magnetic fields**
4. Ionizing and non-ionizing radiation

Explanation: A radio wave consists of electric and magnetic fields that propagate through space. These fields are the fundamental components of electromagnetic waves.

T3B04

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

1. **Speed of light**
2. Speed of sound
3. Speed inversely proportional to its wavelength
4. Speed that increases as the frequency increases

Explanation: 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 frequency or wavelength.

T3B05

What is the relationship between wavelength and frequency?

1. Wavelength gets longer as frequency increases
2. **Wavelength gets shorter as frequency increases**
3. Wavelength and frequency are unrelated
4. Wavelength and frequency increase as path length increases

Explanation: Wavelength and frequency are inversely related. As frequency increases, wavelength decreases, and vice versa. This relationship is described by the equation $v = f\lambda$, where v is the velocity of the wave.

T3B06

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

1. Wavelength in meters equals frequency in hertz multiplied by 300
2. Wavelength in meters equals frequency in hertz divided by 300
3. Wavelength in meters equals frequency in megahertz divided by 300
4. **Wavelength in meters equals 300 divided by frequency in megahertz**

Explanation: The formula $\lambda = \frac{300}{f}$ is used to convert frequency in megahertz to wavelength in meters. This formula is derived from the relationship $v = f\lambda$, where v is the speed of light.

T3B07

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

1. **The approximate wavelength in meters**
2. Traditional letter/number designators
3. Channel numbers
4. All these choices are correct

Explanation: Amateur radio bands are often identified by their approximate wavelength in meters, such as the 2-meter band or the 70-centimeter band.

T3B08

What frequency range is referred to as VHF?

1. 30 kHz to 300 kHz
2. **30 MHz to 300 MHz**
3. 300 kHz to 3000 kHz
4. 300 MHz to 3000 MHz

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

3.3 Propagation Basics

This section covers the fundamental concepts of radio signal propagation, including UHF, HF, and VHF communication, as well as various propagation mechanisms such as auroral backscatter, sporadic E propagation, knife-edge diffraction, tropospheric ducting, and meteor scatter. Each concept is explained in detail, supported by figures and tables.

UHF Signal Propagation

UHF signals are rarely heard beyond the radio horizon due to their limited propagation characteristics. Unlike HF signals, which can be reflected by the ionosphere, UHF signals typically travel in straight lines and are not significantly refracted or reflected by the ionosphere. This limits their range to the line of sight, making them unsuitable for long-distance communication beyond the horizon.

Figure 3.5: UHF signal propagation and horizon limitations.

HF vs. VHF Communication

HF communication is characterized by its ability to utilize ionospheric propagation, allowing signals to travel long distances by reflecting off the ionosphere. In contrast, VHF and higher frequencies primarily rely on line-of-sight propagation, making them less effective for long-distance communication without the aid of repeaters or other propagation mechanisms.

Auroral Backscatter

VHF signals received via auroral backscatter are often distorted, with signal strength varying considerably. This phenomenon occurs when VHF signals are scattered by the auroral ionization in the Earth's atmosphere, resulting in irregular and fluctuating signal reception.

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 occurs due to the formation of dense ionization patches in the E layer of the ionosphere, which can reflect VHF signals over long distances.

Knife-Edge Diffraction

Knife-edge diffraction allows radio signals to travel beyond obstructions by bending around sharp edges, such as mountain ridges or buildings. This effect enables signals to reach receivers that would otherwise be blocked by terrain or structures.

Tropospheric Ducting

Tropospheric ducting is a propagation mechanism that allows VHF and UHF signals to travel beyond the horizon by being trapped in atmospheric ducts formed by temperature inversions. This phenomenon can enable communication over distances of approximately 300 miles on a regular basis.

Figure 3.6: Tropospheric ducting mechanism.

Meteor Scatter

The 6-meter band is particularly well-suited for meteor scatter communication. This propagation mode relies on the ionization trails left by meteors as they enter the Earth's atmosphere, which can reflect VHF signals over long distances.

Temperature Inversions

Temperature inversions in the atmosphere are the primary cause of tropospheric ducting. These inversions create layers of warm air above cooler air, forming ducts that can trap and guide radio signals over long distances.

Table 3.3: Propagation mechanisms and their effects.

Propagation Mechanism	**Characteristics**
Ionospheric Propagation	Long-distance communication via ionosphere reflection
Tropospheric Ducting	VHF/UHF signals trapped in atmospheric ducts
Knife-Edge Diffraction	Signals bend around obstacles
Sporadic E Propagation	Dense ionization patches in the E layer
Auroral Backscatter	Scattering by auroral ionization
Meteor Scatter	Reflection off meteor ionization trails

Multiple Choice Questions

T3C01

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

1. They are too weak to go very far
2. FCC regulations prohibit them from going more than 50 miles
3. **UHF signals are usually not propagated by the ionosphere**
4. UHF signals are absorbed by the ionospheric D region

Explanation: UHF signals are rarely heard beyond the radio horizon because they are not typically propagated by the ionosphere. Instead, they travel in straight lines and are limited to line-of-sight communication. Option A is incorrect because signal strength is not the primary limiting factor. Option B is incorrect as FCC regulations do not impose such a restriction. Option D is incorrect because UHF signals are not absorbed by the D region of the ionosphere.

T3C02

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

1. HF antennas are generally smaller
2. HF accommodates wider bandwidth signals
3. **Long-distance ionospheric propagation is far more common on HF**
4. There is less atmospheric interference (static) on HF

Explanation: HF communication is characterized by its ability to utilize ionospheric propagation, enabling long-distance communication. 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?

1. They are often received from 10,000 miles or more
2. **They are distorted and signal strength varies considerably**
3. They occur only during winter nighttime hours
4. They are generally strongest when your antenna is aimed west

Explanation: VHF signals received via auroral backscatter are often distorted, with signal strength varying considerably due to the irregular nature of auroral ionization. Option A is incorrect because auroral backscatter does not typically result in signals traveling 10,000 miles. Option C is incorrect as it can occur at any time, not just during winter nights. Option D is incorrect because antenna direction is not a determining factor.

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?

1. Backscatter
2. **Sporadic E**
3. D region absorption
4. Gray-line propagation

Explanation: Sporadic E propagation is responsible for occasional strong signals on the 10, 6, and 2-meter bands from beyond the radio horizon. Option A is incorrect because backscatter is not typically associated with these bands. Option C is incorrect as D region absorption attenuates signals rather than enhancing them. Option D is incorrect because gray-line propagation is not the primary mechanism for these signals.

T3C05

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

1. **Knife-edge diffraction**
2. Faraday rotation
3. Quantum tunneling
4. Doppler shift

Explanation: Knife-edge diffraction allows radio signals to bend around sharp edges, enabling them to travel beyond obstructions. Option B is incorrect because Faraday rotation affects polarization, not signal path. Option C is incorrect as quantum tunneling is not applicable to radio propagation. Option D is incorrect because Doppler shift affects frequency, not signal path.

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?

1. **Tropospheric ducting**
2. D region refraction
3. F2 region refraction
4. Faraday rotation

Explanation: Tropospheric ducting is responsible for over-the-horizon VHF and UHF communications by trapping signals in atmospheric ducts. Option B is incorrect because D region refraction does not support VHF/UHF propagation. Option C is incorrect as F2 region refraction is associated with HF propagation. Option D is incorrect because Faraday rotation does not enable long-distance communication.

T3C07

What band is best suited for communicating via meteor scatter?

1. 33 centimeters
2. **6 meters**
3. 2 meters
4. 70 centimeters

Explanation: The 6-meter band is best suited for meteor scatter communication due to its optimal wavelength for reflecting off meteor ionization trails. Option A is incorrect because 33 centimeters is not ideal for meteor scatter. Option C is incorrect as 2 meters is less effective. Option D is incorrect because 70 centimeters is not the best choice for this mode.

T3C08

What causes tropospheric ducting?

1. Discharges of lightning during electrical storms
2. Sunspots and solar flares
3. Updrafts from hurricanes and tornadoes
4. **Temperature inversions in the atmosphere**

Explanation: Tropospheric ducting is caused by temperature inversions in the atmosphere, which create layers of warm air above cooler air. Option A is incorrect because lightning discharges do not cause ducting. Option B is incorrect as sunspots and solar flares affect ionospheric propagation, not tropospheric. Option C is incorrect because updrafts from storms do not create ducting conditions.

Chapter 4 AMATEUR RADIO PRACTICES

4.1 Power Supplies and Critical Connections

Power Supply Ratings

Selecting the correct power supply rating for a mobile FM transceiver is crucial to ensure optimal performance and longevity of the equipment. The power supply must provide sufficient voltage and current to meet the transceiver's requirements without causing overheating or voltage drops. For example, a typical 50-watt output mobile FM transceiver requires a power supply rated at **13.8 volts at 12 amperes**. This ensures the transceiver operates efficiently while minimizing the risk of damage.

Voltage Drop Minimization

Short, heavy-gauge wires are used for DC power connections in transceivers to minimize voltage drop, especially during transmission. Voltage drop can lead to reduced performance and potential damage to the equipment. Heavy-gauge wires have lower resistance, which helps maintain a stable voltage supply even under high current loads.

RF Power Meter Installation

The optimal placement of an RF power meter is in the feed line, between the transmitter and the antenna. This allows for accurate measurement of the power being delivered to the antenna, ensuring the system operates within safe and efficient parameters. Refer to Figure 4.1 for a diagram showing the correct installation.

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 surface area, which minimizes RF interference and ensures effective grounding. Other materials, such as steel wire or twisted-pair cable, are less effective because they have higher resistance and are more prone to interference.

Battery Power Calculations

To determine the length of time equipment can be powered from a battery, divide the battery's ampere-hour (Ah) rating by the average current draw of the equipment. For example, if a battery has a rating of 50 Ah and the equipment draws an average of 5 amperes, the operational time is calculated as follows:

$$\text{Operational Time} = \frac{\text{Battery Ah Rating}}{\text{Average Current Draw}} = \frac{50\,\text{Ah}}{5\,\text{A}} = 10\,\text{hours}$$

Vehicle Grounding

The negative power return of a mobile transceiver should be connected to the 12-volt battery chassis ground in a vehicle. This ensures a stable and low-impedance ground connection, which is essential for minimizing electrical noise and ensuring proper operation of the transceiver. Refer to Figure 4.2 for an illustration of the grounding setup.

Figure 4.2: Vehicle Grounding Setup

Power Supply Ratings Comparison

Table 4.1 provides a comparison of different power supply ratings and their suitability for various transceivers.

Table 4.1: Power Supply Ratings Comparison

Voltage (V)	**Current (A)**	**Suitability**
13.8	12	Suitable for 50W transceivers
24.0	4	Insufficient for 50W transceivers
13.8	4	Insufficient for 50W transceivers
24.0	12	Overkill for 50W transceivers

Multiple Choice Questions

T4A01

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

1. 24.0 volts at 4 amperes
2. 13.8 volts at 4 amperes
3. 24.0 volts at 12 amperes
4. **13.8 volts at 12 amperes**

Explanation: A 50-watt transceiver typically requires a power supply rated at 13.8 volts and 12 amperes to ensure sufficient power delivery. Options A and B provide insufficient current, while option C provides excessive voltage.

T4A03

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

1. **To minimize voltage drop when transmitting**
2. To provide a good counterpoise for the antenna
3. To avoid RF interference
4. All these choices are correct

Explanation: Heavy-gauge wires minimize voltage drop by reducing resistance, ensuring stable power delivery during transmission. Options B and C are incorrect because heavy-gauge wires are not primarily used for counterpoise or RF interference avoidance.

T4A05

Where should an RF power meter be installed?

1. **In the feed line, between the transmitter and antenna**
2. At the power supply output
3. In parallel with the push-to-talk line and the antenna
4. In the power supply cable, as close as possible to the radio

Explanation: An RF power meter should be installed in the feed line to measure the power delivered to the antenna accurately. Other locations do not provide meaningful measurements.

T4A08

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

1. Copper braid removed from coaxial cable
2. Steel wire
3. Twisted-pair cable
4. **Flat copper strap**

Explanation: Flat copper strap is preferred for RF bonding due to its low impedance and high surface area, which minimizes RF interference. Other options are less effective.

T4A09

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

1. Divide the watt-hour rating of the battery by the peak power consumption of the equipment
2. **Divide the battery ampere-hour rating by the average current draw of the equipment**
3. Multiply the watts per hour consumed by the equipment by the battery power rating
4. Multiply the square of the current rating of the battery by the input resistance of the equipment

Explanation: The operational time is calculated by dividing the battery's ampere-hour rating by the average current draw of the equipment. This provides a realistic estimate of how long the battery will last under normal operating conditions.

T4A11

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

1. **At the 12 volt battery chassis ground**
2. At the antenna mount
3. To any metal part of the vehicle
4. Through the transceiver's mounting bracket

Explanation: The negative power return should be connected to the 12-volt battery chassis ground to ensure a stable and low-impedance ground connection. Other options may result in poor grounding and increased electrical noise.

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 the audio input and output of a computer running WSJT-X software. This setup allows the computer to decode and encode the digital signals transmitted and received by the transceiver. The WSJT-X software handles the modulation and demodulation of the FT8 signals, making it a crucial component of the setup.

Computer-Radio Interfaces

In digital mode operation, the computer-radio interface typically uses three main signals: receive audio, transmit audio, and transmitter keying. These signals facilitate the communication between the computer and the transceiver, enabling the transmission and reception of digital data. The receive audio signal carries the incoming audio from the transceiver to the computer, while the transmit audio signal carries the outgoing audio from the computer to the transceiver. The transmitter keying signal is used to control the transceiver's transmit/receive switching.

Table 4.2: Computer-Radio Interface Signals

Signal	**Description**
Receive Audio	Carries incoming audio from transceiver to computer
Transmit Audio	Carries outgoing audio from computer to transceiver
Transmitter Keying	Controls transceiver's transmit/receive switching

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 radio and the internet, enabling operators to connect to digital networks such as DMR, D-STAR, or Fusion. The hot spot typically connects to the transceiver and a computer, facilitating the transmission and reception of digital signals over the internet.

Figure 4.3: 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 way to send Morse code compared to manual keying. The keyer typically has a paddle that the operator uses to input the Morse code, and it generates the corresponding dots and dashes electronically. This ensures that the timing and spacing of the Morse code are consistent, which is crucial for effective communication.

Figure 4.4: Computer-Radio Interface

Multiple Choice Questions

T4A04

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

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

Explanation: The correct answer is B. In an FT8 setup, the transceiver's audio input and output are connected to the audio input and output of a computer running WSJT-X software. This allows the computer to decode and encode the digital signals transmitted and received by the transceiver. The other options are incorrect because they describe setups that are not used for FT8 operation.

T4A06

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

1. Receive and transmit mode, status, and location
2. Antenna and RF power
3. **Receive audio, transmit audio, and transmitter keying**
4. NMEA GPS location and DC power

Explanation: The correct answer is C. The computer-radio interface for digital mode operation typically uses receive audio, transmit audio, and transmitter keying signals. These signals facilitate the communication between the computer and the transceiver, enabling the transmission and reception of digital data. The other options are incorrect because they describe signals that are not typically used in a computer-radio interface for digital modes.

T4A07

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

1. Computer "line out" to transceiver push-to-talk
2. Computer "line in" to transceiver push-to-talk
3. **Computer "line in" to transceiver speaker connector**
4. Computer "line out" to transceiver speaker connector

Explanation: The correct answer is C. When operating digital modes, the computer's "line in" is connected to the transceiver's speaker connector. This allows the computer to receive the audio signals from the transceiver for decoding. The other options are incorrect because they describe connections that are not typically used for digital mode operation.

T4A10

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

1. **Communication using digital voice or data systems via the internet**
2. FT8 digital communications via AFSK
3. RTTY encoding and decoding without a computer
4. High-speed digital communications for meteor scatter

Explanation: The correct answer is A. A digital mode hot spot allows communication using digital voice or data systems via the internet. It acts as a bridge between the radio and the internet, enabling operators to connect to digital networks such as DMR, D-STAR, or Fusion. The other options are incorrect because they describe functions that are not performed by a digital mode hot spot.

T4A12

What is an electronic keyer?

1. A device for switching antennas from transmit to receive
2. A device for voice activated switching from receive to transmit
3. **A device that assists in manual sending of Morse code**
4. An interlock to prevent unauthorized use of a radio

Explanation: The correct answer is C. An electronic keyer is a device that assists in the manual sending of Morse code. It provides a more consistent and accurate way to send Morse code compared to manual keying. The other options are incorrect because they describe functions that are not performed by an electronic keyer.

4.3 Audio and Signal Processing

This section covers key concepts related to audio and signal processing in radio communications, including microphone gain effects, squelch adjustment, RIT and Clarifier controls, receiver bandwidth selection, signal-to-noise ratio, and FM signal distortion.

Microphone Gain Effects

Excessive microphone gain in SSB transmissions can lead to distorted transmitted audio. This occurs because the audio signal becomes overdriven, causing clipping and harmonic distortion. Proper adjustment of microphone gain is essential to maintain clear and intelligible communication.

Figure 4.5: Microphone Gain Effects

Squelch Adjustment

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, as the squelch does not mute the audio output. Adjusting the squelch properly is crucial for effective communication in noisy environments.

Figure 4.6: Squelch Adjustment

RIT and Clarifier Controls

The RIT (Receiver Incremental Tuning) or Clarifier controls are used to adjust the frequency of the received signal in SSB communication. This is particularly useful when the voice pitch of a returning signal seems too high or low. By fine-tuning the frequency, the audio can be made more natural and easier to understand.

Receiver Bandwidth Selection

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 clarity of the received signal and enhances overall communication quality.

Table 4.3: Receiver Bandwidth and SNR

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

Signal-to-Noise Ratio in SSB Reception

The signal-to-noise ratio (SNR) in SSB reception is directly influenced by the receiver filter bandwidth. A wider bandwidth, such as 2400 Hz, provides a better SNR compared to narrower bandwidths like 500 Hz or 1000 Hz. This is because a wider bandwidth allows more of the signal's energy to pass through, improving the overall signal quality.

FM Signal Distortion

Tuning an FM receiver above or below a signal's frequency can result in distortion of the signal's audio. This occurs because the receiver is not properly aligned with the signal's center frequency, leading to demodulation errors and degraded audio quality.

Multiple Choice Questions

T4B01

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

1. Frequency instability
2. **Distorted transmitted audio**
3. Increased SWR
4. All these choices are correct

Explanation: Excessive microphone gain causes the audio signal to be overdriven, leading to clipping and harmonic distortion. This results in distorted transmitted audio, making the communication less clear. The other options are incorrect because excessive microphone gain does not directly cause frequency instability or increased SWR.

T4B03

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

1. **Set the squelch threshold so that receiver output audio is on all the time**
2. Turn up the audio level until it overcomes the squelch threshold
3. Turn on the anti-squelch function
4. Enable squelch enhancement

Explanation: Setting the squelch threshold so that the receiver output audio is always on ensures that weak signals are not muted. This is the correct approach to hear weak FM signals. The other options are incorrect because they either do not address the squelch threshold or involve unnecessary adjustments.

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?

1. The AGC or limiter
2. The bandwidth selection
3. The tone squelch
4. **The RIT or Clarifier**

Explanation: The RIT or Clarifier controls are used to fine-tune the frequency of the received signal, which adjusts the voice pitch to a more natural level. The other options are incorrect because they do not directly affect the frequency or pitch of the received signal.

T4B08

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

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

Explanation: Multiple receive bandwidth choices allow for noise or interference reduction by selecting a bandwidth that matches the mode being used. This improves the clarity of the received signal. The other options are incorrect because they do not directly relate to the primary advantage of bandwidth selection.

T4B10

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

1. 500 Hz
2. 1000 Hz
3. **2400 Hz**
4. 5000 Hz

Explanation: A receiver filter bandwidth of 2400 Hz provides the best signal-to-noise ratio for SSB reception because it allows more of the signal's energy to pass through, improving the overall signal quality. The other options are incorrect because they either provide a narrower bandwidth (resulting in lower SNR) or an excessively wide bandwidth (which may include more noise).

T4B12

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

1. Change in audio pitch
2. Sideband inversion
3. Generation of a heterodyne tone
4. **Distortion of the signal's audio**

Explanation: Tuning an FM receiver above or below a signal's frequency results in distortion of the signal's audio because the receiver is not properly aligned with the signal's center frequency. This leads to demodulation errors and degraded audio quality. The other options are incorrect because they do not accurately describe the primary effect of misalignment in FM reception.

4.4 Frequency Management and Memory Channels

Frequency Entry Methods

To enter a transceiver's operating frequency, the most common methods include using the keypad or the VFO (Variable Frequency Oscillator) knob. The keypad allows for direct numerical input of the desired frequency, while the VFO knob enables manual tuning by rotating the knob to adjust the frequency. These methods provide flexibility and precision in setting the operating frequency.

Figure 4.7: Frequency Entry Methods

Memory Channels

Memory channels are a convenient feature in transceivers that allow users to store and quickly access their favorite frequencies. By saving a frequency to a memory channel, the user can recall it with a single button press or menu selection, eliminating the need to manually re-enter the frequency. This is particularly useful for frequently used frequencies, such as those for local repeaters or emergency channels.

Scanning Function

The scanning function in an FM transceiver is designed to automatically tune through a predefined range of frequencies to check for activity. This is useful for monitoring multiple channels or frequencies without manually adjusting the transceiver. When the scanning function detects a signal, it stops on that frequency, allowing the user to listen to the transmission.

DMR Code Plug

A DMR (Digital Mobile Radio) code plug is a configuration file that contains access information for repeaters and talkgroups. It is used to program a DMR transceiver with the necessary settings for operation, such as frequency lists, channel configurations, and contact information. The code plug simplifies the setup process and ensures consistent operation across different devices.

Figure 4.8: DMR Code Plug

Group Selection in Digital Voice

In digital voice transceivers, selecting a specific group of stations is typically done by entering the group's identification code. This allows the user to communicate with a predefined group of stations, such as a club or team, without manually configuring each station's frequency or settings. The group identification code ensures that only the intended stations receive the transmission.

D-STAR Programming

Programming a D-STAR digital transceiver involves several steps, including entering your call sign, setting the output power, and configuring the codec type. The call sign is essential for identification and must be programmed before transmitting. The output power and codec settings ensure optimal performance and compatibility with other D-STAR devices.

Table 4.4: D-STAR Programming Steps

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

Questions and Explanations

T4B02

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

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

Explanation: The correct answer is **A**. The keypad or VFO knob are the primary methods for entering a transceiver's operating frequency. The CTCSS or DTMF encoder (B) is used for tone encoding, not frequency entry. The Automatic Frequency Control (C) is used to stabilize the frequency, not to enter it. Therefore, option D is incorrect.

T4B04

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

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

Explanation: The correct answer is **B**. Storing a favorite frequency in a memory channel allows for quick access. Enabling the frequency offset (A) or VOX (C) does not provide quick access to a specific frequency. Using the scan mode (D) is for monitoring multiple frequencies, not for quick access to a specific one.

T4B05

What does the scanning function of an FM transceiver do?

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

Explanation: The correct answer is **C**. The scanning function tunes through a range of frequencies to check for activity. It does not check signal deviation (A), prevent interference (B), or check for digital messages (D).

T4B07

What does a DMR "code plug" contain?

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

Explanation: The correct answer is **B**. A DMR code plug contains access information for repeaters and talkgroups. It does not contain a call sign in CW (A), a codec (C), or software version information (D).

T4B09

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

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

Explanation: The correct answer is **C**. A specific group of stations is selected by entering the group's identification code. Retrieving frequencies from memory (A) or enabling CTCSS tones (B) does not select a group. Automatic identification (D) is unrelated to group selection.

T4B11

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

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

Explanation: The correct answer is **A**. Your call sign must be programmed into a D-STAR transceiver before transmitting. While output power (B) and codec type (C) are important, they are not mandatory for transmission. Therefore, option D is incorrect.

Chapter 5 ELECTRICAL PRINCIPLES

5.1 Electrical Units and Concepts

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:

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

Here, voltage is the electrical potential difference that drives the current, and resistance is the opposition to the flow of current. The unit of resistance is the **Ohm** (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 efficient 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 frequency is the **Hertz** (Hz), named after Heinrich Hertz. One hertz is equivalent to one cycle per second. For example, a signal with a frequency of 50 Hz completes 50 cycles every second.

Difference Between Conductors and Insulators

Conductors are materials that allow the free flow of electric charge, typically due to the presence of free electrons. Examples include metals like copper and aluminum. Insulators, on the other hand, are materials that resist the flow of electric charge. They have few free electrons and are used to prevent unwanted current flow. Examples of insulators include glass and rubber.

Figure 5.1: Electron flow in a conductor. The diagram illustrates the movement of free electrons in response to an applied electric field.

Table 5.1: Units of Electrical Measurement

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

T5A01

Electrical current is measured in which of the following units?

1. Volts
2. Watts
3. Ohms
4. **Amperes**

Explanation: 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?

1. Volts
2. **Watts**
3. Watt-hours
4. Amperes

Explanation: 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?

1. Voltage
2. Resistance
3. Capacitance
4. **Current**

Explanation: The flow of electrons in an electric circuit is called current. Voltage is the potential difference, resistance opposes current, and capacitance stores energy in an electric field.

T5A04

What are the units of electrical resistance?

1. Siemens
2. Mhos
3. **Ohms**
4. Coulombs

Explanation: 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?

1. **Voltage**
2. Ampere-hours
3. Capacitance
4. Inductance

Explanation: Voltage is the electrical term for the force that causes electron flow. Ampere-hours measure charge, capacitance stores energy, and inductance opposes changes in current.

T5A06

What is the unit of frequency?

1. **Hertz**
2. Henry
3. Farad
4. Tesla

Explanation: The unit of frequency is 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?

1. They have relatively high density
2. **They have many free electrons**
3. They have many free protons
4. All these choices are correct

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

T5A08

Which of the following is a good electrical insulator?

1. Copper
2. **Glass**
3. Aluminum
4. Mercury

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

5.2 Alternating Current and Power

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, constant direction, AC alternates between positive and negative directions. This periodic reversal is typically sinusoidal, as shown in Figure 5.2. The frequency of this oscillation is measured in hertz (Hz) and determines how many times the current changes direction per second.

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

Electrical Power

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

$$P = V \cdot I \tag{5.3}$$

where P is power in watts (W), V is voltage in volts (V), and I is current in amperes (A). In AC circuits, power can also be influenced by the phase difference between voltage and current, which is described by the power factor.

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:

$$V = I \cdot R \tag{5.4}$$

where R is resistance in ohms (Ω). However, in AC circuits, the opposition to current flow is not only due to resistance but also due to reactance, which arises from inductors and capacitors in the circuit.

Frequency of Alternating Current

The frequency of alternating current is the number of complete cycles the current makes per second. It is measured in hertz (Hz). For example, a frequency of 60 Hz means the current completes 60 cycles per second. Frequency is a critical parameter in AC systems because it determines the behavior of the circuit and the compatibility of electrical devices.

Questions

T5A09

Which of the following describes alternating current?

1. Current that alternates between a positive direction and zero
2. Current that alternates between a negative direction and zero
3. **Current that alternates between positive and negative directions**
4. All these answers are correct

Explanation: Alternating current (AC) periodically reverses direction, alternating between positive and negative directions. This is the defining characteristic of AC. Options A and B are incorrect because they describe partial alternation, not complete reversal. Option D is incorrect because not all the options are correct.

T5A10

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

1. Resistance
2. Current
3. **Power**
4. Voltage

Explanation: Power is the rate at which electrical energy is used or transferred. Resistance opposes current flow, current is the flow of charge, and voltage is the potential difference.

T5A11

What type of current flow is opposed by resistance?

1. Direct current
2. Alternating current
3. RF current
4. **All these choices are correct**

Explanation: Resistance opposes all types of current flow, including direct current (DC), alternating current (AC), and radio frequency (RF) current.

T5A12

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

1. Pulse rate
2. Speed
3. Wavelength
4. **Frequency**

Explanation: Frequency is the term that describes the number of complete cycles per second in an alternating current. Pulse rate, speed, and wavelength are not applicable in this context.

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, and hertz to kilohertz. Understanding these conversions is crucial for accurate measurements and calculations. For example, to convert amperes to milliamperes, you multiply by 1000:

$$1\,\mathrm{A} = 1000\,\mathrm{mA} \tag{5.5}$$

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

$$1\,\mathrm{Hz} = 0.001\,\mathrm{kHz} \tag{5.6}$$

Significance of Frequency

Frequency, measured in hertz (Hz), is a critical parameter in electrical measurements, especially in alternating current (AC) circuits and radio communications. Higher frequencies, such as kilohertz (kHz) and megahertz (MHz), are commonly used in radio technology. For example, 1.5 MHz is equivalent to 1500 kHz:

$$1.5\,\text{MHz} = 1500\,\text{kHz} \tag{5.7}$$

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 as follows:

$$1\,\text{V} = 1000\,\text{mV} = 1,000,000\,\mu\text{V} \tag{5.8}$$

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

$$1\,\mu\text{V} = 10^{-6}\,\text{V} \tag{5.9}$$

Capacitance and Its Units

Capacitance, measured in farads (F), describes the ability of a component to store electrical energy. Smaller units like microfarads (µF) and picofarads (pF) are commonly used. The conversion between these units is:

$$1\,\text{F} = 1,000,000\,\mu\text{F} = 1,000,000,000,000\,\text{pF} \tag{5.10}$$

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

$$1\,\mu\text{F} = 1,000,000\,\text{pF} \tag{5.11}$$

Common Electrical Unit Conversions

Table 5.2 summarizes common electrical unit conversions for quick reference.

Table 5.2: Common Electrical Unit Conversions

Unit	**Conversion**	**Example**
Amperes (A)	1 A = 1000 mA	1.5 A = 1500 mA
Hertz (Hz)	1 Hz = 0.001 kHz	1.5 MHz = 1500 kHz
Volts (V)	1 V = 1000 mV	1 V = 1,000,000 µV
Farads (F)	1 F = 1,000,000 µF	1 µF = 1,000,000 pF

Visualizing Unit Conversions

Figure 5.3 provides a diagrammatic representation of unit conversions for electrical measurements.

Figure 5.3: Unit conversions for electrical measurements

Practice Questions

T5B01

How many milliamperes is 1.5 amperes?

1. 15 milliamperes
2. 150 milliamperes
3. **1500 milliamperes**
4. 15,000 milliamperes

Explanation: To convert amperes to milliamperes, multiply by 1000. Therefore, 1.5 A = 1500 mA. The correct answer is **C**.

T5B02

Which is equal to 1,500,000 hertz?

1. **1500 kHz**
2. 1500 MHz
3. 15 GHz
4. 150 kHz

Explanation: To convert hertz to kilohertz, divide by 1000. Therefore, 1,500,000 Hz = 1500 kHz. The correct answer is **A**.

T5B03

Which is equal to one kilovolt?

1. One one-thousandth of a volt
2. One hundred volts
3. **One thousand volts**
4. One million volts

Explanation: One kilovolt (kV) is equal to 1000 volts (V). The correct answer is **C**.

T5B04

Which is equal to one microvolt?

1. **One one-millionth of a volt**
2. One million volts
3. One thousand kilovolts
4. One one-thousandth of a volt

Explanation: One microvolt (µV) is equal to one-millionth of a volt (10^{-6} V). The correct answer is **A**.

T5B05

Which is equal to 500 milliwatts?

1. 0.02 watts
2. **0.5 watts**
3. 5 watts
4. 50 watts

Explanation: To convert milliwatts to watts, divide by 1000. Therefore, 500 mW = 0.5 W. The correct answer is **B**.

T5B06

Which is equal to 3000 milliamperes?

1. 0.003 amperes
2. 0.3 amperes
3. 3,000,000 amperes
4. **3 amperes**

Explanation: To convert milliamperes to amperes, divide by 1000. Therefore, 3000 mA = 3 A. The correct answer is **D**.

T5B07

Which is equal to 3.525 MHz?

1. 0.003525 kHz
2. 35.25 kHz
3. **3525 kHz**
4. 3,525,000 kHz

Explanation: To convert megahertz to kilohertz, multiply by 1000. Therefore, 3.525 MHz = 3525 kHz. The correct answer is **C**.

T5B08

Which is equal to 1,000,000 picofarads?

1. 0.001 microfarads
2. **1 microfarad**
3. 1000 microfarads
4. 1,000,000,000 microfarads

Explanation: To convert picofarads to microfarads, divide by 1,000,000. Therefore, 1,000,000 pF = 1 µF. The correct answer is **B**.

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 describe power gains or losses in a system. The decibel scale is particularly useful because it allows for the representation of very large or very small power ratios in a compact form.

Understanding Decibels

The decibel is defined as:

$$\text{dB} = 10\log_{10}\left(\frac{P_2}{P_1}\right) \tag{5.12}$$

where P_1 is the reference power level and P_2 is the power level being compared. 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 5.12. For example, if the power increases from 5 watts to 10 watts, the decibel value is:

$$\text{dB} = 10\log_{10}\left(\frac{10}{5}\right) = 10\log_{10}(2) \approx 3 \text{ dB}. \tag{5.13}$$

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

$$\text{dB} = 10\log_{10}\left(\frac{3}{12}\right) = 10\log_{10}(0.25) \approx -6 \text{ dB}. \tag{5.14}$$

Logarithmic Nature of Decibels

The decibel scale is logarithmic, meaning that equal ratios correspond to equal differences in decibels. For instance, a power increase from 20 watts to 200 watts is:

$$\text{dB} = 10\log_{10}\left(\frac{200}{20}\right) = 10\log_{10}(10) = 10 \text{ dB}. \tag{5.15}$$

This logarithmic nature makes the decibel scale particularly useful for representing large ranges of power levels.

Figure 5.4: Power changes in decibels.

Questions and Explanations

T5B09

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

1. A) 2 dB
2. **B) 3 dB**
3. C) 5 dB
4. D) 10 dB

Explanation: The correct answer is B) 3 dB. Using Equation 5.12, the decibel value is calculated as $10\log_{10}(10/5) = 10\log_{10}(2) \approx 3$ dB. The other options do not match this calculation.

T5B10

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

1. A) -1 dB
2. B) -3 dB
3. **C) -6 dB**
4. D) -9 dB

Explanation: The correct answer is C) -6 dB. Using Equation 5.12, the decibel value is calculated as $10\log_{10}(3/12) = 10\log_{10}(0.25) \approx -6$ dB. The other options do not match this calculation.

T5B11

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

1. **A) 10 dB**
2. B) 12 dB
3. C) 18 dB
4. D) 28 dB

Explanation: The correct answer is A) 10 dB. Using Equation 5.12, the decibel value is calculated as $10\log_{10}(200/20) = 10\log_{10}(10) = 10$ dB. The other options do not match this calculation.

5.5 Capacitance and Inductance

Capacitance

Capacitance is the ability of a system to store energy in an electric field. It is a fundamental property of capacitors, which are devices designed to store electric charge. The unit of capacitance is the **farad** (F), named after the English physicist Michael Faraday. A capacitor with a capacitance of one farad can store one coulomb of charge when a voltage of one volt is applied across its terminals. The relationship between charge (Q), voltage (V), and capacitance (C) is given by:

$$Q = C \cdot V \tag{5.16}$$

Inductance

Inductance, on the other hand, describes the ability of a system to store energy in a magnetic field. This property is most commonly associated with inductors, which are components that resist changes in electric current. The unit of inductance is the **henry** (H), named after the American scientist Joseph Henry. An inductor with an inductance of one henry will induce a voltage of one volt when the current through it changes at a rate of one ampere per second. The relationship between voltage (V), inductance (L), and the rate of change of current ($\frac{dI}{dt}$) is given by:

$$V = L \cdot \frac{dI}{dt} \tag{5.17}$$

Impedance

Impedance is a measure of the opposition to alternating current (AC) flow in a circuit. It is a complex quantity that combines resistance (R) and reactance (X), where reactance is the opposition due to capacitance and inductance. The unit of impedance is the **ohm** (Ω), the same as resistance. Impedance is particularly important in AC circuits because it affects the phase relationship between voltage and current. The impedance (Z) of a circuit is given by:

$$Z = R + jX \tag{5.18}$$

where 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:

$$E = \frac{1}{2}CV^2 \tag{5.19}$$

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

$$E = \frac{1}{2}LI^2 \tag{5.20}$$

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

T5C01

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

1. Inductance
2. Resistance
3. Tolerance
4. **Capacitance**

Explanation: Capacitance is the ability to store energy in an electric field, as described by Equation 5.16. 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?

1. **The farad**
2. The ohm
3. The volt
4. The henry

Explanation: The unit of capacitance is the farad (F), as mentioned in the section on capacitance. The other units are for resistance (ohm), voltage (volt), and inductance (henry).

T5C03

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

1. Admittance
2. Capacitance
3. Resistance
4. **Inductance**

Explanation: Inductance describes the ability to store energy in a magnetic field, as explained in the section on inductance. The other options are incorrect because admittance is the inverse of impedance, capacitance relates to electric fields, and resistance opposes current flow.

T5C04

What is the unit of inductance?

1. The coulomb
2. The farad
3. **The henry**
4. The ohm

Explanation: The unit of inductance is the henry (H), as discussed in the section on inductance. The other units are for charge (coulomb), capacitance (farad), and resistance (ohm).

T5C05

What is the unit of impedance?

1. The volt
2. The ampere
3. The coulomb
4. **The ohm**

Explanation: The unit of impedance is the ohm (Ω), as explained in the section on impedance. The other units are for voltage (volt), current (ampere), and charge (coulomb).

T5C12

What is impedance?

1. **The opposition to AC current flow**
2. The inverse of resistance
3. The Q or Quality Factor of a component
4. The power handling capability of a component

Explanation: Impedance is the opposition to AC current flow, as described in the section on impedance. The other options are incorrect because 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.

5.6 Power Calculations

In this section, we will explore the fundamental concepts of electrical power in DC circuits, focusing on the relationship between power, voltage, and current. Understanding these relationships is crucial for designing and analyzing circuits in radio technology.

Electrical Power Formula

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

$$P = I \cdot E \tag{5.21}$$

where:

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

This formula, known as Joule's Law, states that the power delivered to a circuit is the product of the voltage across the circuit and the current flowing through it. For example, if a circuit has a voltage of 12 volts and a current of 2.5 amperes, the power delivered is:

$$P = 12\,\text{V} \times 2.5\,\text{A} = 30\,\text{W}.$$

Calculating Power from Voltage and Current

To calculate the power delivered by a given voltage and current, simply multiply the two values. For instance, a voltage of 13.8 volts and a current of 10 amperes deliver:

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

Relationship Between Power, Voltage, and Current

The relationship between power, voltage, and current is linear. If the voltage or current increases, the power delivered to the circuit also increases proportionally. Conversely, if either voltage or current decreases, the power decreases. This relationship is fundamental in designing circuits to ensure they operate within safe power limits.

Figure 5.6: Power calculation in a DC circuit. The diagram illustrates the relationship between voltage, current, and power.

Practice Questions

T5C08

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

1. **P = I E**
2. P = E / I
3. P = E – I
4. P = I + E

Explanation: The correct formula for calculating electrical power in a DC circuit is $P = I \cdot E$, as shown in Equation 5.21. The other options are incorrect because they do not represent the correct relationship between power, voltage, and current.

T5C09

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

1. **138 watts**
2. 0.7 watts
3. 23.8 watts
4. 3.8 watts

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

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

The other options are incorrect because they do not match the result of this calculation.

T5C10

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

1. 4.8 watts
2. **30 watts**
3. 14.5 watts
4. 0.208 watts

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

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

The other options are incorrect because they do not match the result of this calculation.

T5C11

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

1. 0.1 amperes
2. **10 amperes**
3. 12 amperes
4. 132 amperes

Explanation: To find the current, rearrange the power formula:

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

The other options are incorrect because they do not match the result of this calculation.

5.7 Circuit Analysis

Ohm's Law and Its Significance

Ohm's Law is a fundamental principle in electrical engineering and physics that describes the relationship between voltage (E), current (I), and resistance (R) in an electrical circuit. The law is mathematically expressed as:

$$E = I \times R \tag{5.22}$$

This equation states that the voltage across a conductor is directly proportional to the current flowing through it, provided the temperature and other physical conditions remain constant. Ohm's Law is crucial for analyzing and designing electrical circuits, as it allows us to calculate any one of the three quantities if 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 in a circuit can be calculated using the formula:

$$I = \frac{E}{R} \tag{5.23}$$

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

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

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

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

Relationship Between Voltage, Current, and Resistance

The relationship between voltage, current, and resistance is linear and can be visualized using a simple diagram. Figure 5.7 illustrates this relationship, showing how changes in voltage or resistance affect the current in a circuit.

Figure 5.7: Ohm's Law: Relationship between voltage, current, and resistance.

Practice Questions

T5D01

What formula is used to calculate current in a circuit?

1. $I = ER$
2. $I = E/R$
3. $I = E + R$
4. $I = E - R$

Explanation: The correct formula for calculating current is $I = E/R$, as derived from Ohm's Law (Equation 5.23). 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?

1. $E = I \times R$
2. $E = I/R$
3. $E = I + R$
4. $E = I - R$

Explanation: The correct formula for calculating voltage is $E = I \times R$, as derived from Ohm's Law (Equation 5.24). 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?

1. $R = E \times I$
2. $R = E/I$
3. $R = E + I$
4. $R = E - I$

Explanation: The correct formula for calculating resistance is $R = E/I$, 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.

T5D04

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

1. 3 ohms
2. **30 ohms**
3. 93 ohms
4. 270 ohms

Explanation: Using the formula $R = E/I$ (Equation 5.25), we can calculate the resistance as $R = 90\,\mathrm{V}/3\,\mathrm{A} = 30\,\Omega$. The other options are incorrect because they do not match this calculation.

T5D05

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

1. 18 ohms
2. 0.125 ohms
3. **8 ohms**
4. 13.5 ohms

Explanation: Using the formula $R = E/I$ (Equation 5.25), we can calculate the resistance as $R = 12\,\mathrm{V}/1.5\,\mathrm{A} = 8\,\Omega$. The other options are incorrect because they do not match this calculation.

T5D06

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

1. **3 ohms**
2. 16 ohms
3. 48 ohms
4. 8 ohms

Explanation: Using the formula $R = E/I$ (Equation 5.25), we can calculate the resistance as $R = 12\,\mathrm{V}/4\,\mathrm{A} = 3\,\Omega$. The other options are incorrect because they do not match this calculation.

T5D07

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

1. 9600 amperes
2. 200 amperes
3. 0.667 amperes
4. **1.5 amperes**

Explanation: Using the formula $I = E/R$ (Equation 5.23), we can calculate the current as $I = 120\,\mathrm{V}/80\,\Omega = 1.5\,\mathrm{A}$. The other options are incorrect because they do not match this calculation.

T5D08

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

1. 20,000 amperes
2. 0.5 amperes
3. **2 amperes**
4. 100 amperes

Explanation: Using the formula $I = E/R$ (Equation 5.23), we can calculate the current as $I = 200\,\mathrm{V}/100\,\Omega = 2\,\mathrm{A}$. The other options are incorrect because they do not match this calculation.

5.8 Series and Parallel Circuits

In this section, we will explore the fundamental characteristics of series and parallel circuits, focusing on how current and voltage behave in each configuration. Understanding these concepts is crucial for analyzing and designing electrical circuits.

Series Circuits

A series circuit is a configuration where components are connected end-to-end, forming a single path for current to flow. In a series circuit, the current through each component is the same. This is because there is only one path for the electrons to follow, and the same amount of charge flows through each component in sequence. The total voltage across the series circuit is the sum of the voltages across each individual component. Mathematically, this can be expressed as:

$$V_{\text{total}} = V_1 + V_2 + V_3 + \cdots + V_n \tag{5.26}$$

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

Parallel Circuits

In contrast, a parallel circuit is a configuration where components are connected across the same two points, providing multiple paths for current to flow. In a parallel circuit, the voltage across each component is the same. This is because all components are connected directly to the same voltage source. However, the total current in the circuit is the sum of the currents through each individual branch. This relationship can be expressed as:

$$I_{\text{total}} = I_1 + I_2 + I_3 + \cdots + I_n \tag{5.27}$$

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

Current and Voltage in Series and Parallel Circuits

The behavior of current and voltage in series and parallel circuits is fundamentally different. In a series circuit, the current is constant throughout, while the voltage is divided among the components. In a parallel circuit, the voltage is constant across all components, while the current is divided among the branches. These differences are summarized in Figure 5.8.

Figure 5.8: Series and parallel circuits. The left diagram shows a series circuit with three resistors, and the right diagram shows a parallel circuit with three resistors.

Questions

T5D13

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

1. **A. Series**
2. B. Parallel
3. C. Resonant
4. D. Branch

Explanation: In a series circuit, the current is the same through all components because there is only one path for the current to flow. This is a fundamental characteristic of series circuits, as discussed earlier. In parallel circuits, the current is divided among the branches, so it is not the same through all components. Resonant and branch circuits are not relevant to this question.
%memory_tric T5D13

T5D14

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

1. A. Series
2. **B. Parallel**
3. C. Resonant
4. D. Branch

Explanation: In a parallel circuit, the voltage across each component is the same because all components are connected directly to the same voltage source. This is a key characteristic of parallel circuits, as explained in the section. In series circuits, the voltage is divided among the components, so it is not the same across all components. Resonant and branch circuits are not relevant to this question.
%memory_tric T5D14

Chapter 6 ELECTRONIC AND ELECTRICAL COMPONENTS

Chapter 7 PRACTICAL CIRCUITS

Chapter 8 SIGNALS AND EMISSIONS

Chapter 9 ANTENNAS AND FEED LINES

Chapter 10 SAFETY