HamElmer.com
Technician Test
Self Study Guide

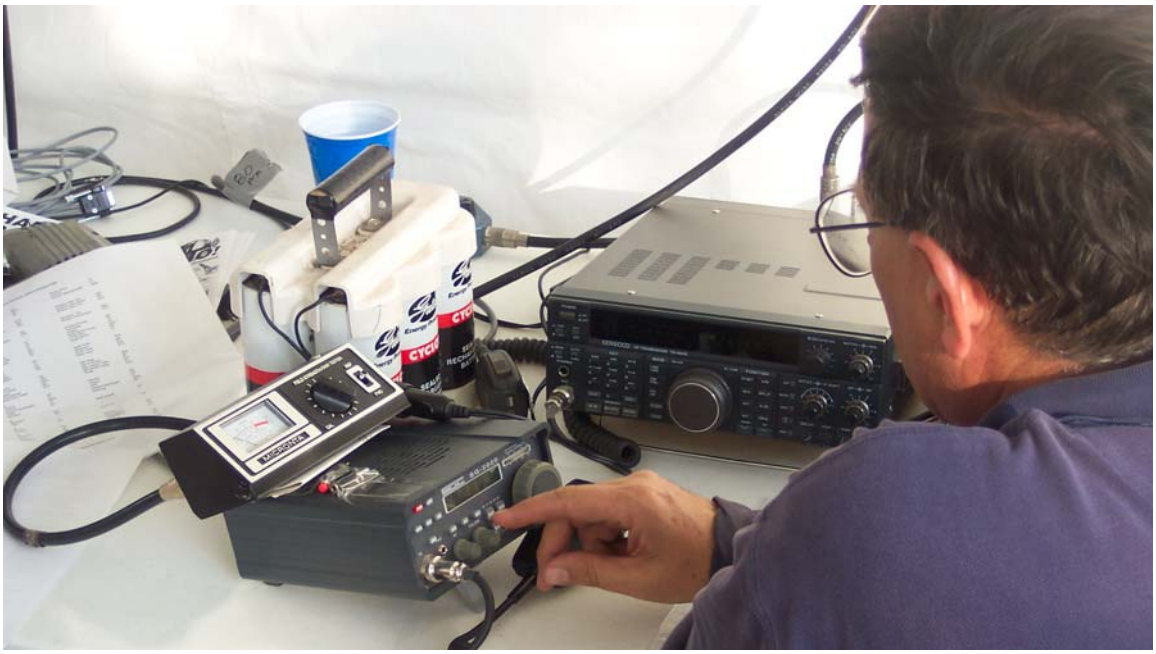

Figure 1 - WB5ACN at the San Antonio Radio Club Field Day 2003. Photo by N5NTG.

Since February, 23 2007
No Morse Code is required for any Amateur Radio License!

Version 2.1

SECOND PRINTING – May 2007

Please email any corrections or omissions to

RadioTeacher@gmail.com

The source documents used to create this guide are:
Technicians Question Pool (February 6th, 2006 Release)
for tests after July 1st, 2006 till June 30th, 2010.
Amateur Radio Rules, Code of Federal Regulations Title 47, Volume 5 Part 97.

The source information is available to the public.

If you have any questions or comments please post a message at
http://groups.yahoo.com/group/HamElmer/

Forward

The Radio Teacher Project, now called HamElmer.com, goal is to provide free documentation for Amateur Radio Tests.

In early 2006 Google started giving 100 MB of web space for free to its registered users. Using an @gmail.com email account for "RadioTeacher" the web site was created as radioteacher.googlepages.com for the project.

The San Antonio Radio Club needed an instructor in 2001 to teach the Technicians class and I gladly accepted the job. I feel that the only way to grow the hobby was to teach and Elmer (the Amateur Radio term for mentor) anyone with a desire to become an amateur radio operator.

I owe a lot to the hobby/service. In the 1980's I worked as a laborer and carpenter on the coast of South Texas. In December of 1986 I earned a Technicians license as N5IUT. In a short time I was communicating over packet radio to San Antonio 150 miles away via a digipeater to Harry Ridenour, N0CCW on two meters. Harry was the first radio operator on packet radio in San Antonio and a wealth of packet radio information. Harry (my Elmer) and my father encouraged me to learn more about packet radio, computers and build many projects. My father Louis, N5JKH, and I installed and maintained many Packet Radio nodes during that time. In 1991 with a practical knowledge in computers and networking I changed careers to computers.

I owe the success of my career to Amateur Radio.

Paul Guido, N5IUT
Editor, HamElmer.com

Dedication

This work is dedicated to my friend and Elmer, Harry Ridenour, N0CCW (SK) and my friend Carl Ray Finke, W5CRF (SK).

Acknowledgements

Ed Franks, KE5CAX and his wife Roberta for their help in pointing out an error the Study Guide version 2.0 that is now corrected.

I would like to thank Bob Bytheway, K3DIO for his steady hand, help and encouragement at every phase of this project.

Les Warriner, WA7HAM for his editing skills and ideas that made this a much better document.

Alan Sewell, N5NA for helping me find the XML version of the Technicians Question Pool and running a great web site full of information for students and instructors. Thank you for linking to this guide from your site. http://www.hamradioinstructor.com/index.html

Earl Paazig, N8KBR for providing me his study guide on the new pool that accelerated the development of this guide. He also runs a very informative web site that is a great resource for all Amateur Radio tests. http://studyguide.eqth.org/

Michael Ballbach, N0ZTQ for making the technician.xml file available on his web site at http://www.palmve.net/

Mike Anderson, N4MAA from St. Petersburg, Florida for his assistance and providing HamElmer.com an alternate location to host this document at http://n4maa.us/

How to use this Study Guide

Read each chapter and answer the review questions at the end of chapters. Each chapter should only take 10 to 30 minutes to complete.

After reading the guide, take some practice tests. You can do this by using the free software from http://www.shenware.com/

The best free Internet site for taking practice tests is http://www.kb0mga.net/exams/ Ron has done a great job of programming a first class testing site.

Other Internet sites for testing are
At http://www.aa9pw.com/radio/ you can print a test to take later.
QRZ.com at http://www.qrz.com/ is a popular practice test site.

Write down information about the questions that you missed. Then you can lookup more information on the topics in this guide or online. There is a glossary in Appendix B and a full index to the guide in Appendix D.

Search for information on the Internet using:

http://www.google.com/ this is Google's main search page.
http://en.wikipedia.org/wiki/Main_Page Wikipedia, the free encyclopedia.

If this does not help, post a message to the Ham Radio Help Yahoo Group. It is the best group on the Internet to ask an Amateur Radio related question.
http://groups.yahoo.com/group/HamRadioHelpGroup/

This Self Study Guide is a work in progress. Check to see if you have a recent version of the guide by visiting: http://HamElmer.com

Test Session information:
Some Volunteer Examiners accept walk in applicants others do not, please contact the VE team that you will be testing with to find out their policy.

The Technician test (Element 2 is the formal name of the test) is 35 questions and is not timed. It is a written test with multiple choice questions. To pass you must get at least 26 of the 35 questions correct (74%). The price currently set on the test is $14.00. Taking a check or the exact change is nice for the VE team. Most VE teams require two forms of identification (a photo ID plus another ID). Also, take a blue or black pen, and a calculator.

If you are consistently passing the practice tests, find a test session in your area by searching here: http://www.arrl.org and choosing Exams in the search box.

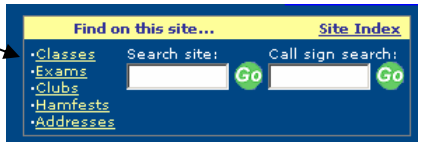

Figure 2 - Screenshot of search box. www.arrl.org

Get to the test session early. The Volunteer Examiner (VE) in charge of the session will normally go over the procedures and policies of the session. Feel free to ask anyone on the VE team questions.

If you have a disability or special needs, contact the VE team prior to the session to see if they have the resources to accommodate.

When finished with the test pass it back to the VE team for grading. A VE team member will call you over with the results and…when you pass give you a CSCE for credit. The VE team will turn over the results of the session to their Volunteer Examiner Coordinator (VEC). The VEC will send the information to the FCC. The FCC will update its database and your new callsign will be listed on the Internet. You will be able to find your new callsign by searching the ULS database at http://wireless.fcc.gov/uls/ .

You can start using your privileges as an Amateur Radio Operator as soon as your name and callsign appears in the ULS database.

More Information:

If you complete this guide and still need more information to pass the test please try the following books and training. Please make sure that the book you buy covers the current test.

The ARRL Ham Radio License Manual, from http://www.arrl.org or Gordon West's *Technician Book,* from http://www.w5yi.com

If you learn better in a classroom environment locate a club in your area by searching at http://www.arrl.org and choosing Clubs from the search box. Then contact the local club to see when they are having classes.

One Internet training site that is not free for Amateur Radio that I hear good things about is http://www.hamtestonline.com/ if looking to train online please check it out.

The ARRL also provides online training.

Guide Sources and Layout:
This guide is based on the Technician's Question pool released on February 6, 2006. The editors of this guide have included information and images to answer all 391 questions in this pool. Since this pool was released one question has been withdrawn.

Chapter 1 of this guide contains the information needed to answer the questions of subelement T1. Chapter 10 corresponds with subelement T0 of the Technicians Question Pool. The text in each chapter was rearranged in an effort to keep like subject matter together.

REACT International
This Study Guide has received an endorsement from *REACT* International for the training of it membership. You can find out more about *REACT* International from their web site at http://www.reactintl.org/

Internet Links

Online Training Links:
This Study Guide has a new home at http://HamElmer.com Please look to see if you have the latest version of the Study Guide.

If you have any questions or comments about the Study Guide, please post a message at http://groups.yahoo.com/group/HamElmer/

For some students this guide has too many features of a text book. For a very well thought out Technician or General Study guide that gets right to the point, please check out Dan Romanchik's, KB6NU, No-Nonsense study guides. Both are downloadable from the web page.
http://kb6nu.com/no-nonsense-general-class-study-guide/

Visit http://www.hamradioinstructor.com/index.html N5NA's web site for other teaching and training resources for all Amateur Radio Tests.

Earl Paazig runs a very informative web site that is a great resource for all Amateur Radio tests. http://studyguide.eqth.org/

One Amateur Radio Internet training site that is not free that I hear very good things about is http://www.hamtestonline.com/. If looking to train online please check it out.

The ARRL also provides online training at http://www.arrl.org

Software Practice Tests:
Download free software to practice all tests at http://www.shenware.com/

Online Practice Tests:
http://www.kb0mga.net/exams/ The best on the net!
http://www.aa9pw.com/radio/
http://www.qrz.com/

For more help:
Post a message to the Ham Radio Help Yahoo Group. It is the friendliest group on the Internet to ask an Amateur Radio related question.
http://groups.yahoo.com/group/HamRadioHelpGroup/

Related Books:
The ARRL Ham Radio License Manual, from http://www.arrl.org
Gordon West's Technician Book, from http://www.w5yi.com

If you learn better in a classroom environment locate a club in your area by searching at http://www.arrl.org and choosing Clubs from the search box. Then contact the local club to see when they are having classes.

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Chapter 1

Basic definitions, license information, authorized transmissions, prohibited transmissions and available frequencies

Purpose:
The Amateur Radio service provides voluntary noncommercial communications to the public, particularly in times of emergency. The service also increases the number of trained radio operators and electronics experts, and improves international goodwill.

Figure 3 - San Antonio Radio Club live demonstration June 2004. Photo by N5IUT

Definitions:
Amateur operator: A person holding a written authorization to be the control operator of an amateur station.

Amateur station: A station in an amateur radio service consisting of the apparatus necessary for carrying on radio communications.

Figure 4 – Station on St. Martin (left) Yaesu FT-857 (center) Vintage gear at Swapfest (right). Photo by N5IUT

Definitions continued:

Harmful interference: Interference which endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radio communication service operating in accordance with the Radio Regulations.

ITU: International Telecommunication Union.

Universal Licensing Service (ULS): This database is on the Internet at http://wireless.fcc.gov/uls/ . The database contains information about licensed services such as the Amateur Radio Service. With it one can search by name or callsign and find out an amateurs' status, expiration date, and station location.

Figure 5 - ITU Logo

Figure 6 - ULS web site - http://wireless.fcc.gov/uls/

Volunteer Examiner: An amateur accredited by one or more Volunteer Examiner Coordinators (VEC's) who administers amateur license exams.

Certificate of Successful Completion of Examination (CSCE): A document earned by an individual passing one or more elements (tests) for an Amateur Radio license. A CSCE is valid for license upgrade purposes for 365 days.

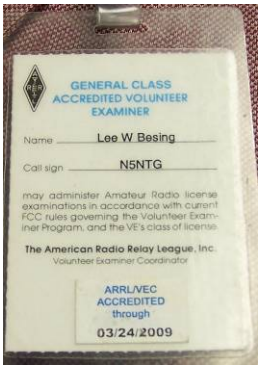


Figure 7 - ARRL/VEC ID Badge. Photo by N5IUT

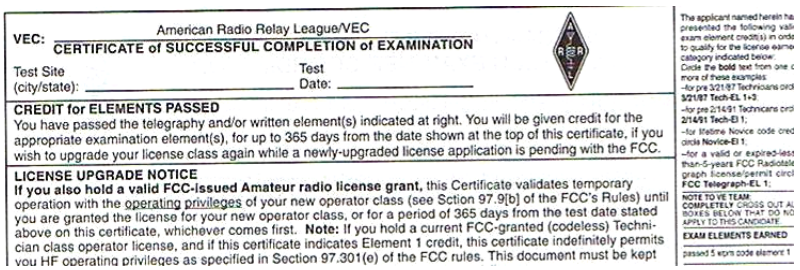

VEC: American Radio Relay League/VEC
CERTIFICATE of SUCCESSFUL COMPLETION of EXAMINATION
Test Site (city/state): _____ Test Date: _____
CREDIT for ELEMENTS PASSED
You have passed the telegraphy and/or written element(s) indicated at right. You will be given credit for the appropriate examination element(s), for up to 365 days from the date shown at the top of this certificate, if you wish to upgrade your license class again while a newly-upgraded license application is pending with the FCC.
LICENSE UPGRADE NOTICE
If you also hold a valid FCC-issued Amateur radio license grant, this Certificate validates temporary operation with the operating privileges of your new operator class (see Sction 97.9[b] of the FCC's Rules) until you are granted the license for your new operator class, or for a period of 365 days from the test date stated above on this certificate, whichever comes first. **Note:** If you hold a current FCC-granted (codeless) Technician class operator license, and if this certificate indicates Element 1 credit, this certificate indefinitely permits you HF operating privileges as specified in Section 97.301(e) of the FCC rules. This document must be kept
EXAM ELEMENTS EARNED

Figure 8 - Part of the CSCE form that you would receive after passing any element of an Amateur Radio Exam. Photo by WA7HAM

The Station license grant:
The Federal Communications Commission (FCC) enforces the rules and grants Amateur Radio licenses in the United States.

Before you can control an amateur station you must be named in the FCC amateur license database, or be an alien with reciprocal operating authorization.

You can transmit as soon as your license grant appears in the FCC's Universal Licensing Service (ULS) database. This database can be queried on the Internet.

After the license is granted you are allowed to transmit within the privileges of your license class wherever the Amateur Radio Service is regulated by the FCC or where reciprocal agreements are in place.

Application for new license grant:
There is no minimum age requirement for a license and anyone can get a license except a representative of a foreign government.

Figure 9 - Scout on radio. Photo by KF5WT

Upon passing this test the FCC will issue you an operator station license for the Amateur Radio Service. New amateur radio call signs are assigned in sequential order. The new call sign will start with an A, K, N and W as the first letter and contain a single digit from 0 through 9.

KB3TMJ is an example of a valid US callsign.

You can apply for an amateur radio club call sign by applying through a Club Station Call Sign Administrator.

Application for a vanity call sign:
If you want a call sign with your initials or to get back a call sign you once held, you can apply for it with the vanity call sign program.

VE Requirements for Technician test:
Three Examiners holding a General Class license or higher are required to administer an Element 2 Technician written exam.

License Data:
The grace period during which the FCC will renew an expired ten year license without re-examination is two years. You are not allowed to transmit after your ten year license expires.

Make sure your mailing address is correct with the FCC. This is so you can receive official mail from the FCC. If the FCC receives returned mail as undeliverable, they could revoke or suspend your license. This address must be your station license mailing address.

On June 28, 2006 the FCC suspended two Amateur Radio Operators licenses because the holders had failed to maintain correct mailing addresses in the ULS database.

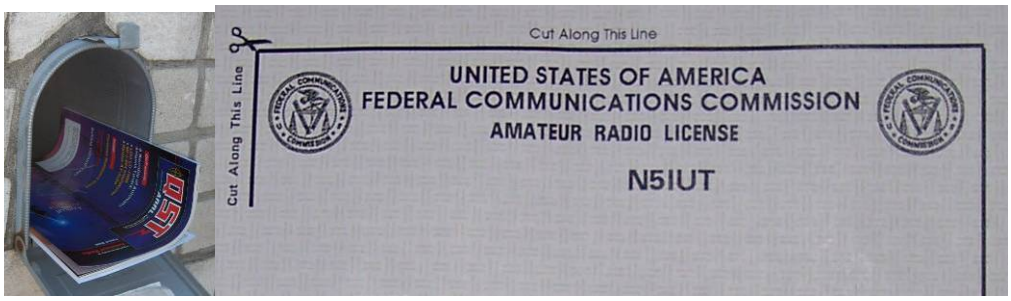


Figure 10 – QST in mailbox - Part of license received from the FCC. Photos by N5IUT

As stated above the normal term for an amateur station license grant is 10 years.

Your responsibility as a station licensee is to operate in accordance with the FCC rules.

Reciprocal operating authority:
You are allowed to operate your amateur station in a foreign country when there is a reciprocal operating agreement between the countries.

Authorized transmissions:
When authorized by the FCC, amateur stations are allowed to communicate with stations operating in other radio services.

A United States amateur operator may communicate with an amateur in a foreign country unless prohibited by either government.

Prohibited transmissions:
Communications on a regular basis that could reasonably be furnished alternatively through other radio services are not permitted in the Amateur Radio Service.

ITU Regions:
ITU Regions are used to assist in the management of frequency allocations.

Figure 11 - Alaska, Hawaii and the lower 48 states are in ITU Region 2.

The table below shows only the information needed for answering Subelement T1 questions. It does not contain all bands and frequencies available to the Amateur Radio Technician licensee.

Wavelength band	**ITU--Region 2**	**Frequency Examples**
VHF	**MHz**	
6 m	50-54	52.525 MHz
2 m	144-148	146.52 MHz
1.25 m	222-225	223.50 MHz
UHF	**MHz**	
70 cm	420-450	443.350 MHz
23 cm	1240-1300	1296 MHz

Figure 12 - Partial Table ITU Region 2 Amateur Radio Operating Frequencies

52.525 MHz is a frequency within the 6-meter band.

When transmitting on 146.52 MHz you would be on the 2 meter amateur band.

Transmitting on 223.50 MHz you would be on the 1.25 meter amateur band.

443.350 MHz on the 70-centimeter band is authorized to a Technician class license holder operating in ITU Region 2.

1296 MHz on the 23 centimeter band is authorized to a Technician class license holder operating in ITU Region 2.

Additional Information:

If Amateur Radio is available on a secondary basis on a given band or location, the FCC rules state that amateurs may not cause harmful interference to primary users.

Technician, General and Extra are the only US amateur radio licenses that may currently be earned.

Any FCC-licensed amateur is eligible to apply for temporary use of a 1-by-1 format Special Event call sign.

Chapter 1

Review Questions

Answers in Appendix A

1. How soon may you transmit after passing the required examination elements for your first amateur radio license?
A. Immediately
B. 30 days after the test date
C. As soon as your license grant appears in the FCC's ULS database
D. As soon as you receive your license in the mail from the FCC

2. How many and what class of Volunteer Examiners are required to administer an Element 2 Technician written exam?
A. Three Examiners holding any class of license
B. Two Examiners holding any class of license
C. Three Examiners holding a Technician Class license
D. Three Examiners holding a General Class license or higher

3. What are two of the five fundamental purposes for the Amateur Radio Service?
A. To protect historical radio data, and help the public understand radio history
B. To aid foreign countries in improving radio communications and encourage visits from foreign hams
C. To modernize radio electronic design theory and improve schematic drawings
D. To increase the number of trained radio operators and electronics experts, and improve international goodwill

4. What is the purpose of ITU Regions?
A. They are used to assist in the management of frequency allocations
B. They are useful when operating maritime mobile
C. They are used in call sign assignments
D. They must be used after your call sign to indicate your location

5. When are you allowed to operate your amateur station in a foreign country?
A. When there is a reciprocal operating agreement between the countries
B. When there is a mutual agreement allowing third party communications
C. When authorization permits amateur communications in a foreign language
D. When you are communicating with non-licensed individuals in another country

6. What letters must be used for the first letter in US amateur call signs?
A. K, N, U and W
B. A, K, N and W
C. A, B, C and D
D. A, N, V and W

7. What is required before you can control an amateur station in the US?
A. You must hold an FCC restricted operator's permit for a licensed radio station
B. You must submit an FCC Form 605 with a license examination fee
C. You must be named in the FCC amateur license database, or be an alien with reciprocal operating authorization
D. The FCC must issue you a Certificate of Successful Completion of Amateur Training

8. Which 23 centimeter frequency is authorized to a Technician class license holder operating in ITU Region 2?
A. 2315 MHz
B. 1296 MHz
C. 3390 MHz
D. 146.52 MHz

9. What do the FCC rules mean when an amateur frequency band is said to be available on a secondary basis?
A. Secondary users of a frequency have equal rights to operate
B. Amateurs are only allowed to use the frequency at night
C. Amateurs may not cause harmful interference to primary users
D. Secondary users are not allowed on amateur bands

10. What classes of US amateur radio licenses may currently be earned by examination?
A. Novice, Technician, General, Advanced
B. Technician, General, Advanced
C. Technician, General, Extra
D. Technician, Tech Plus, General

11. What is the grace period during which the FCC will renew an expired 10-year license without re-examination?
A. 2 years
B. 5 years
C. 10 years
D. There is no grace period

12. When are you permitted to continue to transmit if you forget to renew your amateur license and it expires?
A. Transmitting is not allowed until the license is renewed and appears on the FCC ULS database
B. When you identify using the suffix EXP
C. When you notify the FCC you intend to renew within 90 days
D. Transmitting is allowed any time during the 2-year grace period

Chapter 2

Basic definitions, privileges, responsibilities and identification

Definitions:
Broadcasting: One way transmissions intended for reception by the general public, either direct or relayed.

An amateur station is never authorized to transmit information to the general public. No broadcasting.

Control operator: The person responsible for the transmissions from an amateur station and assures compliance with FCC rules. Every amateur station must have a control operator when transmitting.

Control point: The location at which the control operator function is performed.

Figure 13 - Microphone and J-38 Morse code Key. Photo by N5IUT

Local, remote and automatic control: The three types of station control permitted and recognized by FCC rules.

An example of local control would be an Amateur Radio Station transmitting using a handheld radio.

Figure 14 - Yaesu VX-5R. Photo by N5IUT

Remote control is used when the control operator is not at the station location but can still make changes to a transmitter.

Automatic control is used on a repeater when the control operator is not present. This type of control does not require a control operator to be at the control point. The minimum class of amateur license you must hold to be a control operator of a repeater station is Technician.

Definitions continued:
Third-party communications: Any message that is sent between two amateur stations for someone else.

Privileges:
Only one amateur operator / primary station license may be held by one person.

A club of at least four members is required for a club station license to be issued by the FCC.

Figure 15 - The San Antonio Radio Club has been affiliated with the ARRL since January 2, 1920. SARC Archive

You may operate your amateur station aboard an aircraft only with the approval of the pilot in command and not using the aircraft's radio equipment.

If you transmit from another amateur's station you are both responsible for the proper operation of the station.

The FCC can inspect your station equipment and station records at anytime upon request.

Authorized control operator:
No unlicensed transmissions are allowed from your station. This includes non-licensed family members. A licensed amateur radio operator must be at the control point when transmitting.

> Disconnecting the power and microphone cables from your equipment is one the best ways keep unauthorized persons from using your amateur station.

If you are the control operator of a station of a higher class licensed operator you will have only the privileges allowed by your license. If a higher class licensed operator is the control operator of your station you can use all privileges allowed by the higher class license. The control operator license class determines the privileges for the station.

The correct way to identify when visiting a station if you hold a higher class license than that of the station licensee and you are using a frequency not authorized to his class of license is to send his call sign first, followed by your call sign.

Prohibited communications:
Only when transmitting control commands to space stations or radio control craft, the transmission of codes or ciphers are allowed to hide the meaning of a message transmitted by an amateur station. But an amateur station is never allowed to transmit false or deceptive signals.

Indecent and obscene language is specifically prohibited in the Amateur Radio Service

You may transmit unidentified communications only if you are in radio control of a model craft or located on a space station.

You can not use amateur radio for conducting business. An example of this would be calling your employer requesting directions to a customer's office.

Compensation:
If a control operator of an amateur station sends information bulletins or Morse code practice transmissions for at least 40 hours per week, it is permissible for the club station operator to accept compensation in accordance with part 97 rules. This is the only method of communication for hire or material compensation allowed by the rules for the amateur operator.

You can offer for sale or trade amateur radio equipment over the air on an occasional basis but not as a business.

Identification:
To identify your own station you must transmit your own call sign at least every ten minutes and at the end of each communication. In a conversation (QSO) each station must transmit its own call sign.

Unidentified communications are prohibited except when sent from a space station or to control a model craft.

Figure 16 - The 2006 International Space Station crew are all Amateur Radio Operators.
Flight Engineer Astronaut Thomas Reiter of Germany, DF4TR (left),
Commander Pavel Vinogradov of Russia, RV3BS (center)
and Flight Engineer Jeff Williams of the United States, KD5TVQ (right). NASA Photo

Identification continued:
A repeater station can send its identification by phone using the English language, by video image conforming to applicable standards, by Morse code at a speed not to exceed 20 words per minute.

Even if you are speaking to another amateur operator using a language other than English, you must identify using the English language.

You must identify using your assigned call sign when operating a special event call sign once per hour.

When using one or more self-assigned indicators with your assigned call sign, the indicator must not conflict with an indicator specified by FCC rules or with a prefix assigned to another country.

When exercising the operating privileges earned by examination upgrade, the use of the indicator "/AG" denotes Authorized General and "/AE" would be for Authorized Extra.

Review Questions
Chapter 2
Answers in Appendix A

1. When is the transmission of codes or ciphers allowed to hide the meaning of a message transmitted by an amateur station?
A. Only during contests
B. Only when operating mobile
C. Only when transmitting control commands to space stations or radio control craft
D. Only when frequencies above 1280 MHz are used

2. When does the FCC allow an amateur radio station to be used as a method of communication for hire or material compensation?
A. Only when making test transmissions
B. Only when news is being broadcast in times of emergency
C. Only when in accordance with part 97 rules
D. Only when your employer is using amateur radio to broadcast advertising

3. What type of communications are prohibited when using a repeater autopatch?
A. Calls to a recorded weather report
B. Calls to your employer requesting directions to a customer's office
C. Calls to the police reporting a traffic accident
D. Calls to a public utility reporting an outage of your telephone

4. What is the longest period of time an amateur station can operate without transmitting its call sign?
A. 5 minutes
B. 10 minutes
C. 15 minutes
D. 30 minutes

5. How many amateur operator / primary station licenses may be held by one person?
A. As many as desired
B. One for each portable transmitter
C. Only one
D. One for each station location

6. What is the correct way to identify when visiting a station if you hold a higher class license than that of the station licensee and you are using a frequency not authorized to his class of license?
A. Send your call sign first, followed by his call sign
B. Send his call sign first, followed by your call sign
C. Send your call sign only, his is not required
D. Send his call sign followed by "/KT"

7. What is a permissible way to identify your station when you are speaking to another amateur operator using a language other than English?
A. You must identify using the official version of the foreign language
B. Identification is not required when using other languages
C. You must identify using the English language
D. You must identify using phonetics

8. What is the control point of an amateur station?
A. The on/off switch of the transmitter
B. The input/output port of a packet controller
C. The variable frequency oscillator of a transmitter
D. The location at which the control operator function is performed

9. What are the three types of station control permitted and recognized by FCC rule?
A. Local, remote and automatic control
B. Local, distant and automatic control
C. Remote, distant and unauthorized control
D. All of the choices are correct

10. What operating privileges are allowed when another amateur holding a higher class license is controlling your station?
A. All privileges allowed by the higher class license
B. Only the privileges allowed by your license
C. All the emission privileges of the higher class license, but only the frequency privileges of your license
D. All the frequency privileges of the higher class license, but only the emission privileges of your license

11. What operating privileges are allowed when you are the control operator at the station of another amateur who has a higher class license than yours?
A. Any privileges allowed by the higher class license
B. Only the privileges allowed by your license
C. All the emission privileges of the higher class license, but only the frequency privileges of your license
D. All the frequency privileges of the higher class license, but only the emission privileges of your license

12. When is it permissible for the control operator of a club station to accept compensation for sending information bulletins or Morse code practice?
A. When compensation is paid from a non-profit organization
B. When the club station license is held by a non-profit organization
C. Anytime compensation is needed
D. When the station makes those transmissions for at least 40 hours per week

Chapter 3

Operating Practices

Definitions:

RACES: Radio Amateur Civil Emergency Service. This service started originally for war time use. Since the role of civil defense has changed to civil preparedness the role of RACES has also expanded. It now includes hurricanes, floods, fires and other disasters such as train wrecks. Radio Amateur Civil Emergency Service (RACES) organizations are restricted to serving local, state, and federal government emergency management agencies. You must register with the responsible civil defense organization before you can participate in RACES activities.

ARES: Amateur Radio Emergency Service. ARES is sponsored by the Amateur Radio Relay League (ARRL). The only qualification for membership is an amateur radio license and a desire to serve. ARES members assist with communications for non-governmental agencies in times of need. Amateur Radio Emergency Service (ARES) supports non-governmental agencies like the Red Cross and National Weather Service.

Both organizations RACES and ARES provide communications during emergencies

Phonetic Alphabet:

The words used in the International Telecommunication Union (ITU) phonetic alphabet have been carefully chosen so that no two words sound the same. The words are internationally recognized substitutes for letters. You should learn and use this phonetic alphabet. Using cute phrases or other word combinations can cause confusion and are not easily understood by some operators. The Phonetic Alphabet is listed in Appendix C. None of the individual words are on the test.

CQ:
"CQ" is the procedural signal for calling any station.

If you are looking for any station with which to make contact you should: Listen to make sure that the frequency is not busy then call "CQ" followed by your callsign. When responding to another stations CQ you should say the other station's callsign followed by your callsign.

If you hear a brief tone followed by a station from Russia calling CQ on a local 2-meter repeater, the repeater is connected via the Internet to the DX station. See Chapter 6 for more information on Internet Repeater Linking Project (IRLP).

If you are using a repeater, you can say your callsign instead of CQ to indicate that you are listening for calls from any station.

As stated above, you should always listen to determine if a frequency is busy before transmitting.

Specific Station:
If you know the station's callsign you wish to communicate with say the other stations' callsign followed by your callsign.

Band Plans: Voluntary guidelines, beyond the divisions established by the FCC for using different operating modes within an amateur band that provide a more efficient use of the radio spectrum. The amateur community develops the band plans used by the amateur radio service.

The recognized frequency coordination body is in charge of the repeater frequency band plan in your local area. The main purpose of repeater coordination is to reduce interference and promote proper use of spectrum.

The transmitting station is accountable if a repeater station inadvertently retransmits communications that violate FCC rules.

The 6-meter, 2-meter, and 1 1/4-meter bands have mode restricted sub-bands available to Technician class licensees.

CW (Morse code) is the only mode permitted in the restricted sub-band at 50.0-50.1 MHz or at 144.0-144.1 MHz.

CW (Morse code) and Data are permitted in the restricted portion of the 1 1/4-meter band?

Test Transmissions:
An amateur must properly identify their station when making a transmission to test equipment or antennas. Normal rules apply for identifying test transmissions. Station identification is required at least every ten minutes and at the end of every transmission.

A brief test transmission that does not include any station identification is an illegal unidentified transmission.

Power:
An amateur must use the **minimum** transmitter power necessary to carry out the desired communication.

Good engineering:
Good engineering and amateur practices must be applied to amateur station operation when circumstances are not specifically covered by FCC rules.

Operating Practices:
If you hear a newly licensed operator that is having trouble with their station one should contact them and offer to help with the problem. Also, if you are contacted by an operator that there is an issue with your signal please do not take offence and investigate the matter objectively.

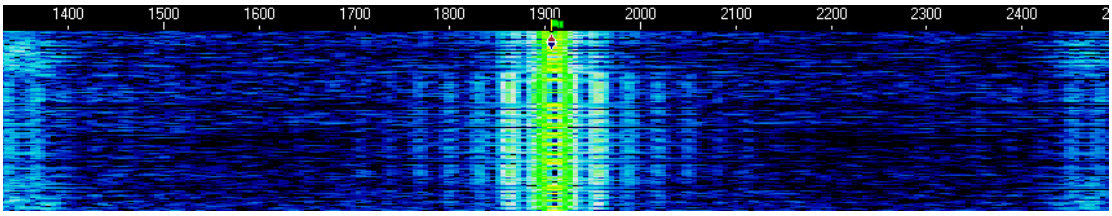


Figure 17 - Displayed above is a PSK31 signal that is transmitting a signal that is having some trouble. From N6CCR

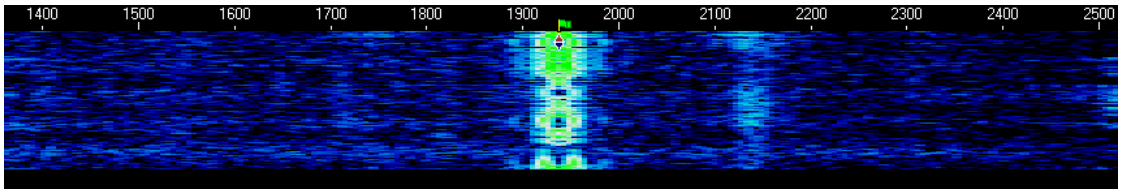


Figure 18 - Displayed above is a normal PSK31 signal. From N6CCR

For more information on the screen shots above read the article, *The Good Bad and Ugly* on PSK31 on http://www.eHam.net by Steve N6CCR. http://www.eham.net/articles/12626

Operating Practices continued:
If you want to break into a conversation between stations that are using the frequency just say your call sign between their transmissions.

If two amateur stations want to use the same frequency, remember that no frequency will be assigned for the exclusive use of any station and neither has priority.

Make sure you are operating on a permissible frequency for your license class before responding to another stations call.

Monitoring before transmitting, keeping transmissions short, identifying legally and using the minimum amount of transmitter power necessary is considered to be proper repeater operating practice.

Indecent and obscene language is prohibited in the Amateur Service because it is offensive to some individuals, because young children may intercept amateur communications with readily available receiving equipment and because such language is specifically prohibited by FCC rules. There is no official list of prohibited obscene and indecent words.

Avoid the use of racial or ethnic slurs when talking to other stations because it is offensive to some people and reflects a poor public image on all amateur radio operators.

Political jokes, jokes, stories and religious preferences are not prohibited communications while using amateur radio.

FCC rules apply to your station when using amateur radio at the request of public service officials or at the scene of an emergency.

If you unintentionally interfere with another station, properly identify your station and move to a different frequency.

You may never deliberately interfere with another station's communications.

No station has exclusive use of a specific frequency.

Interference:
One of the most difficult aspects of Amateur Radio public relations happens when your neighbors TV or telephone receives interference from your transmitting equipment. First check that your transmitter is in proper working order. At this point you should work with the neighbor, if possible, to assist in taking care of the issue.

If you receive a report that your transmissions are causing splatter or interference on nearby frequencies check your transmitter for off frequency operation or spurious emissions. Splatter can also be caused by "Over Driving": Speaking to close to your microphone or by misadjusting an amplified microphone.

If the transmitter complies with FCC rules, it is the responsibility of the owner of the television receiver or telephone to correct the issue. Even so, as a courtesy, you should assist the neighbor in correcting the issue.

Interference caused by strong signals from a nearby source is called "receiver front-end overload". The owner of the television receiver is responsible for taking care of the interference if signals from your transmitter is causing front end overload on their TV. Of course your transmitter must be in proper working order for this to be true.

If the cable of a cable television system is broken or has loose connections, TV interference may result when the amateur station is transmitting, or interference may occur to the amateur receiver.

The best way to reduce on the air interference when testing your transmitter is to use a dummy load. A dummy load is normally a 50 ohm resistive element that connects to the transmitter. It dissipates the transmitters' power into heat.

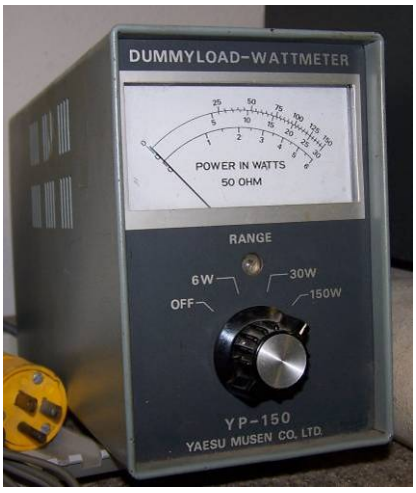


Figure 19 - Yaesu Dummyload Wattmeter. Photo by N5IUT

Notes

Review Questions
Chapter 3
Answers in Appendix A

1. How do you call another station on a repeater if you know the station's call sign?
A. Say "break, break" then say the station's call sign
B. Say the station's call sign then identify your own station
C. Say "CQ" three times then the other station's call sign
D. Wait for the station to call "CQ" then answer it

2. What term describes a brief test transmission that does not include any station identification?
A. A test emission with no identification required
B. An illegal un-modulated transmission
C. An illegal unidentified transmission
D. A non-voice ID transmission

3. Which of the following is true when making a test transmission?
A. Station identification is not required if the transmission is less than 15 seconds
B. Station identification is not required if the transmission is less than 1 watt
C. Station identification is required only if your station can be heard
D. Station identification is required at least every ten minutes and at the end of every transmission.

4. What is the main purpose of repeater coordination?
A. To reduce interference and promote proper use of spectrum
B. To coordinate as many repeaters as possible in a small area
C. To coordinate all possible frequencies available for repeater use
D. To promote and encourage use of simplex frequencies

5. Which of these statements is true about legal power levels on the amateur bands?
A. Always use the maximum power allowed to ensure that you complete the contact
B. An amateur may use no more than 200 Watts PEP to make an amateur contact
C. An amateur may use up to 1500 Watts PEP on any amateur frequency
D. An amateur must use the minimum transmitter power necessary to carry out the desired communication

6. What emission modes are permitted in the restricted portion of the 1 1/4-meter band?
A. Data only
B. CW and SSB
C. CW and Data
D. SSB and FM

7. What is considered to be proper repeater operating practice?
A. Monitor before transmitting and keep transmissions short
B. Identify legally
C. Use the minimum amount of transmitter power necessary
D. All of these answers are correct

8. What rule applies if two amateur stations want to use the same frequency?
A. The station operator with a lesser class of license must yield the frequency to a higher-class licensee
B. The station operator with a lower power output must yield the frequency to the station with a higher power output
C. No frequency will be assigned for the exclusive use of any station and neither has priority
D. Station operators in ITU Regions 1 and 3 must yield the frequency to stations in ITU Region 2

9. When circumstances are not specifically covered by FCC rules what general operating standard must be applied to amateur station operation?
A. Designated operator control
B. Politically correct control
C. Good engineering and amateur practices
D. Reasonable operator control

10. What is the major cause of telephone interference?
A. The telephone wiring is inadequate
B. Tropospheric ducting at UHF frequencies
C. The telephone was not equipped with adequate interference protection when manufactured.
D. Improper location of the telephone in the home

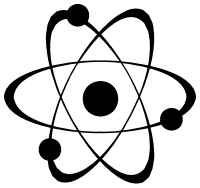
11. When may you deliberately interfere with another station's communications?
A. Only if the station is operating illegally
B. Only if the station begins transmitting on a frequency you are using
C. Never
D. You may cause deliberate interference because it can't be helped during crowded band conditions

12. What effect might a break in a cable television transmission line have on amateur communications?
A. A break cannot affect amateur communications
B. Harmonic radiation from the TV may cause the amateur transmitter to transmit off-frequency
C. TV interference may result when the amateur station is transmitting, or interference may occur to the amateur receiver
D. The broken cable may pick up very high voltages when the amateur station is transmitting

Chapter 4

Radio and electronic fundamentals, definitions of electrical terms, Ohm's Law, power calculations and the relationship between wavelength and frequency

Current:
Current is the term used to describe the flow of electrons in an electric circuit. Electrical current is measured in Amperes and we use the letter **I** to express current in equations.



The flow of electrons in direct current is only in one direction. An alternating current reverses electron flow direction on a regular basis.

An Ammeter is used to measure the flow of current in an electrical circuit.

Electromotive Force (EMF):
The unit of measurement for Electromotive Force (EMF) is Volts. The letter **E** is used to describe voltage in equations.

A Voltmeter is the instrument used to measure Electromotive Force (EMF) between two points such as the poles of a battery.

For example an automobile battery usually supplies about **12 volts**.

Resistance:
Resistance is the term used to describe opposition to current flow in ordinary conductors such as wires. Resistance is measured in ohms and the letter **R** is used to express resistance in equations. It is also expressed as the Greek letter omega **Ω**. The ohm is the basic unit of resistance.

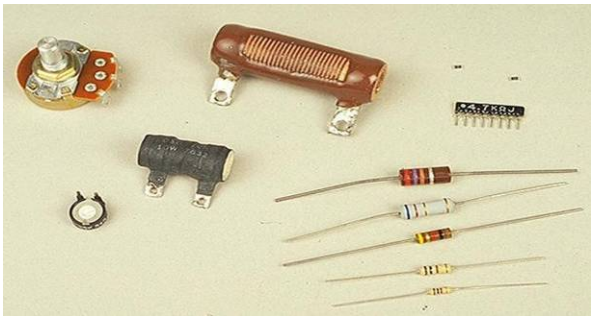


Figure 20 - Different types and values of resistors. Photo by KF5WT

Ohms Law:
The relationship between voltage, current and resistance can be described mathematically in Ohms Law.

Using Ohms Law it is easy to determine circuit voltage**(E)**. Do this by multiplying the circuit current **(I)** by the circuit resistance **(R)**. **E=I*R**

You will be solving equations using Ohm's law below. One way to remember the equation is with the circle below. If you put your finger over the part of the equation that you are trying to solve, the solution for the problem remains.

For example, if you are trying to solve for current put your finger over the **I** and it will leave visible **E** over **R**. So **I=E/R**

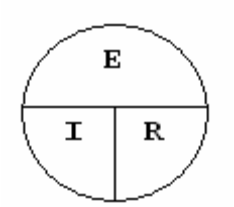


Figure 21 - Ohms Law Circle

Ohms Law Practice:
What is the resistance of a circuit when a current of 3 amperes flows through a resistor connected to 90 volts? To solve this use the Ohm's Law circle above. Covering **R** in the circle leaves **E** over **I** so **R=E/I.** 90 volts/3 amps= 30 ohms

What is the resistance in a circuit where the applied voltage is 12 volts and the current flow is 1.5 amperes? As above we would use **R=E/I**. 12 volts/ 1.5 amps= 8 ohms

What is the current flow in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms? For this one would use **I=E/R** 120 volts/80 ohms=1.5 amperes

What is the current flowing through a 100 ohm resistor connected across 200 volts? As above you would use **I=E/R** 200 volts/100 ohms=2 amperes

What is the current flowing through a 24 ohm resistor connected across 240 volts? **I=E/R** 240 volts/24 ohms=10 amperes

What is the voltage across the resistor if a current of 0.5 amperes flows through a 2 ohm resistor? For this solution use **E=I*R**. 0.5 amperes multiplied by 2 ohms equals 1 volt.

What is the voltage across the resistor if a current of 1 ampere flows through a 10 ohm resistor? Again use **E=I*R** 1 ampere multiplied by 10 ohms equals 10 volts.

What is the voltage across the resistor if a current of 2 amperes flows through a 10 ohm resistor? **E=I*R** 2 amperes multiplied by 10 ohms equals 20 volts

Conductors:
Most metals make very good conductors of electricity. Some examples of conductors are Gold, Silver, Copper and Aluminum. Most house wiring is copper.

Figure 22 - Copper is a good conductor. Photo by N5IUT

Insulators:
Insulators on the other hand are very poor conductors of electricity. Glass, Bakelite, Rubber and Mica are very good insulators. Railroad communication lines next to the tracks had green Glass insulators on the poles holding up the wires.

Figure 23 - Glass Pyrex Insulator for wire antennas. Photo by N5IUT

Power:
The Watt is the unit used to describe electrical power. The letter used for power in an equation is **P**. Power**(P)**can be calculated by multiplying the circuit current**(I)**by the circuit voltage **(E)**. This can be expressed as **P=I*E**.

You will be solving equations using the power equation below. There is a circle for Power solving below. If you put your finger over the part of the equation that you are trying to solve, the solution for the problem remains.

For example if you are trying to solve or voltage put your finger over the **E** and it will leave visible **P** over **I**. So **E=P/I**

How can you determine how many watts are being drawn by your transceiver when you are transmitting? Just measure the direct current (DC) voltage at the transceiver and multiply by the current drawn when you transmit.

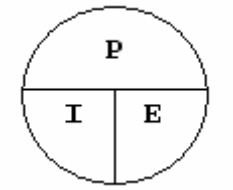


Figure 24 - Power Equation Circle

Power Calculation Practice:
Power **(P)** equals voltage **(E)** multiplied by current **(I)** is the formula used to calculate electrical power in a DC circuit. **P=I*E or P=E*I**

How much power is represented by a voltage of 13.8 volts DC and a current of 10 amperes? As stated above **P=E*I**. 13.8 volts multiplied by 10 amperes equals 138 watts.

How much power is being used in a circuit when the voltage is 120 volts DC and the current is 2.5 amperes? **P=E*I** 120 volts multiplied by 2.5 amperes equals 300 watts.

How many amperes are flowing in a circuit when the applied voltage is 120 volts DC and the load is 1200 watts? Using the power circle I can see that **I=P/E**. 1200 watts divided by 120 volts equals 10 amperes.

Batteries:
Of the battery types listed below Lithium-ion offers the longest life when used with a hand-held radio, assuming each battery is the same physical size.

Lithium-ion, Lead-acid, Alkaline and Nickel-cadmium are four types of batteries used in radio equipment.

Figure 25 – Displayed from Left to Right is a 9 Volt Alkaline, a 12 Volt 1.3 Amp/hour Sealed Lead Acid, a 1.2 Volt Nickel-cadmium size AA and a 7.3 Volt 1 Amp/Hour Lithium-ion camera battery. Photo by N5IUT

The voltage per cell of a fully charged nickel-cadmium battery is 1.2 volts.

Remember that Carbon-zinc batteries are not designed to be re-charged.

To keep rechargeable batteries in good condition and ready for emergencies you should inspect them for physical damage, replace them when necessary, store them in a cool dry location and give them a maintenance recharge at least every 6 months.

The best way to get the most amount of energy from a battery is to draw current from the battery at the slowest rate needed.

Frequency:
Frequency describes the number of times that an alternating current flows back and forth per second. The Hertz is the standard unit of frequency. Frequency in an equation is expressed as the lower case letter **f** but when written the abbreviation **Hz** is used.

Think of a station on 146.88 MHz as an example of a frequency. A frequency of **146.88 MHz** can also be expressed as **146,880,000 Hz** or **cycles per second**. A frequency of **60 Hz** can also be stated as **60 cycles per second**.

50 to 54 MHz is the frequency range of the **6 meter** band.
144 to 148 MHz is the frequency range of the **2 meter** band.
420 to 450 MHz is the frequency range of the **70 centimeter** band.

Wavelength:
Wavelength (λ) is the distance a radio wave travels during one complete cycle. Radio waves travel through space at the speed of light(c).

The formula for converting a frequency to a wavelength in meters is **300 divided by the frequency in megahertz**. For example 300 divided by 146.88 MHz equals 2.04 meters. Thus one complete cycle of a signal at 146.88 MHz travels at the speed of light 2.04 meters. $c/f=\lambda$
300/146.88MHz=2.04 meters

The physical length of the wave is often used to identify the different bands amateur radio operators use. Examples are 6 meters (50 to 54 MHz), 2 meters (144 to 148 MHz) and 70 centimeters (430 MHz to 450MHz).

Electromagnetic waves that oscillate at more than 20,000 times per second as they travel through space are generally referred to as radio waves.

Wavelength vs. Frequency:
Wavelengths get shorter as frequencies increase. One way to think of this is: Low frequency speakers "woofers" have very long wavelengths and large speakers and enclosures. High frequency speakers "tweeters" have much shorter wavelengths and smaller speakers and enclosures. As the frequency increases the wavelength decreases.

Audio Frequency (Voice):
Voice frequencies are sound waves in the range between 300 and 3000 Hertz.

Radio Basics:

Receivers are used to convert radio signals into sounds we can hear.

Figure 26 - Hallicrafters S-38E General coverage Receiver. Photo by N5IUT

A transmitter is used to convert sounds from our voice into radio signals.

A receiver and a transmitter combined into one device is called a transceiver.

Figure 27 - Elecraft K2 HF Transceiver. Photo by N5IUT

Radio operators use a Power Supply to convert the alternating current from a wall outlet into low-voltage direct current.

Figure 28 – Two 12 Volt regulated power supplies. Photos by N5IUT

Amplifier:

To increase the output of a 10 watt radio to 100 watts an amplifier can be added between the radio and the antenna.

Metric Conversion Factors:

Prefix	Symbol		Multiplication Factor
mega	M	10^6	1,000,000
kilo	k	10^3	1,000
(unit)		10^0	1
milli	m	10^{-3}	0.001
micro	μ	10^{-6}	0.000001

Figure 29 - Metric Conversion Factors.

How many milliamperes is the same as 1.5 amperes? 1500 milliamperes

What is another way to specify the frequency of a radio signal that is oscillating at 1,500,000 Hertz? 1500 kHz

How many volts are equal to one kilovolt? One thousand volts

How many volts are equal to one microvolt? One one-millionth of a volt

How many watts does a hand-held transceiver put out if the output power is 500 milliwatts? 0.5 watts

Chapter 4

Review Questions

Answers in Appendix A

1. What is the name for the flow of electrons in an electric circuit?
A. Voltage
B. Resistance
C. Capacitance
D. Current

2. What is the standard unit of frequency?
A. The megacycle
B. The Hertz
C. One thousand cycles per second
D. The electromagnetic force

3. What is the term used to describe opposition to current flow in ordinary conductors such as wires?
A. Inductance
B. Resistance
C. Counter EMF
D. Magnetism

4. Electromagnetic waves that oscillate more than 20,000 times per second as they travel through space are generally referred to as what?
A. Gravity waves
B. Sound waves
C. Radio waves
D. Gamma radiation

5. How fast does a radio wave travel through space?
A. At the speed of light
B. At the speed of sound
C. Its speed is inversely proportional to its wavelength
D. Its speed increases as the frequency increases

6. What is the frequency range of the 70 centimeter band in the United States?
A. 144 to 148 MHz
B. 222 to 225 MHz
C. 420 to 450 MHz
D. 50 to 54 MHz

7. What is used to convert sounds from our voice into radio signals?
A. Transmitter
B. Receiver
C. Speaker
D. Antenna

8. Which of the battery types listed below offers the longest life when used with a hand-held radio, assuming each battery is the same physical size?
A. Lead-acid
B. Alkaline
C. Nickel-cadmium
D. Lithium-ion

9. What is required to keep rechargeable batteries in good condition and ready for emergencies?
A. They must be inspected for physical damage and replaced if necessary
B. They should be stored in a cool and dry location
C. They must be given a maintenance recharge at least every 6 months
D. All of these answers are correct

10. What formula is used to calculate resistance in a circuit?
A. Resistance (R) equals voltage (E) multiplied by current (I)
B. Resistance (R) equals voltage (E) divided by current (I)
C. Resistance (R) equals voltage (E) added to current (I)
D. Resistance (R) equals voltage (E) minus current (I)

11. What is the current flow in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms?
A. 9600 amperes
B. 200 amperes
C. 0.667 amperes
D. 1.5 amperes

12. What is the voltage across the resistor if a current of 2 amperes flows through a 10 ohm resistor?
A. 20 volts
B. 0.2 volts
C. 12 volts
D. 8 volts

13. How much power is being used in a circuit when the voltage is 120 volts DC and the current is 2.5 amperes?
A. 1440 watts
B. 300 watts
C. 48 watts
D. 30 watts

14. How can you determine how many watts are being drawn by your transceiver when you are transmitting?
A. Measure the DC voltage and divide it by 60 Hz
B. Check the fuse in the power leads to see what size it is
C. Look in the Radio Amateur's Handbook
D. Measure the DC voltage at the transceiver and multiply by the current drawn when you transmit

15. How many watts does a hand-held transceiver put out if the output power is 500 milliwatts?
A. 0.02 watts
B. 0.5 watts
C. 5 watts
D. 50 watts

Chapter 5

Repeaters, radio operation, controls, and trouble shooting

Microphones, Speakers and Headphones:
A microphone connects to a transmitter in a basic amateur radio station for phone (voice) operation. The microphone converts your voice into electrical signals. At the receiving station a speaker or headphones convert electrical signals to sound waves

Figure 30 - Photo by N5IUT

If a speaker from a receiving radio is too close to the microphone transmitting, Audio Feedback will result.

Ways to reduce audio feedback are to use headphones or to separate the microphone from the speaker a greater distance or to lower the speaker volume. Headphones can also be used in noisy areas to improve the operators' ability to copy signals.

Regulated Power Supply:
To protect equipment from voltage fluctuations use a regulated power supply for all communications equipment.

Figure 31 - Regulated DC Power supply. Photo by N5IUT

Emissions and RF Overload:
Spurious emissions can be created by your transmitter. These emissions are signals that are not on the frequency you wish to operate on and can cause interference to others trying to use their radios. The best way to reduce spurious emissions is to install a filter at the transmitter.

Another problem that can occur is RF Overload. If you are using a 2-meter transmitter near a TV, the TV will try to receive the 2-meter signal. One way to help the TV to not be bothered by the 2-meter transmitter is to install a notch filter on the TV's antenna jack. This notch filter should be tuned to the 2-meter band and help block the 2-meter transmissions from the TV receiver but will allow the TV signals trough.

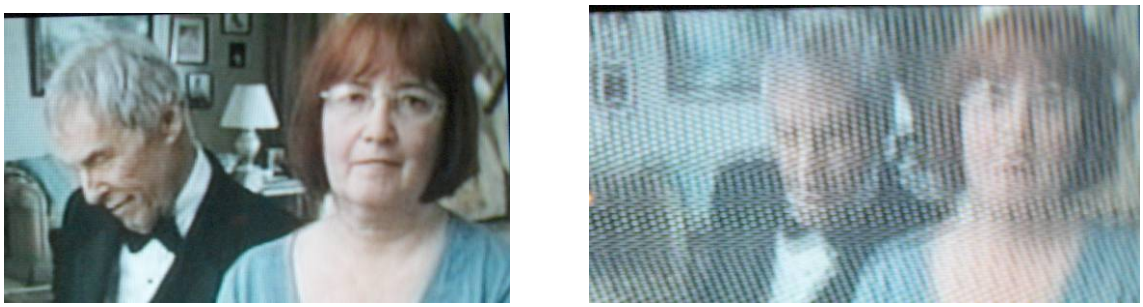


Figure 32 - TV with normal picture and TV with 2 meter interference. Photo by N5IUT

Photo of normal TV reception and of TVI on cable channel 18 using 100mW of power on 146.28 MHz by N5IUT (FYI, I identified my test transmission)

Packet Radio and Data Transmissions:
In the 1980's a new mode for amateur radio started called Packet Radio. Packet radio is easy to operate due to protocols and hardware developed by amateur radio operators for amateur radio operators. Building on the pioneering work from Montreal and Vancouver, Canada the Tucson Amateur Packet Radio (TAPR) group in Arizona started developing the protocols, hardware and software that is still used today.

Figure 33 - Original TNC 1 from 1982. Photo by N5IUT

Using packet radio one amateur station can send text, chat or send files to another amateur station error free. This activity is slow by today's standards but still has many uses such as finding resources like busses or medical personnel at a marathon using Automatic Position Reporting System (APRS).

A simple packet radio station consists of a computer terminal (laptop), a Terminal Node Controller (TNC) and a radio. You can send text and receive text on the computer and then it is processed on the Terminal Node Controller (TNC). The TNC is wired to the radio and transmits your text to another connected station.

Figure 34 - A Kantronics KPC-3 TNC. Photo by N5IUT

A microphone is not required since the audio coming to and from the radio is sent to the Terminal Node Controller (TNC).

Software has now been developed to utilize a Computer and a Sound Card to send and receive Packet Radio. This same setup can be used for many other modes that used to take dedicated hardware such as Radio Teletype (RTTY) and Slow Scan TV (SSTV). To operate a Sound Card mode this one needs to connect the computer Sound Card to the Radio. You can build or buy these interfaces as required for your radio.

Signal reports:
If another operator tells you he is hearing a variable high-pitched whine on the signals from your mobile transmitter the power wiring for your radio is picking up noise from the vehicle's electrical system.

If you receive a signal report that your SSB signal is very garbled and breaks up, RF energy may be getting into the microphone circuit and causing feedback.

If you receive a report that your signal through the repeater is distorted or weak, your transmitter may be slightly off frequency, your batteries may be running low or you could be in a bad location.

Operation notes and procedures:
If a transmitter is operated with the microphone gain set too high it may cause the signal to become distorted and unreadable.

The operator of a VHF/UHF transceiver can store information about repeater systems in memory. This is a great help since repeaters require certain settings for use. Storing in memory the transmit frequency, receive frequency, CTCSS (Continuous Tone Coded Squelch System also call PL or Private Line®) tone frequency and transmit power level makes using repeaters much easier.

Storing the frequencies in memory channels enables quick access to favorite frequencies on your transceiver.

Most radios have two ways to select a frequency. It can be either entered directly on a keypad or by turning the VFO knob. The VFO that most people are familiar with is the "TUNE" knob on a car radio. Buttons labeled "up" and "down" on many radio microphones make it easy to change memories and frequency. This is just like choosing different radio stations you store in the on the car radio buttons.

Figure 35 - Microphone for controlling a radio and the Tune knob on a car radio.

When no signal is being received you can use the squelch control to quiet the transceiver.

To improve the reception if the station is hard to copy because of ignition noise interference turn on the noise blanker.

The purpose of the "shift" control found on many VHF/UHF transceivers is to adjust the offset between transmit and receive frequency for repeater operation.

Receiver Incremental Tuning (RIT) allows the operator to adjust the receive frequency independently without moving the transmit frequency.

Figure 36 - The small knob on the right adjusts the RIT
when the RIT button beside it is activated. Photo by K3DIO

The "step" menu function sets the tuning rate when changing frequencies.

Because of the complexity of many radios each button can have many functions. To access some of these alternate functions you might have to press the "F" or function key.

Digital vs. Analog Signals:
One of the reasons to use digital signals instead of analog signals to communicate with another station is that many digital systems can automatically correct errors caused by noise and interference.

Repeater Operations:
The best way to extend the usable range of mobile and low-power stations on VHF and higher frequencies is to use a repeater. A repeater receives on one frequency and retransmits the audio received on another frequency.

The most important information to know before using a repeater is the repeater input and output frequencies. The next item to know is the repeater's offset. For two meters (144 MHz to 148 MHz) the most common offset is 0.6 MHz and for the 70 centimeter band (430 MHz to 450 MHz) the offset is normally 5.0 MHz.

For example if a hand held radio transmitting FM on 146.34 MHz can be received by the repeater listening on 146.34 then the repeater can send that audio to its transmitter on 146.94 MHz. After transmitting with a hand held you would need to listen to the repeater's transmitter on 146.94 MHz to hear any other stations reply through the repeater.

Repeater Operations continued:
To keep the repeater transmitter from overpowering the repeater receiver a number of methods can be used. The most popular method is to use a duplexer filter. This type of filter blocks the repeater transmitter's signal from the repeaters receiver.

Repeaters use a controller to enable and disable certain features and functions. One of the features is called a courtesy tone. A courtesy tone is used to indicate when a station's transmission is complete.

You should pause briefly between transmissions when using a repeater to listen for anyone wanting to break in.

Simplex Operation:
Transmitting and receiving on the same frequency is called simplex operation. One reason to use simplex instead of a repeater is to avoid tieing up the repeater when direct contact is possible.

You can find out if you can communicate with a station using simplex instead of a repeater by listening to the input frequency of the repeater. If you can hear the station that you are talking to on the input frequency then you can communicate to them simplex.

Linked Repeaters:
A "linked repeater system" is a series of repeaters that can be connected to one another to provide users with a wider coverage.

Repeater Coordination:
The main reason repeaters should be approved by the local frequency coordinator before being installed is that coordination minimizes interference between repeaters and makes the most efficient use of available frequencies. Also, in a dispute or interference complaint with the FCC the coordinated repeater has a better standing.

Repeater access limits:
Access to any repeater may be limited by the repeater owner. A closed repeater is generally restricted to the members of a club or group that owns or controls the repeater.

Interference causes and remediation:
"Fundamental Overload" in reference to a receiver is interference caused by very strong signals from a nearby source. It is very similar to front end overload discussed in the subelement T4 notes.

The most likely cause of telephone interference from a nearby transmitter is that the transmitter's signals are causing the telephone to act like a radio receiver.

One step when attempting to cure a radio frequency interference (RFI) problem in a nearby telephone is to install an RF filter at the telephone

Snap-on ferrite chokes, low-pass filters and high-pass filters may be useful in correcting a radio frequency interference problem.

Figure 37 - Three types of Snap-on Chokes. Photo by N5IUT

The first action you should take if someone tells you that you are causing interference is to make sure that your station is operating properly and make sure it meets the standards of good amateur practice.

If a neighbors TV reception is having problems when you transmit, see if your transmitter causes interference to your own television.

Interference causes and remediation continued:
If a "Part 15" device in your neighbor's home is causing harmful interference to your amateur station you should work with your neighbor to identify the offending device, politely inform your neighbor about the rules that require him to stop using the device if it causes interference, check your station and make sure it meets the standards of good amateur practice.

Figure 38 - Part 15 Label from a Clock Radio. Photo by N5IUT

FYI, "Doppler Shift" in amateur radio normally is a concern of operators working satellites in space. Doppler Shift has nothing to do with RF Interference.

For more information on Satellites see Chapter 7.

Figure 39 - W5IU works a LEO satellite at the Austin Summerfest 2006.

Chapter 5

Review Questions

Answers in Appendix A

1. What is the term used to describe what happens when a microphone and speaker are too close to each other?
A. Excessive wind noise
B. Audio feedback
C. Inverted signal patterns
D. Poor electrical grounding

2. Where must a filter be installed to reduce spurious emissions?
A. At the transmitter
B. At the receiver
C. At the station power supply
D. At the microphone

3. What is connected between the transceiver and computer terminal in a packet radio station?
A. Transmatch
B. Mixer
C. Terminal Node Controller
D. Antenna

4. What is the purpose of the squelch control on a transceiver?
A. It is used to set the highest level of volume desired
B. It is used to set the transmitter power level
C. It is used to adjust the antenna polarization
D. It is used to quiet noise when no signal is being received

5. What is the purpose of the "shift" control found on many VHF/UHF transceivers?
A. Adjust transmitter power level
B. Change bands
C. Adjust the offset between transmit and receive frequency
D. Change modes

6. What does RIT mean?
A. Receiver Input Tone
B. Receiver Incremental Tuning
C. Rectifier Inverter Test
D. Remote Input Transmitter

7. Which of the following is the most important information to know before using a repeater?
A. The repeater input and output frequencies
B. The repeater call sign
C. The repeater power level
D. Whether or not the repeater has an autopatch

8. What is the meaning of the term simplex operation?
A. Transmitting and receiving on the same frequency
B. Transmitting and receiving over a wide area
C. Transmitting on one frequency and receiving on another
D. Transmitting one-way communications

9. What is the main reason repeaters should be approved by the local frequency coordinator before being installed?
A. Coordination minimizes interference between repeaters and makes the most efficient use of available frequencies
B. Coordination is required by the FCC
C. Repeater manufacturers have exclusive territories and you could be fined for using the wrong equipment
D. Only coordinated systems will be approved by the officers of the local radio club

10. What is the most likely cause of telephone interference from a nearby transmitter?
A. Harmonics from the transmitter
B. The transmitter's signals are causing the telephone to act like a radio receiver
C. Poor station grounding
D. Improper transmitter adjustment

11. Which of the following may be useful in correcting a radio frequency interference problem?
A. Snap-on ferrite chokes
B. Low-pass and high-pass filters
C. Notch and band-pass filters
D. All of these answers are correct

12. What is one of the reasons to use digital signals instead of analog signals to communicate with another station?
A. Digital systems are less expensive than analog systems
B. Many digital systems can automatically correct errors caused by noise and interference
C. Digital modulation circuits are much less complicated than any other types
D. All digital signals allow higher transmit power levels

Chapter 6

Different phone (voice) and data modes of communication such as Amplitude Modulation (AM), Frequency Modulation (FM), Single Side Band (SSB), linking systems over the Internet, data communications and image communications

Single Side Band:
All voice transmissions by radio are "phone" transmissions

Single sideband is a form of Amplitude Modulation (AM). For a video on Amplitude Modulation go to http://HamElmer.com and click on the Video Library link.

Single Side Band (SSB) is the most often used for long distance and weak signal contacts on the VHF and UHF bands. The primary advantage of single sideband over FM for voice transmissions is that SSB signals use much less bandwidth than FM signals.

Upper sideband is normally used for VHF and UHF SSB communications. Between 2 and 3 kHz is the approximate bandwidth of a single-sideband voice signal.

Frequency Modulation:
Frequency Modulation (FM) is most commonly used for VHF and UHF voice repeaters. The approximate bandwidth of a frequency-modulated voice signal is between 5 and 15 kHz. For a video on Frequency Modulation go to http://HamElmer.com and click on the Video Library link.

Bandwidth:
The normal bandwidth required for a conventional fast-scan TV transmission using combined video and audio on the 70-centimeter band is about 6 MHz. This contrasts with CW that is one of the narrowest bandwidth modes, typically about 100 to 250 Hz.

Mode	Bandwidth
CW	100 to 250 Hz
SSB	2 to 3 kHz
FM	5 to 15 kHz
Fast Scan TV	6 MHz

Figure 40 - Mode and Bandwidth Table

EchoLink and IRLP:
EchoLink allows computer-to-radio linking for voice transmission. Internet Radio Linking Project (IRLP) is a method of linking between two or more amateur stations using the Internet. Typically this is done between repeaters. The repeaters can be across town or around the world.

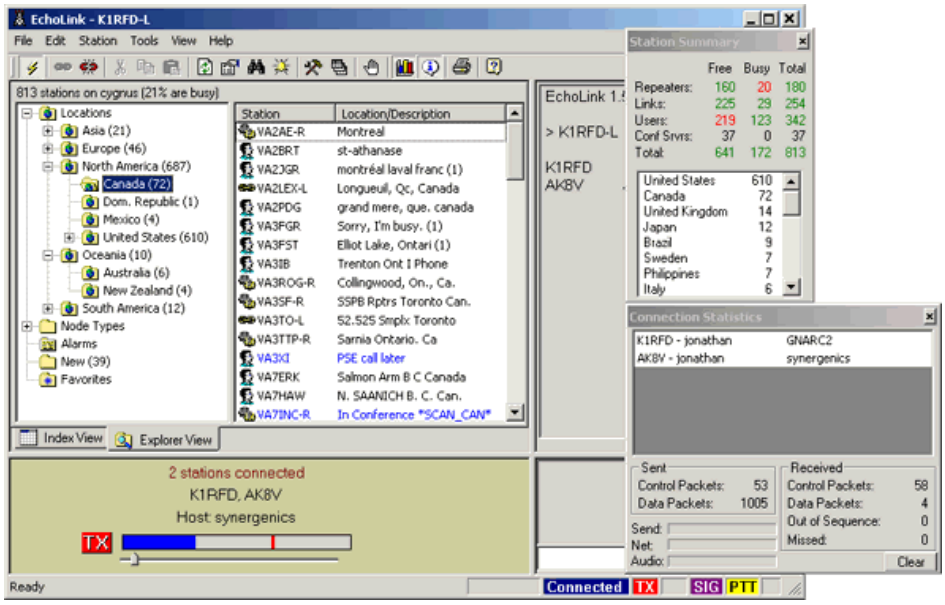


Figure 41 - Screenshot from the http://www.echolink.org/ web site.

EchoLink information is transmitted between stations using the Internet and can be used by any licensed amateur radio operator.

VoIP:
Both EchoLink and IRLP use Voice over Internet protocol (VoIP) technology.

You can find a list of active nodes using VoIP in a repeater directory or on the Internet.

IRLP:
When using a portable transceiver you can select a specific IRLP node by using the keypad to transmit the IRLP node numbers.

If you hear a brief tone followed by a station from Russia calling CQ on a local 2-meter repeater, the repeater is connected via the Internet to the DX station.

Internet Gateway:
The name given to an amateur radio station that is used to connect other amateur stations to the Internet is a "gateway". This term can be used for APRS, IRLP and many other modes.

Packet Radio:
Packet radio is a great example of a digital communications method. Automatic Position Reporting System (APRS) mode can broadcast your location on a regular interval. This information can then be used to coordinate activities of a group such as search and rescue or providing safety information for runners of a race. It was also used to find stolen amateur radio operators cars before commercial products were available.

A global positioning system (GPS) receiver is required along with a TNC and your normal radio for sending automatic location reports.

NTSC:
A standard **fast scan television** signal is denoted by the standard term of NTSC. NTSC specifies the signal needed to provide a US television picture.

Figure 42 - A regular television uses the NTSC standard in the United States. Photo by N5IUT

Data modes on 1.25 meters:
Point-to-point digital message forwarding mode may be used by a Technician class operator in the 219 - 220 MHz frequency range.

PSK:
Phase Shift Keying (PSK) denotes a signal that uses a shift in the phase of a signal to transmit data. PSK31 is a low-rate data transmission mode that works well in noisy conditions

Morse Code:
You should not send Morse code faster then the speed that you can reliably receive. A practical reason for being able to copy CW when using repeaters is to decode the ID sent in Morse code.

Figure 43 - J-38 Morse code Key. Photo by N5IUT

Q Signals:
The "Q" signal used to indicate that you are receiving interference from other stations is **QRM**. The "Q" signal used to indicate that you are changing frequency is **QSY**.

Notes

Chapter 6

Review Questions

Answers in Appendix A

1. Which of the following is a form of amplitude modulation?
A. Frequency modulation
B. Phase modulation
C. Single sideband
D. Phase shift keying

2. Which emission type has the narrowest bandwidth?
A. FM voice
B. SSB voice
C. CW
D. Slow-scan TV

3. What is the normal bandwidth required for a conventional fast-scan TV transmission using combined video and audio on the 70-centimeter band?
A. More than 10 MHz
B. About 6 MHz
C. About 3 MHz
D. About 1 MHz

4. What technology do Echolink and IRLP have in common?
A. Voice over Internet protocol
B. Ionospheric propagation
C. AC power lines
D. PSK31

5. What are you listening to if you hear a brief tone and then a station from Russia calling CQ on a 2-meter repeater?
A. An ionospheric band opening on VHF
B. A prohibited transmission
C. An Internet linked DX station
D. None of these answers are correct

6. When using a portable transceiver how do you select a specific IRLP node?
A. Choose a specific CTCSS tone
B. Choose the correct DSC tone
C. Access the repeater autopatch
D. Use the keypad to transmit the IRLP node numbers

7. What type of transmission is indicated by the term NTSC?
A. A Normal Transmission mode in Static Circuit
B. A special mode for earth satellite uplink
C. A standard fast scan color television signal
D. A frame compression scheme for TV signal

8. What is PSK31?
A. A high-rate data transmission mode used to transmit files
B. A method of reducing noise interference to FM signals
C. A type of television signal
D. A low-rate data transmission mode that works well in noisy conditions

9. What is the "Q" signal used to indicate that you are changing frequency?
A. QRU
B. QSY
C. QSL
D. QRZ

Chapter 7

Field operations, radio direction finding, radio control, contests, special event stations, satellite operations and operating protocols

Field Operations:
When operating a hand-held transceiver away from home take one or more fully charged spare battery packs. Use an external antenna instead of the rubber-duck antenna to make the signal from a hand-held radio stronger when operating in the field.

Figure 44 - San Antonio Radio Club - Field Day 2003. Photo by N5IUT

One item that you do not need for field operations is a 1500 watt output linear amplifier. An amplifier of that size takes a lot of power and is not needed for regional communications.

Figure 45 - Henry 3K Liner Classic (left) Headset/Microphone (right).

As stated in another chapter, a combination headset and microphone would be a good thing to have when operating from a location that includes lots of crowd noise.

Radio Direction Finding:
Radio direction finding (RDF) is used to locate transmitters, RF noise, interference and jamming. Radio direction finding can be used to find lost and downed airplanes, lost hikers and boats in distress. A directional antenna is most useful for hidden transmitter hunting.

Figure 46 - KA8VIT and a RDF 3 element beam made from a tape measure. Photo by KA8VIT

Bill, KA8VIT has web page for building the antenna pictured above at the `http://ka8vit.com/TMBeam/TMBeam.htm` address. The beam has a 50dB null on the back end of its pattern that is used to find the direction of the transmitter.

Contesting and Special Event Stations:
Contesting is a popular operating activity that involves contacting as many stations as possible during a specified period of time. Usually the contesters exchange information such as signal reports, station location or grid locator. A grid locator is a letter-number designator assigned to a geographic location.

A special event station is a temporary station that operates in conjunction with an activity of special significance.

Satellite Operations:
AMSAT is the group that coordinates the building and launching of the largest number of amateur radio satellites.

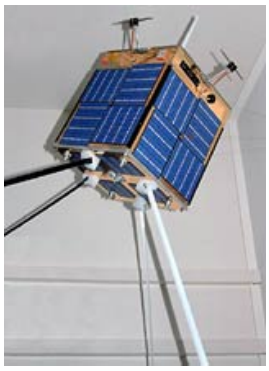


Figure 47 - KiwiSat is set to launch on June 15, 2008. AMSAT-New Zealand

Any amateur whose license allows them to transmit on the satellite uplink frequency can use amateur satellites. Always use the minimum amount of power needed to complete the contact when using an amateur satellite. If you use too much power other stations will not be able to use the satellite. Using satellites you can talk to amateur radio operators in other countries.

A satellite beacon contains information about a satellite. The beacon can contain its systems status and current operating modes.

Use a satellite tracking program to determine when you can try to access an amateur satellite. You must have line of sight to work the satellite.

The initials **LEO** tell you that the satellite is in a **Low Earth Orbit**.

Any amateur with a Technician or higher class license can make contact with an astronaut on the International Space Station using amateur radio frequencies.

Doppler shift is a change in signal frequency caused by the satellite's motion through space relative to your position.

The satellite sub-band is a portion of a band where satellite operations are permitted. The satellite sub-band on 70-CM is 435 to 438 MHz.

Radio Controlled Models:
The maximum power allowed when transmitting telecommand signals to radio controlled models is 1 watt. A label indicating the licensee's call sign and address must be affixed to the transmitter when sending commands to a radio control model using amateur frequencies.

Figure 48 - A transmitter with call sign and radio controlled model.

Notes

Chapter 7

Review Questions

Answers in Appendix A

1. How can you make the signal from a hand-held radio stronger when operating in the field?
A. Switch to VFO mode
B. Use an external antenna instead of the rubber-duck antenna
C. Stand so there is a metal building between you and other stations
D. Speak as loudly as you can

2. What is a popular operating activity that involves contacting as many stations as possible during a specified period of time?
A. Contesting
B. Net operations
C. Public service events
D. Simulated emergency exercises

3. What is a grid locator?
A. A letter-number designator assigned to a geographic location
B. Your azimuth and elevation
C. Your UTC location
D. The 4 digits that follow your ZIP code

4. What class of license is required to use amateur satellites?
A. Only Extra class licensees can use amateur radio satellites
B. General or higher class licensees who have a satellite operator certification
C. Only persons who are AMSAT members and who have paid their dues
D. Any amateur whose license allows them to transmit on the satellite uplink frequency

5. What is Doppler shift?
A. A change in the satellite orbit
B. A mode where the satellite receives signals on one band and transmits on another
C. A change in signal frequency caused by motion through space
D. A special digital communications mode for some satellites

6. What is the satellite sub-band on 70-CM?
A. 420 to 450 MHz
B. 435 to 438 MHz
C. 440 to 450 MHz
D. 432 to 433 MHz

Notes

Chapter 8

Emergency operations, Tactical call signs, RACES/ARES and Net operations

Declaration of a Communications Emergency:
Any special conditions and rules to be observed during the emergency are included in a Federal Communications Commission (FCC) declaration of a temporary state of communication emergency. After the FCC has declared a communications emergency you must avoid those frequencies dedicated to supporting the emergency unless you are participating in the relief effort. An FCC declaration of a communications emergency is legally required to restrict a frequency to emergency-only communication.

Only when specially authorized by the FCC, or in an actual emergency are amateur stations allowed to communicate with stations operating in other radio services.

Figure 49 - Hurricane Katrina at Category 4, Max sustained wind 175MPH 2005.08.28 at 1515Z GOES-12 1 km visible imagery. NOAA

No station has exclusive use of a frequency if the FCC has not declared a communication emergency.

RACES:
Radio Amateur Civil Emergency Service (RACES) organizations are restricted to serving local, state, and the Federal Emergency Management Agency (FEMA).

You must register with the responsible civil defense organization before you can participate in RACES activities.

ARES:
Amateur Radio Emergency Service (ARES) supports non-governmental agencies like the Red Cross and National Weather Service.

You must have an amateur radio license before you can join an ARES group.

Operations and Rules:
Casual conversation between stations during a public service event should be avoided because idle chatter may interfere with important traffic.

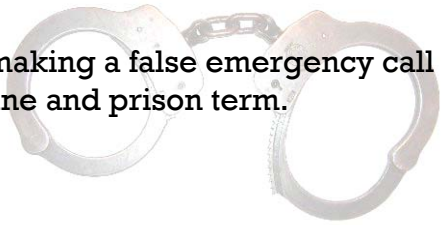
If a reporter asks to use your amateur radio transceiver to make a news report, advise them that the FCC prohibits such use.

Emergency Operations:
If you are in contact with another station and an emergency call is heard you should stop your contact immediately and take the emergency call.

If you hear someone reporting an emergency assume the emergency is real and act accordingly.

To initiate an emergency call on amateur radio say "Mayday, Mayday, Mayday" followed by "any station come in please" and identify your station. Transmitting on any radio "Mayday, Mayday, Mayday" is like dialing 911.

To help coordinate public-service communications and provide more efficient net operations use tactical call signs such as "command post" or "weather center" during an emergency. Remember that tactical call signs do not take the place of proper identification every ten minutes as required by Part 97.



The penalties for making a false emergency call include having your license revoked, a large fine and prison term.

Emergency communications has priority at all times and on all frequencies in the Amateur Radio Service.

To be prepared for an emergency situation where your assistance might be needed one should check at least twice a year to make sure you have all of your emergency response equipment and know where it is, make sure you have a way to run your equipment if there is a power failure in your area and participate in drills that test your ability to set up and operate in the field.

You may use your amateur station to transmit a "SOS" or "MAYDAY" signal when there is immediate threat to human life or property.

Figure 50 - KD5UT and WB4WBL, Hancock County, Mississippi outside the Emergency Operations Center right after Hurricane Katrina. Photo by N4MAA

Danny Conner KD5UT is standing using a TRW Flyaway HF sending traffic and seated at a kiddies picnic table operating WINLINK 2000 is Jim La Follett WB4WBL.

Some alternate sources of power to operate your radio equipment during emergencies can be the battery in a car or truck, a bicycle generator or a portable solar panel.

You may use non-amateur frequencies or equipment to call for help in a situation involving immediate danger to life or property. You can use a modified amateur radio transceiver to transmit on the local fire department frequency in an emergency.

In a genuine emergency you may use any means at your disposal to call for help on any frequency.

Net Operations:
Emergency traffic has the highest priority.

Personal information concerning victims should not be transmitted over amateur radio frequencies during emergencies.

Once you have checked in do not transmit on the net frequency until asked to do so by the net control station. This should minimize disruptions to the emergency traffic net.

Net Operations continued:
One thing that must be included when passing emergency messages is the name of the person originating the message.

One way to reduce the chances of casual listeners overhearing sensitive emergency traffic is to pass messages using a non-voice mode such as packet radio or Morse code.

A strong and clear signal is of primary importance for a net control station.

The net control station should stop all net activity if someone breaks in with emergency traffic until the emergency has been handled.

If a large scale emergency has just occurred and no net control station is available you should open the emergency net immediately and ask for check-ins.

Message Handling:
The preamble of a message contains the information needed to track the message as it passes through the amateur radio traffic handling system.

The "check" of a message is a count of the number of words in the message.

The recommended guideline of 25 words is the maximum to be included in the text of an emergency message.

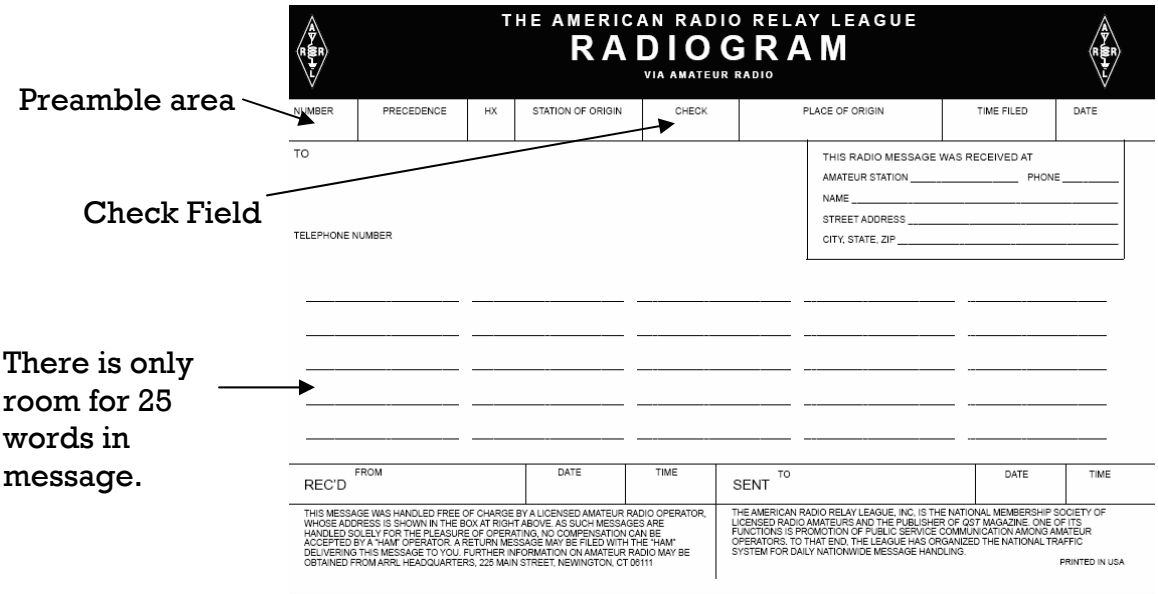


Figure 51 - ARRL Radiogram. For the complete image go to http://www.arrl.org/FandES/field/forms on the ARRL Web site.

Chapter 8

Review Questions

Answers in Appendix A

1. Under what conditions are amateur stations allowed to communicate with stations operating in other radio services?
A. When communicating with the space shuttle
B. When specially authorized by the FCC, or in an actual emergency
C. When communicating with stations in the Citizens Radio Service
D. When a commercial broadcast station is reporting news during a natural disaster

2. What is legally required to restrict a frequency to emergency-only communication?
A. An FCC declaration of a communications emergency
B. Determination by the designated net manager for an emergency net
C. Authorization by an ARES/RACES emergency coordinator
D. A Congressional declaration of intent

3. When must priority be given to stations providing emergency communications?
A. Only when operating under RACES
B. Only when an emergency has been declared
C. Any time a net control station is on the air
D. At all times and on all frequencies

4. What is the primary function of RACES in relation to emergency activities?
A. RACES organizations are restricted to serving local, state, and federal government emergency management agencies
B. RACES supports agencies like the Red Cross, Salvation Army, and National Weather Service
C. RACES supports the National Traffic System
D. RACES is a part of the National Emergency Warning System

5. What could be used as an alternate source of power to operate radio equipment during emergencies?
A. The battery in a car or truck
B. A bicycle generator
C. A portable solar panel
D. All of these answers are correct

6. When can you use non-amateur frequencies or equipment to call for help in a situation involving immediate danger to life or property?
A. Never; your license only allows you to use the frequencies authorized to your class of license
B. In a genuine emergency you may use any means at your disposal to call for help on any frequency
C. When you have permission from the owner of the set
D. When you have permission from a police officer on the scene

7. What type of messages should not be transmitted over amateur radio frequencies during emergencies?
A. Requests for supplies
B. Personal information concerning victims
C. A schedule of relief operators
D. Estimates of how much longer the emergency will last

8. What is of primary importance for a net control station?
A. A dual-band transceiver
B. A network card
C. A strong and clear signal
D. The ability to speak several languages

9. What is the preamble of a message?
A. The first paragraph of the message text
B. The message number
C. The priority handling indicator for the message
D. The information needed to track the message as it passes through the amateur radio traffic handling system

Chapter 9

Antennas, propagation feedlines and matching

Antennas:
"Beam" antennas concentrate signals in one direction. Antennas such as the quad, Yagi, and dish are directional or beam antennas.


Figure 52 - HF Quad and 6 Meter Yagi. Photos by WA5UTK and K3DIO

A vertical antenna consists of a single element mounted perpendicular to the Earth's surface.

A horizontal antenna is a simple dipole mounted so the elements are parallel to the Earth's surface.


Figure 53 - Buddi Pole HF dipole above and 440 MHz vertical on the right. Photos by K3DIO

The "rubber duck" antenna supplied with most hand held radio transceivers does not transmit or receive as effectively as a full sized antenna.

The physical size of a half-wave dipole antenna ***becomes shorter as the frequency increases***.

The vertical 5/8 wavelength antenna radiation pattern concentrates energy at lower angles than you have with a 1/4 wavelength vertical antenna.

Dummy Load:
A dummy load's primary purpose is to dissipate the transmitter power as heat and not to radiate interfering signals when making tests.

Ideal antennas vs. Practical Antennas:
The fictional ideal antenna uses infinitely thin wire suspended in space. A practical antenna uses real copper wire, aluminum rod or tubing and is suspended over ground or near other objects. Because of the larger wire and interaction with other objects real antennas are about 5% shorter than ideal antennas.

A meter equals 39.37 inches but for practical proposes lets multiply 39.37 inches (a real meter in inches) times .95 and get about 37.4 inches.
39.37inches x 0.95 = 37.4

For the following equations let's use 37.4 inches for a practical meter for making antennas.

Antenna Length Questions:
So if asked: What is the approximate length, in inches, of a quarter wavelength vertical antenna for 146 MHz?

To start, 146 MHz is in the two meter band and our practical meter is 37.4 inches. 2 (for the two meter band) times 37.4 equal 74.8 inches. That answer gives us the full wave at 2 meters. The question asks for a quarter wave antenna so we need to divide 74.8 inches by 4 and that equals 18.7 inches. As we round up 18.7 inches we see one answer is 19 inches. 19 inches is the correct answer.

To review we use 37.4 inches for a practical meter for antennas.
2 x 37.4 = 74.8 inches 74.8 inches divided by 4 is 18.7 inches and we see that one answer is 19 inches. The answer is **19 inches**.

What is the approximate length, in inches, of a half wavelength vertical antenna for 6 meters?
6 x 37.4 = 224.4 inches 224.4 inches divided by 2 (the question wants a half wave antenna) is 112.2 inches and we see that one answer is 112 inches.
The answer is **112 inches**

(Editors note: It is easier to memorize the answers to these two questions then the process to solve them.)

Mobile Antennas:
A magnet mount vertical antenna is one type of mobile antenna that offers good efficiency when operating mobile and can be easily installed or removed.

When using a hand held transceiver inside of a vehicle the signals can be up to 10 to 20 times weaker than if you were outside of the vehicle when using a "rubber duck" antenna. This is because with the hand held transceiver in the car the radio is operating inside a metal box. Metal in window tinting makes the car a more complete metal box and causes even higher attenuation of the signals.

Figure 54 - Mobile antennas (above) Handheld radio in car (right). Photo K3DIO

Propagation:
VHF/UHF signals not normally heard over long distances because their signals are usually not reflected by the ionosphere.

When we hear a VHF signal from a long distance the possible cause is sporadic E reflection from a layer in the ionosphere. (Editors note: This is in fact due to refraction but the test answer states "reflection")

If sudden bursts of tones or fragments of different conversations interfere with VHF or UHF communications, strong signals could be overloading the receiver and causing the undesired signals to be heard.

The radio horizon is the point where radio signals between two points are blocked by the curvature of the Earth.

If a station reports that your signals were strong just a moment ago, but now they are weak or distorted, try moving a few feet, random reflections may be causing multi-path distortion.

The shorter wavelength of the UHF signals permit easier penetration in urban areas and buildings than VHF signals.

Propagation Continued:
Keep the antenna as close to vertical as you can when using your hand-held VHF or UHF radio to reach a distant repeater. Signals could be as much as 100 times weaker if the antennas at opposite ends of a VHF or UHF line of sight radio link are not using the same polarization.

The antennas pictured to the right shows two horizontally polarized two meter beams above and below a vertically polarized two meter beam. The Amateur Operator mounted the two horizontally polarized antennas to achieve almost 3db more gain when working weak signal SSB and CW contacts. Horizontally polarized antennas pick up less man made noise since most man made noise is vertically polarized.

For ease of use, most FM repeaters are vertically polarized. So, to talk to a distant repeater they use the vertically polarized 2 meter beam in the center. Photo by N5IUT

Try using a directional antenna to find a path that reflects signals to the repeater if buildings or obstructions are blocking the direct line of sight path.

Picket fencing is a commonly used term to describe the rapid fluttering sound sometimes heard from mobile stations that are moving while transmitting

VHF and UHF Radio signals usually travel about a third farther than the visual line of sight distance between 2 stations because the Earth seems less curved to radio waves than to light.

Feedlines:
Standing wave ratio (SWR) in general terms is a measure of how well a load is matched to a transmitter.

A "1 to 1" (normally written 1:1) reading on a SWR meter indicates a perfect impedance match between the antenna and the feed line. This would indicate that all of the transmitters' power is delivered to the feedline and antenna.

A better match produces a better transfer of power.

A loose connection in your antenna or feedline might be indicated by erratic changes in SWR readings.

A 2 to 1 (2:1) SWR value is when the protection circuits in most solid-state transmitters begin to reduce transmitter power.

Power lost in a feed line is converted into heat by losses in the feedline.

Figure 55 - MFJ's Giant SWR/Wattmeter. Photo by N5IUT

One can use a directional wattmeter to determine if your feedline and antenna are properly matched.

Maintaining low SWR in an antenna system that uses coaxial cable feedline allows the efficient transfer of power and reduces losses. Losses can increase dramatically in older coaxial cables that are exposed to weather and sunlight for several years.

Moisture contamination is the most common reason for failure of coaxial cables.

The outer sheath of most coaxial cables is black in color to provide protection against ultraviolet damage.

Figure 56 - Bird Directional Wattmeter. Photo by N5IUT

50 Ohms is the impedance of the most commonly used coaxial cable in typical amateur radio installations.

Because of its ease of use and few special installation considerations coaxial cable is used more often than any other feed line for amateur radio antenna systems.

Notes

Chapter 9

Review Questions

Answers in Appendix A

1. What is a beam antenna?
A. An antenna built from metal I-beams
B. An antenna that transmits and receives equally well in all directions
C. An antenna that concentrates signals in one direction
D. An antenna that reverses the phase of received signals

2. How does the physical size of half-wave dipole antenna change with operating frequency?
A. It becomes longer as the frequency increases
B. It must be made larger because it has to handle more power
C. It becomes shorter as the frequency increases
D. It becomes shorter as the frequency deceases

3. What is a good reason not to use a "rubber duck" antenna inside your car?
A. Signals can be 10 to 20 times weaker than when you are outside of the vehicle
B. RF energy trapped inside the vehicle can distort your signal
C. You might cause a fire in the vehicle upholstery
D. The SWR might increase

4. What might be happening when we hear a VHF signal from long distances?
A. Signals are being reflected from outer space
B. Someone is playing a recording to us
C. Signals are being reflected by lightning storms in our area
D. A possible cause is sporadic E reflection from a layer in the ionosphere

5. Why do UHF signals often work better inside of buildings than VHF signals?
A. VHF signals lose power faster over distance
B. The shorter wavelength of UHF signals allows them to more easily penetrate urban areas and buildings
C. This is incorrect; VHF works better than UHF inside buildings
D. UHF antennas are more efficient than VHF antennas

6. What can happen if the antennas at opposite ends of a VHF or UHF line of sight radio link are not using the same polarization?
A. The modulation sidebands might become inverted
B. Signals could be as much as 100 times weaker
C. Signals have an echo effect on voices
D. Nothing significant will happen

7. What is the SWR value where the protection circuits in most solid-state transmitters begin to reduce transmitter power?
A. 2 to 1
B. 1 to 2
C. 6 to 1
D. 10 to 1

8. What instrument other than a SWR meter could you use to determine if your feedline and antenna are properly matched?
A. Voltmeter
B. Ohmmeter
C. Iambic pentameter
D. Directional wattmeter

9. Why is the outer sheath of most coaxial cables black in color?
A. It is the cheapest color to use
B. To see nicks and cracks in the cable
C. Black cables have less loss
D. Black provides protection against ultraviolet damage

Chapter 10

Basic safety practices working with Power, Antennas, Towers and Radio Frequency energy

Power Safety:

30 volts is a commonly accepted value for the lowest voltage that can cause a dangerous electric shock. 100 milliamperes is the lowest amount of electrical current flowing through the human body that is likely to cause death.

Always keep one hand in a pocket when working on any energized circuit. If a shock occurs this simple action should prevent the current from flowing across your heart.

The green wire in a properly wired three-wire electrical plug is the ground wire.

Figure 57 - Three wire plug. The green wire is ground. Photo by N5IUT

A fuse in an electrical circuit interrupts power in case of overload.

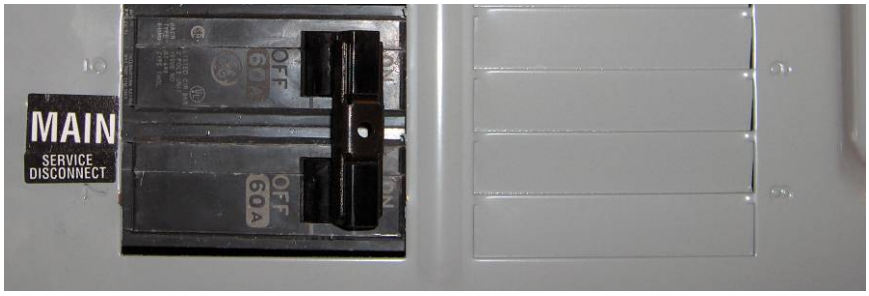


Figure 58 - Breaker box Service Disconnect on left. Photo by N5IUT

To guard against electrical shock at your station use 3-wire cords and plugs for all AC powered equipment, connect all AC powered station equipment to a common ground and use a ground-fault interrupter at each electrical outlet.

It is most important that everyone at your home should know where the emergency disconnect switch at your station is and how to use it.

Batteries:
To recharge a 12-volt battery without commercial power, connect the battery to a car's battery and run the engine.

A conventional 12-volt storage battery presents a number of hazards, it contains dangerous acid that can spill and cause injury, short circuits can damage wiring and possibly cause a fire and explosive gas can collect if not properly vented. Please use safety glasses when working with Lead Acid car batteries.

A storage battery could overheat and give off dangerous gas or explode if a battery is charged or discharged too quickly.

If you install a 20-ampere fuse in your transceiver in the place of a 5-ampere fuse the circuit could draw excessive current and cause a fire.

Power Supply:
You might receive an electric shock from stored charges in large capacitors within a power supply when it is turned off and disconnected. These capacitors can store energy for some time after the unit is turned off.

Figure 59 - Power Supply capacitors. Photo by N5IUT

Tower Safety:
To protect your head and eyes in case something accidentally falls from the tower you should wear a hard hat and safety glasses if you are on the ground helping someone work on an antenna tower. The person on the tower should also wear a hard hat to protect them from guy wires and antenna mounts when climbing.

Figure 60 - Club Station Equipment for the San Antonio Radio Club W5SC.
On top is a dual band vertical for 2 meters and 70 centimeters. The next antenna down is a horizontal 6 meter 5 element Yagi type beam and on the bottom is a HF Log Periodic Beam.
Photo by N5IUT

Inspect your safety belt (D Rings, buckles and lanyard) for damage or rot and replace any or all of it if needed.

Figure 61 - Check your safety equipment as if your life depends on it.

A good precaution to observe is to put on your hard hat, safety belt and safety glasses before climbing an antenna tower. After putting on your safety belt, test the belt and lanyards at the base of the tower before climbing.

Tower Safety continued:
Before you climb a tower arrange for a helper or observer, inspect the tower for damage or loose hardware and make sure there are no electrical storms nearby.

Before putting up an antenna it is an important consideration to make sure people cannot accidentally come into contact with any part of the antenna. Before erecting an antenna near an airport know the maximum allowed height with regard to nearby airports.

Figure 62 - Keep a First Aid nearby when doing work in the field.

When putting up an antenna tower look for and stay clear of any overhead electrical wires. Before putting up an antenna in a new area make a site survey of any hazards that exist. When erecting the antenna one person should be designated as a Safety Officer. The Safety Officer stands a distance from the antenna and observes the installation while looking for hazards.

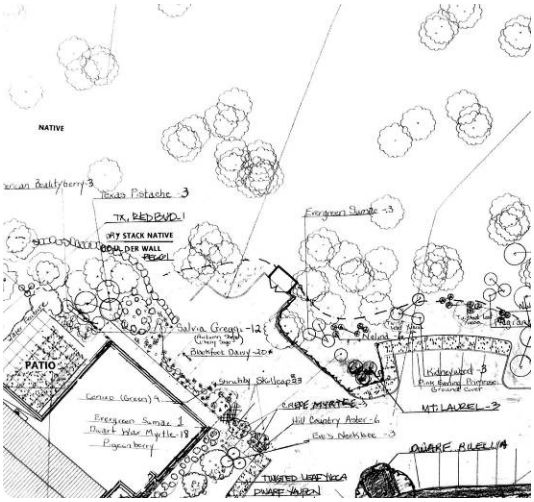


Figure 63 - Print of Field Day Area. Used for planning. Photo by N5IUT

Guy wires for an antenna tower should always be installed in accordance with the tower manufacturer's instructions.

A safe distance when installing an antenna is that if the antenna falls unexpectedly, no part of it can come closer than 10 feet from a power line.

A crank-up tower should never be climbed unless it is in the fully lowered position

Stainless steel hardware is much less likely to corrode. That is why it is common on many antennas instead of other metals.

Separate 8 foot long ground rods for each tower leg, bonded to the tower and each other is considered to be an adequate ground.

Lightning:
Take the following precautions when a lightning storm is expected: Disconnect the antenna cables from your station and move them away from your radio equipment. Unplug all power cords from AC outlets and stop using your radio and move to another room until the storm passes.

It is also prudent to disconnect all telephone and cable connections to phones, televisions and computers.

Fire prevention is the most important reason to have a lightning protection system for your amateur radio station.

RF Effects and Safety:
VHF and UHF radio signals are classified as non-ionizing radiation.

Radio waves can cause injury to the human body only if the combination of signal strength and frequency cause excessive power to be absorbed.

The maximum power level before an RF exposure evaluation is required of an amateur radio station at frequencies above 30 MHz is 50 watts PEP at the antenna.

The factors that affect the RF exposure of people near an amateur transmitter are frequency and power level of the RF field, distance from the antenna to the person and the radiation pattern of the antenna.

The human body absorbs more RF energy at some frequencies than others. This is why the frequency of an RF source is considered when evaluating RF radiation exposure.

You can determine that your station complies with FCC RF exposure regulations by calculation based on FCC OET Bulletin 65, by calculation based on computer modeling or by measurement of field strength using calibrated equipment.

If a person accidentally touched your antenna while you were transmitting they might receive a painful RF burn injury.

Amateur operators can take the following actions to prevent exposure to RF radiation in excess of FCC supplied limits: Altering the antenna patterns, relocating the antenna or changing station parameters such as frequency or power.

You should re-evaluate the station whenever an item of equipment is changed to make sure your station stays in compliance with RF safety regulations

Milliwatts per square centimeter are the units of measurement used to measure RF radiation exposure.

Duty cycle is one of the factors used to determine safe RF radiation exposure levels. It takes into account the amount of time the transmitter is operating

Chapter 10

Review Questions

Answers in Appendix A

1. What is the lowest amount of electrical current flowing through the human body that is likely to cause death?
A. 10 microamperes
B. 100 milliamperes
C. 10 amperes
D. 100 amperes

2. What is a good way to guard against electrical shock at your station?
A. Use 3-wire cords and plugs for all AC powered equipment
B. Connect all AC powered station equipment to a common ground
C. Use a ground-fault interrupter at each electrical outlet
D. All of these answers are correct

3. What can happen if a storage battery is charged or discharged too quickly?
A. The battery could overheat and give off dangerous gas or explode
B. The terminal voltage will oscillate rapidly
C. The warranty will be voided
D. The voltage will be reversed

4. Why should you wear a hard hat and safety glasses if you are on the ground helping someone work on an antenna tower?
A. It is required by FCC rules
B. To keep RF energy away from your head during antenna testing
C. To protect your head and eyes in case something accidentally falls from the tower
D. It is required by the electrical code

5. What is a safe distance from a power line to allow when installing an antenna?
A. Half the width of your property unless the wires are at least 23 feet high
B. 12.5 feet in most metropolitan areas
C. 36 meters plus 1/2 wavelength at the operating frequency
D. So that if the antenna falls unexpectedly, no part of it can come closer than 10 feet to the power wires

6. What is considered to be an adequate ground for a tower?
A. A single 4 foot ground rod, driven into the earth no more than 12 inches from the base
B. A screen of 120 radial wires
C. Separate 8 foot long ground rods for each tower leg, bonded to the tower and each other
D. A connection between the tower base and a cold water pipe

7. What factors affect the RF exposure of people near an amateur transmitter?
A. Frequency and power level of the RF field
B. Distance from the antenna to a person
C. Radiation pattern of the antenna
D. All of these answers are correct

8. What could happen if a person accidentally touched your antenna while you were transmitting?
A. Touching the antenna could cause television interference
B. They might receive a painful RF burn injury
C. They would be able to hear what you are saying
D. Nothing

9. Which of the following units of measurement is used to measure RF radiation exposure?
A. Milliwatts per square centimeter
B. Megohms per square meter
C. Microfarads per foot
D. Megahertz per second

Notes

Appendix A - Review Answers

Chapter 1

1	C
2	D
3	D
4	A
5	A
6	B
7	C
8	B
9	C
10	C
11	A
12	A

Chapter 2

1	C
2	C
3	B
4	B
5	C
6	B
7	C
8	D
9	A
10	A
11	B
12	D

Chapter 3

1	B
2	C
3	D
4	A
5	D
6	C
7	D
8	C
9	C
10	C
11	C
12	C

Chapter4

1	D
2	B
3	B
4	C
5	A
6	C
7	A
8	D
9	D
10	B
11	D
12	A
13	B
14	D
15	B

Chapter 5

1	B
2	A
3	C
4	D
5	C
6	B
7	A
8	A
9	A
10	B
11	D
12	B

Chapter 6

1	C
2	C
3	B
4	A
5	C
6	D
7	C
8	D
9	B

Chapter 7

1	B
2	A
3	A
4	D
5	C
6	B

Chapter 8

1	B
2	A
3	D
4	A
5	D
6	B
7	B
8	C
9	D

Chapter 9

1	C
2	C
3	A
4	D
5	B
6	B
7	A
8	D
9	D

Chapter 10

1	B
2	D
3	A
4	C
5	D
6	C
7	D
8	B
9	A

Appendix B - Glossary

73: A procedural signal for "Best Regards"

AC: An abbreviation for Alternating Current. An alternating current reverses electron flow direction on a regular basis.

AM: An abbreviation for Amplitude Modulation. Amplitude Modulation is a form of modulation in which the amplitude of a carrier wave is varied in direct proportion to that of the modulating signal.

Amateur operator: A person holding a written authorization to be the control operator of an amateur station.

Amateur station: A station in an amateur radio service consisting of the apparatus necessary for carrying on radio communications.

AMSAT: Radio Amateur Satellite Corporation of North America. AMSAT organization designs, builds, arrange launches for Amateur Radio satellites. There are also AMSAT groups in Germany, Japan and other countries.

ARES: (pronounced **AIRees)** Amateur Radio Emergency Service. ARES is sponsored by the Amateur Radio Relay League (ARRL). The only qualification for membership is an amateur radio license and a desire to serve. ARES members assist with communications for non-governmental agencies in times of need. Amateur Radio Emergency Service (ARES) supports non-governmental agencies like the Red Cross and National Weather Service.

Band Plans: Are voluntary guidelines, beyond the divisions established by the FCC for using different operating modes within an amateur band that provide a more efficient use of the radio spectrum. The amateur community develops the band plans used by the amateur radio service.

Broadcasting: One way transmissions intended for reception by the general public, either direct or relayed.

Certificate of Successful Completion of Examination (CSCE): A document earned by an individual passing one or more elements (tests) for an Amateur Radio license. A CSCE is valid for license upgrade purposes for 365 days.

Control operator: The person responsible for the transmissions from an amateur station and assures compliance with FCC rules. Every amateur station must have a control operator when transmitting.

Control point: The location at which the control operator function is performed.

CW see *Morse Code*

DC: An abbreviation for Direct Current. The flow of electrons in direct current is only in one direction.

DX: An abbreviation for long distance communications.

Fast Scan TV see *NTSC*

FCC: An abbreviation for the Federal Communications Commission (FCC). The FCC enforces the rules and grants Amateur Radio licenses in the United States.

FM: An abbreviation for Frequency Modulation. Frequency Modulation is a form of modulation in which the frequency of a carrier wave is varied in direct proportion to that of the modulating signal.

FSK: An abbreviation for Frequency Shift Keying. Using Frequency Shift Keying the carrier wave is shifted between two or more frequencies as determined by the encoding technique and protocols used.

Harmful interference: Interference which endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radio communication service operating in accordance with the Radio Regulations.

IRLP: An abbreviation for Internet Radio Linking Project. IRLP is a method of linking between two or more amateur stations using the Internet. Typically this is done between repeaters. The repeaters can be across town or around the world.

ITU: International Telecommunication Union.

Local, remote and automatic control: The three types of station control permitted and recognized by FCC rules.

Morse Code: Morse code is a method for transmitting information, using standardized sequences of short and long pulses for the letters, numerals, punctuation and special characters of a message. The General and Extra Amateur Radio license classes require the passing of a 5 word per minute Morse code exam.

NTSC: NTSC is the analog television standard in use in the United States. Amateur Radio operators can transmit Fast Scan TV signals using both Vestigial Side Band (VSB is a type of AM modulation) and FM modulation.

PSK31: A digital mode that uses Phase Shift Keying at 31 baud. The mode is normally used for keyboard to keyboard chatting.

QRM: A procedural signal that denotes that a station is receiving interference from a man-made source.

QSO: A procedural signal for the word "Conversation".

QSY: A procedural signal for requesting a change to another frequency or stating that you are changing to another frequency.

RACES: (pronounced **RAYsees)** Radio Amateur Civil Emergency Service. This service started originally for war time use. Since the role of civil defense has changed to civil preparedness the role of RACES has also expanded. It now includes hurricanes, floods, fires and other disasters such as train wrecks. Radio Amateur Civil Emergency Service (RACES) organizations are restricted to serving local, state, and federal government emergency management agencies. You must register with the responsible civil defense organization before you can participate in RACES activities.

Radio Direction Finding: Radio direction finding (RDF) is used to locate transmitters, RF noise, interference and jamming. Radio direction finding can be used to find lost and downed airplanes, lost hikers and boats in distress. A directional antenna is most useful for hidden transmitter hunting.

RDF see *Radio Direction Finding*

RTTY: Radioteletype is one method of digital communications between two Amateur stations. Software has now been developed to utilize a Computer and a Sound Card to send and receive Packet Radio. This same setup can be used for many other modes that used to take dedicated hardware such as Radio Teletype (RTTY) and Slow Scan TV (SSTV). To operate a Sound Card mode this one needs to connect the computer Sound Card to the Radio. You can build or buy these interfaces as required for your radio.

Third-party communications: Any message that is sent between two amateur stations for someone else.

Universal Licensing Service (ULS): This database is on the Internet at http://wireless.fcc.gov/uls/ . The database contains information about licensed services such as the Amateur Radio Service. With it one can search by name or callsign and find out an amateurs' status, expiration date, and station location.

Voice over IP: Voice over Internet Protocol (VoIP) is a method of encoding spoken information and routing it to another location for decoding. VoIP is used for IRLP and EchoLink.

VoIP see *Voice over IP*

Volunteer Examiner: An amateur accredited by one or more Volunteer Examiner Coordinators (VEC's) who administers amateur license exams.

Notes

Appendix C - Supplementary Information

ITU Phonetic Alphabet

This is for reference only not tested on the current test.

Letter	Code word	Spoken – Emphasize bolded syllable
A	Alfa	**AL** FAH
B	Bravo	**BRAH** VOH
C	Charlie	**CHAR** LEE or **SHAR** LEE
D	Delta	**DELL** TAH
E	Echo	**ECK** OH
F	Foxtrot	**FOKS** TROT
G	Golf	GOLF
H	Hotel	HOH **TELL**
I	India	**IN** DEE AH
J	Juliett	**JEW** LEE **ETT**
K	Kilo	**KEY** LOH
L	Lima	**LEE** MAH
M	Mike	MIKE
N	November	NO **VEM** BER
O	Oscar	**OSS** CAH
P	Papa	PAH **PAH**
Q	Quebec	KEH **BECK**
R	Romeo	**ROW** ME OH
S	Sierra	SEE **AIR** RAH
T	Tango	**TANG** GO
U	Uniform	**YOU** NEE FORM or **OO** NEE FORM
V	Victor	**VIK** TAH
W	Whiskey	**WISS** KEY
X	X-ray	**ECKS RAY**
Y	Yankee	**YANG** KEY
Z	Zulu	**ZOO** LOO

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From the center out is the Summary of Ohm's Law, Angle in degrees and the sine of the angle, Resistor color codes, 24 hour clock face and finally a compass rose.

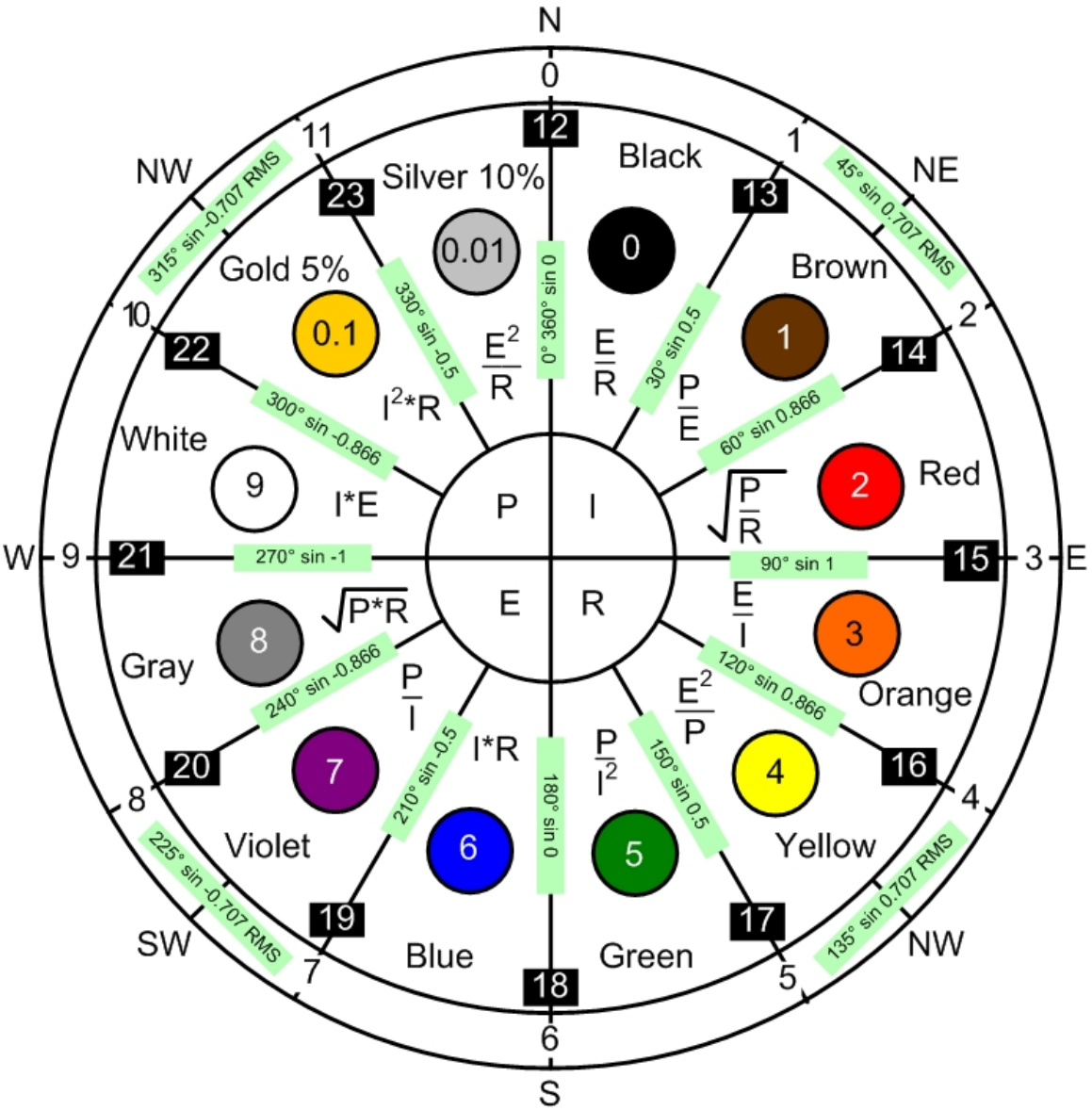

Figure 64 - Ohms Law Summary artwork. N5IUT