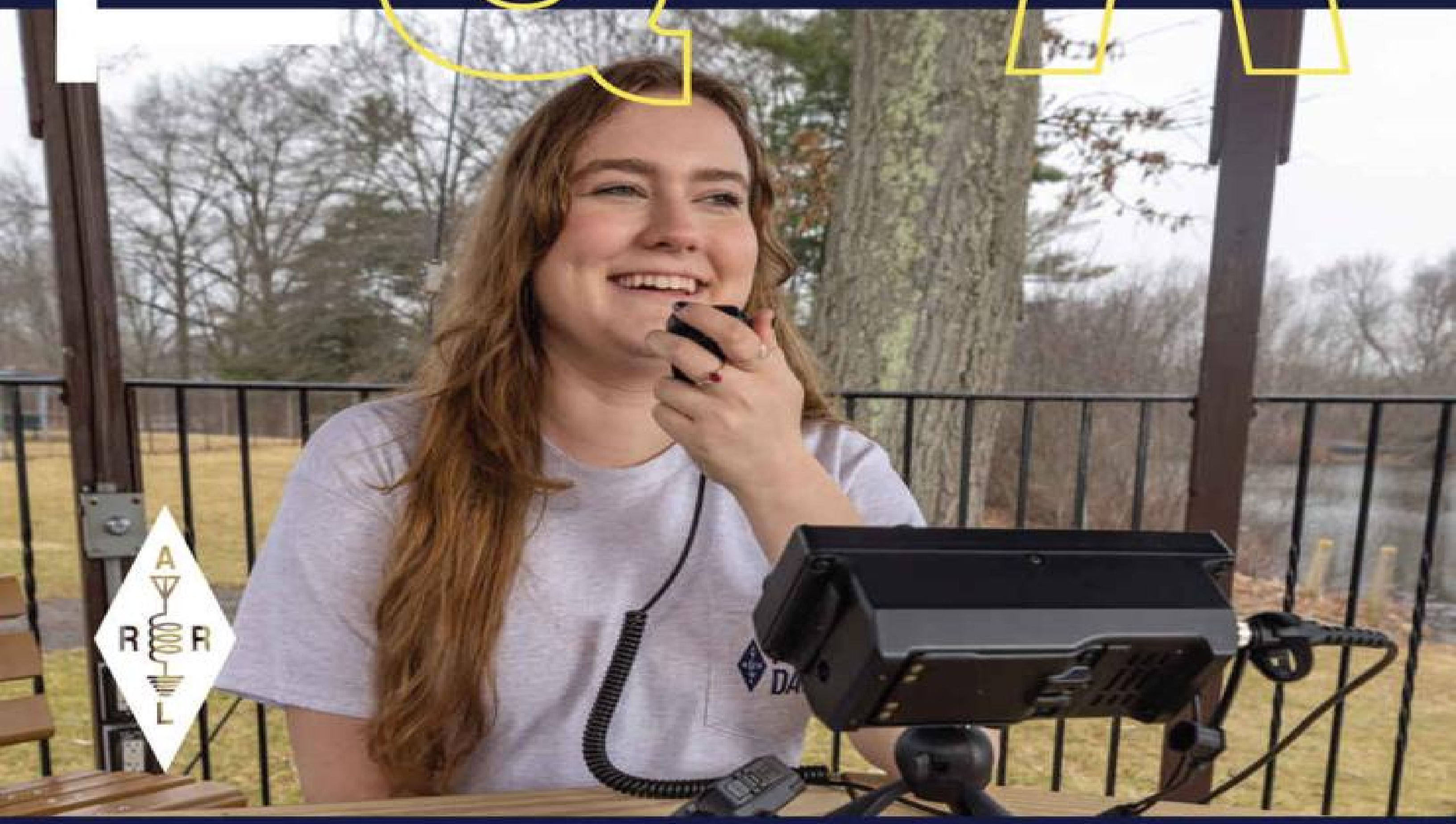
ARRL'S

EIGHTH EDITION

# TECH Q+A



**YOUR QUICK AND EASY PATH TO YOUR FIRST HAM RADIO LICENSE!**

- Includes the latest question pool with answers, for use July 1, 2022 through June 30, 2026.
- Brief, clear explanations for all questions.

# *ARRL's*
# TECH Q&A
## Eighth Edition

225 Main St, Newington, CT 06111-1400 USA
**www.arrl.org**

Printed in USA



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Eighth Edition
First Printing

This book may be used for Technician license exams given beginning July 1, 2022 and ending June 30, 2026. *QST* and the ARRL website (**www.arrl.org**) will have news about any rules changes affecting the Technician class license or any of the material in this book.

**Feedback:** We're interested in hearing your comments on this book and what you'd like to see in future editions. Please email comments to us at **pubsfdbk@arrl.org**, including your name, call sign, email address, and the title, edition and printing of this book.

We strive to produce books without errors. Sometimes mistakes do occur, however. When we become aware of problems in our books (other than obvious typographical errors), we post corrections on the ARRL website. If you think you have found an error, please check **www.arrl.org** for corrections and supplemental material. If you don't find a correction there, please let us know by sending email to **pubsfdbk@arrl.org**.

# CONTENTS

# When to Expect New Books

A Question Pool Committee (QPC) consisting of representatives from the various Volunteer Examiner Coordinators (VECs) prepares the license question pools. The QPC establishes a schedule for revising and implementing new question pools. The current question pool revision schedule is as follows:

| ***Question Pool*** | ***Current Study Guides*** | ***Valid Through*** |
|---|---|---|
| Technician (Element 2) | *The ARRL Ham Radio License Manual*, 5th Edition | **June 30, 2026** |
| | *ARRL's Tech Q&A*, 8th Edition | |
| General (Element 3) | *The ARRL General Class License Manual*, 9th edition | **June 30, 2023** |
| | *ARRL's General Q&A*, 6th Edition | |
| Amateur Extra (Element 4) | *The ARRL Extra Class License Manual*, 12th Edition | **June 30, 2024** |
| | *ARRL's Extra Q&A*, 5th Edition | |

As new question pools are released, ARRL will produce new study materials before the effective date of the new pools. Until then, the current question pools will remain in use, and current ARRL study materials, including this book, will help you prepare for your exam.

As the new question pool schedules are confirmed, the information will be published in *QST* and on the ARRL website at **www.arrl.org**.

# Online Review and Practice Exams

Use this book with the online *ARRL Exam Review for Ham Radio* to take randomly generated practice exams using questions from the actual examination question pool. You won't have any surprises on exam day! Go to **www.arrl.org/examreview**.


## About ARRL

We're the American Radio Relay League, Inc. — better known as ARRL. We're the largest membership association for the amateur radio hobby and service in the US. For over 100 years, we have been the primary source of information about amateur radio, offering a variety of benefits and services to our members, as well as the larger amateur radio community. We publish books on amateur radio, as well as four magazines covering a variety of radio communication interests. In addition, we provide technical advice and assistance to amateur radio enthusiasts, support several education programs, and sponsor a variety of operating events.

One of the primary benefits we offer to the ham radio community is in representing the interests of amateur radio operators before federal regulatory bodies advocating for meaningful access to the radio spectrum. ARRL also serves as the international secretariat of the International Amateur Radio Union, which performs a similar role internationally, advocating for amateur radio interests before the International Telecommunication Union and the World Radiocommunication Conference.

Today, we proudly serve nearly 160,000 members, both in the US and internationally, through our national headquarters and flagship amateur radio station, W1AW, in Newington, Connecticut. Every year we welcome thousands of new licensees to our membership, and we hope you will join us.
Let us be a part of your amateur radio journey. Visit www.arrl.org/join for more information.

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Email: membership@arrl.org
**www.arrl.org**

# Get more from your Technician Class License with ARRL Membership

Membership in ARRL offers unique opportunities to advance and share your knowledge of amateur radio. For over 100 years, advancing the art, science, and enjoyment of amateur radio has been our mission. Your membership helps to ensure that new generations of hams continue to reap the benefits of the amateur radio community.

Here are just a few of the benefits you will receive with your annual membership. For a complete list visit, arrl.org/membership.

## KNOWLEDGE

ARRL offers you a wealth of knowledge to advance your skills with lifelong learning courses, local clubs where you can meet and share ideas, and publications to help you keep up with the latest information from the world of ham radio.

## ADVOCACY

ARRL is a strong national voice for preserving and protecting access to Amateur Radio Service frequencies.

## SERVICES

Our Technical Information Service answers calls and emails about your operating and technical concerns. ARRL offers a range of member services.

## RESOURCES

Digital resources including email forwarding, product review archives, e-newsletters, and more.

## PUBLICATIONS

Members receive digital access to all four ARRL monthly and bimonthly publications – *QST*, the membership journal of ARRL; *On the Air*, an introduction to the world of amateur radio; *QEX*, which covers topics related to amateur radio and radio communications experimentation, and *National Contest Journal* (*NCJ*), covering radio contesting.

## Two Easy Ways to Join

| | |
|---|---|
| **CALL** Member Services toll free at **1-888-277-5289** | **ONLINE** Go to our secure website at **arrl.org/join** |

# Introduction

Welcome to the diverse group of individuals who make up amateur radio! There are about 750,000 amateurs, or “hams,” in the United States and 3,000,000 around the world. Hams come from all walks of life, all ages, and every continent. Hams are busily communicating without regard to the geographic and political barriers that often separate humanity. This is the power of amateur radio — to communicate with each other directly, without any other commercial or government systems.

Hams come to amateur radio from many walks of life and many interests. Perhaps you intend to engage in public service for yourself and your community. Technical experimentation might be your interest, or you might be a habitual tinkerer who is always building, testing, using, and learning. Making new friends via the radio, keeping in touch as you travel, or exploring where a wireless signal can take you — these are all valuable and valued parts of the Amateur Service.

The first step along your ham radio journey, though, is to get your Technician license. That’s where this book comes in. It’s got all the information you need in one compact little package. But more about the book and how to use it later. For now, let’s focus on the opportunities having your Technician class license will open up for you.

Once you’ve got your license, or “ticket” as it’s sometimes known, be sure to explore your local and online ham radio clubs and groups. This is where you’ll find answers to your questions and help in getting on the air. You can start by asking the hams who administer your exam session — their organization can be your first “Elmer,” or mentor. One of ham radio’s strongest traditions is helping other hams learn and grow.

Most active radio amateurs in the United States are ARRL members. They realize that ARRL’s training, sponsorship of activities, and representation both nationally and internationally are second to none. The book you’re reading now, ARRL’s Tech Q&A, is just one of many publications for all levels and interests in amateur radio. You don’t need a license to join ARRL — just be interested in amateur radio and we are interested in you. It’s as simple as that!

Earning a Technician amateur radio license begins your enjoyment of ham radio. Topics covered by the exam provide you with a good introduction to basic radio, and there is no difficult math or electronics background required. You are sure to find the operating privileges available to a Technician licensee to be worth the time spent learning about amateur radio. After passing the exam, you will be able to operate on every frequency above 50 megahertz available to the Amateur Service. You also gain privileges on the traditional "high-frequency (HF)" 80, 40, 15, and 10 meter amateur bands. With this broad set of operating privileges, you'll be ready to experience the excitement of amateur radio!

Perhaps your interest is in amateur radio's long history of public service, such as providing emergency communications in time of need. You might have experience with computer networks leading you to explore the digital mode technology used in ham radio. If your eyes turn to the stars on a clear night, you might enjoy tracking the amateur satellites and using them to relay your signals to other amateurs around the world! Your whole family can enjoy amateur radio, taking part in outdoor activities such as ARRL Field Day and mobile operating during a vacation or weekend drive.

## An Overview of Amateur Radio

Earning an amateur radio license is a special achievement. The more than 750,000 people in the US who call themselves amateur radio operators, or hams, are part of a global family. Radio signals do not know territorial boundaries, so hams have a unique ability to enhance international goodwill. Hams become ambassadors of their country every time they put their stations on the air.

Radio amateurs provide a voluntary, noncommercial, communication service, without any type of payment except the personal satisfaction they feel from a job well done! This is especially true during natural disasters or other emergencies when the normal lines of communication are out of service. In the aftermath of the devasting hurricanes of 2017, for example, hams responded by traveling to Caribbean islands, southeast Texas, and Florida's western cities. They set up temporary communication networks, transferred information into and out of the affected areas, and provided communication support for the authorities until normal systems were working again. They were supported by thousands of hams around the US and the rest of the world. In every US county and city, organized groups of amateur operators train and prepare to support their communities during disasters and emergencies of every type.

Hams have made many important contributions to the field of electronics and communications since amateur radio's beginnings a century ago and this tradition continues. Today, hams relay signals through their own satellites, bounce signals off the moon, relay messages automatically through computerized radio networks and use any number of other “exotic” communications techniques.

Amateur radio experimentation is yet another reason many people become part of this self-trained group of operators, technicians, and electronics experts — an asset to any country. Amateurs talk from hand-held transceivers through mountaintop repeater stations that relay their signals to other hams’ cars or homes or through the Internet around the world. Hams establish wireless data networks, send their own television signals, and talk with other hams around the world by voice. Keeping alive a distinctive traditional skill, they also tap out messages in Morse code.

## *Who Can Be a Ham…and How?*

The US government, through the Federal Communications Commission (FCC), grants all US amateur radio licenses. Because of amateur radio’s tremendously flexible and self-organizing nature, amateurs are expected to know more about their equipment and operating techniques than other radio services. Unlike commercial and household radio users, amateurs organize their own methods of communication, are encouraged to build and repair their own equipment, perform experiments with antennas and with radio propagation, and invent their own protocols and networks. The FCC licensing process ensures that amateurs have the necessary operating skill and electronics know-how to use that flexibility wisely and not interfere with other radio services.

It doesn’t matter how old you are or whether you’re a US citizen. If you pass the examination, the Commission will issue you an amateur license. Any person (except the agent of a foreign government) may take the exam and, if successful, receive an amateur license. It’s important to understand that if a citizen of a foreign country receives an amateur license in this manner, he or she is a US Amateur Radio operator. (This should not be confused with a reciprocal permit, which is covered in the questions of subelement T1.)

## *License Structure*

Anyone earning a new amateur radio license can earn one of three license classes — Technician, General and Amateur Extra. Higher-class licenses have more comprehensive examinations. In return for passing a more difficult exam you earn more frequency privileges (frequency space in the radio spectrum). The vast majority of beginners earn the most basic license, the Technician, before beginning to study for the other licenses.

**Table 1** lists the amateur license classes you can earn, along with a brief description of their exam requirements and operating privileges. A Technician license gives you the freedom to develop operating and technical skills through on-the-air experience. These skills will help you upgrade to a higher class of license and obtain additional privileges.

**Table 1**

**Amateur Operator Licenses**

| ***License Class*** | ***Written Exam*** | ***Privileges*** |
|---|---|---|
| Technician | Basic theory and regulations (Element 2) | All above 50 MHz and limited HF privileges |
| General | Basic theory and regulations; General theory and regulations (Elements 2 and 3) | All except those reserved for Advanced and Amateur Extra |
| Amateur Extra | All lower exam elements, plus Amateur Extra theory (Elements 2, 3 and 4) | All amateur privileges |

The Technician exam, called Element 2, covers some basic radio fundamentals and knowledge of some of the rules and regulations in Part 97 of the FCC Rules. With a little study you'll soon be ready to pass the exam.

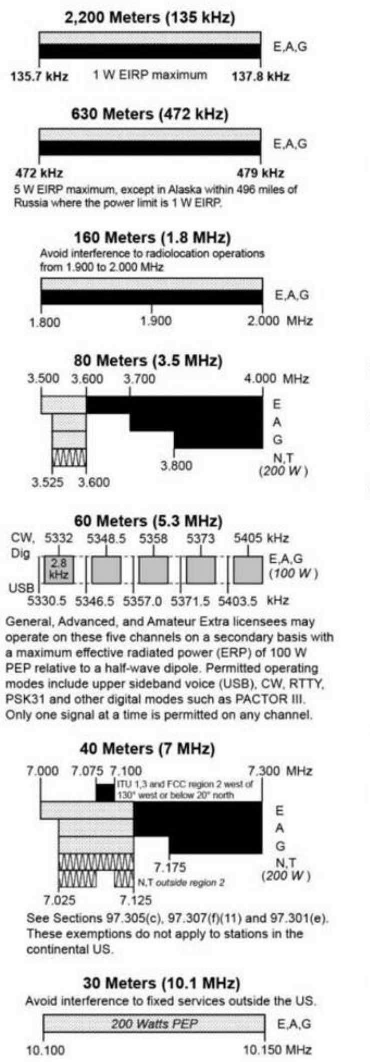
Each step up the amateur radio license ladder requires the applicant to have passed the lower exams. So if you want to start out as a General class or even an Amateur Extra class licensee, you must first have passed the Technician written exam. You retain credit for all the exam elements of any license class you hold. For example, if you hold a Technician license, you will only have to pass the Element 3 General class written exam to obtain a General class license.

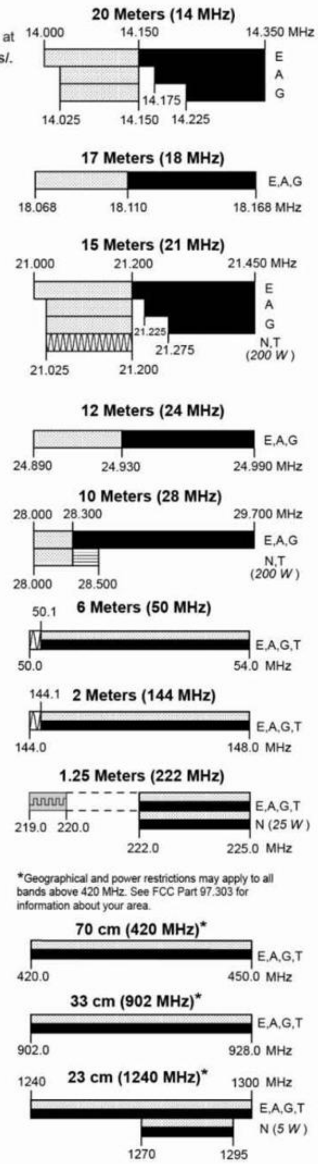
Although there are also other amateur license classes, the FCC is no longer issuing new licenses for them. The Novice license was long considered the beginner's license. Exams for this license were discontinued as of April 15, 2000. The FCC also stopped issuing new Advanced class licenses on that date. They will continue to renew previously issued licenses, however, so you will probably meet some Novice and Advanced class licensees on the air.

As a Technician, you can use a wide range of frequency bands — all amateur bands above 50 MHz (megahertz), in fact. (See **Table 2** and **Figure 1**.) You'll be able to use point-to-point or repeater communications on VHF, use packet radio and other digital modes and networks, even access orbiting satellites or bounce a signal off meteor trails! You can use your operating skills to provide public service through emergency communications and message handling.

# US Amateur Bands

Amateurs wishing to operate on either 2,200 or 630 meters must first register with the Utilities Technology Council online at **https://utc.org/plc-database-amateur-notification-process/.** You need only register once for each band.




## Table 2

## US AMATEUR POWER LIMITS

**FCC 97.313** An amateur station must use the minimum transmitter power necessary to carry out the desired communications.
**(b)** No station may transmit with a transmitter power exceeding **1.5 kW PEP.**

All licensees except Novices are authorized all modes on the following frequencies:

| | | | |
|---|---|---|---|
| 2300-2310 | MHz | 47.0-47.2 | GHz |
| 2390-2450 | MHz | 76.0-81.0 | GHz |
| 3300-3500 | MHz | 122.25-123.0 | GHz |
| 5650-5925 | MHz | 134-141 | GHz |
| 10.0-10.5 | GHz* | 241-250 | GHz |
| 24.0-24.25 | GHz | All above 275 GHz | |

* No pulse emissions

### KEY

*Note:*

**CW** operation is permitted throughout all amateur bands.

**MCW** is authorized above 50.1 MHz, except for 144.0-144.1 and 219-220 MHz.

**Test** transmissions are authorized above 51 MHz, except for 219-220 MHz

= RTTY and data

= phone and image

= CW *only*

= SSB phone

= USB phone, CW, RTTY and data.

= Fixed digital message forwarding systems *only*

**E** = Amateur Extra
**A** = Advanced
**G** = General
**T** = Technician
**N** = Novice

See *www.arrl.org* for more detailed band plans.

## ARRL *We're At Your Service*

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Toll-Free 1-888-277-5289 (860-594-0338)
email: membership@arrl.org

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Toll-Free 1-800-326-3942 (860-594-0355)
email: Newham@arrl.org

**Exams** 860-594-0300 vec@arrl.org

QnAbands4 rev. 6/24/2021

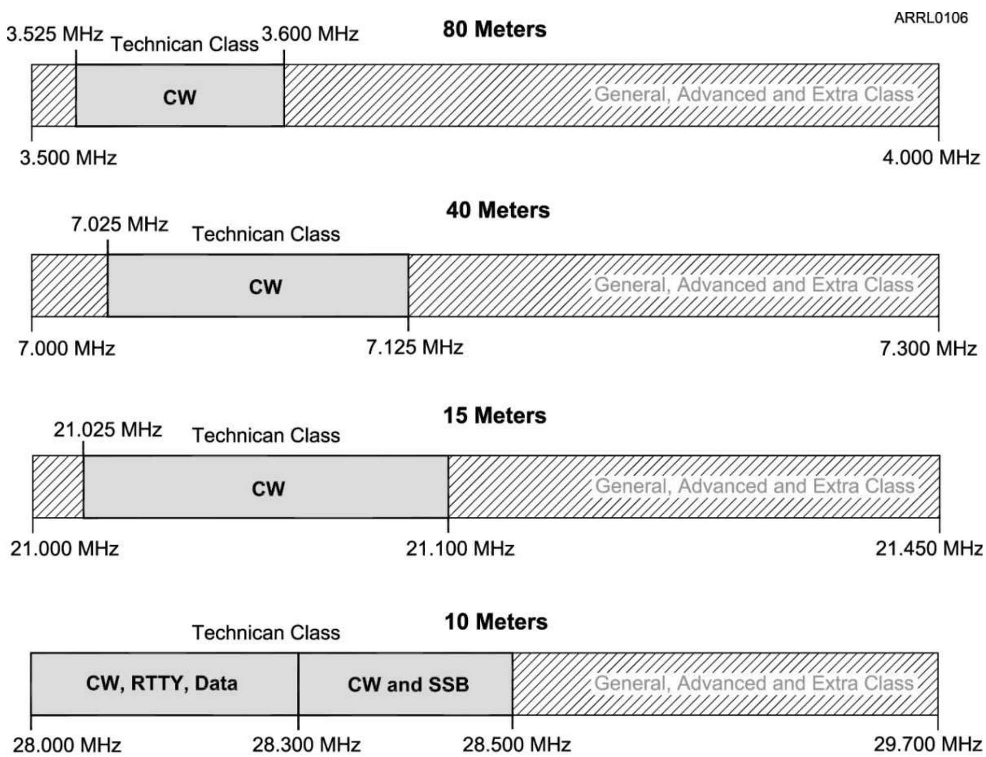



**Figure 1 — This chart details the HF privileges available to Technician licensees.**

### *Station Call Signs*

Many years ago, by international agreement, the nations of the world decided to allocate certain call sign prefixes to each country. This means that if you hear a radio station call sign beginning with W or K, for example, you know the station is licensed by the United States. A call sign beginning with the letter G is licensed by Great Britain, and a call sign beginning with VE is from Canada. (All of the amateur call sign prefixes are listed in a table on ARRL's website, **www.arrl.org**.)

The International Telecommunication Union (ITU) radio regulations outline the basic principles used in forming amateur call signs. According to these regulations, an amateur call sign must be made up of one or two characters (the first one may be a numeral) as a prefix, followed by a numeral, and then a suffix of up to three letters. The prefixes W, K, N and A are used in the United States. When the letter A is used in a US amateur call sign, it will always be with a two-letter prefix, AA to AL. The continental US is divided into 10 amateur radio call districts (commonly called "call areas"), numbered 0 through 9. **Figure 2** is a map showing the US call districts.

You may keep the same call sign when you change license class, if you wish. You must indicate that you want to receive a new call sign when you apply for the exam or change your address.

The FCC also has a vanity call sign system that allows you to change your call sign from the one the FCC assigned you, to one that you like better — provided the call sign is available for use. While there is no fee for an amateur radio license, there is a fee for the selection of a vanity call sign. The current fee and details of the vanity call sign system are available on the ARRL website at **www.arrl.org/vanity-call-signs**.


**Figure 2—There are 10 US call districts or areas. Hawaii and all Pacific possessions are part of the sixth call area and Alaska is part of the seventh. Puerto Rico and the US Virgin Islands are part of the fourth district.**

### *How to Use This Book*

The Element 2 exam consists of 35 questions taken from a pool of around 450 questions. The *ARRL's Tech Q&A* is designed to help you learn about every question in the Technician exam question pool. Every question is presented just as it is in the question pool and as you will encounter it on the exam. Following every question is a short explanation of the answer.

Each chapter of the book covers one subelement from the question pool, beginning with the FCC Rules and ending with Safety. You may study the questions from beginning to end or select topics in an order that appeals to you.

If you are new to radio, you will probably find it easier to begin with the questions in subelement T3, T4 and T7 to learn about amateur equipment and the basics of radio signals. Then you can move on to the more technical topics covered by T5, T6, T8 and T9. Once you've learned about how radios work, the subelements on operating (T2) and FCC Rules (T1) will make more sense. Finish up with T0 — Safety — and you'll be ready for your exam!

The *ARRL Ham Radio License Manual* is a good reference companion to the *Tech Q&A*. At the end of the explanation for every question, there is a reference to the page in the *Ham Radio License Manual* where you can find a discussion of the topics associated with the question.

There is additional material at the ARRL's website **www.arrl.org/ham-radio-license-manual** if you need extra help. In particular, there are links to math tutorials and every math problem on the exam is completely worked out to show you how it's done. To make the best use of the online reference material, bookmark the *Ham Radio License Manual* website to use as an online reference while you study.

The ARRL's New Ham Desk can answer questions emailed to **newham@arrl.org**. Your question may be answered directly or you might be directed to more instruction material. The New Ham Desk can also help you find a local ham to answer questions. Studying with a friend makes learning the material more fun as you help each other over the rough spots and you'll have someone to celebrate with after passing the exam!

### Earning a License

All US amateur exams are administered by Volunteer Examiners who are certified by a Volunteer Examiner Coordinator (VEC) that processes the examination paperwork and license applications for the FCC. A Question Pool Committee selected by the Volunteer Examiner Coordinators maintains the question pools for all amateur exams.

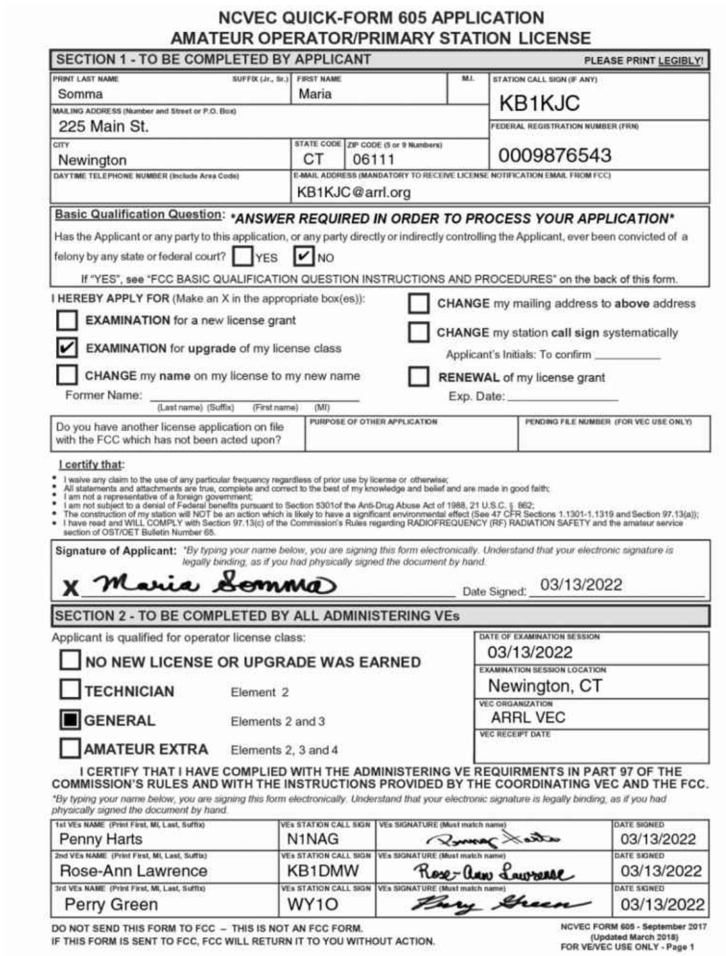
Once you make the commitment to study and learn what it takes to pass the exam, you will accomplish your goal. Many people pass the exam on their first try, so if you study the material and are prepared, chances are good that you will soon have your license. It may take you more than one attempt to pass the Technician license exam, but that’s okay. There is no limit to how many times you can take it. Many Volunteer Examiner teams have several exam versions available, so you may even be able to try the exam again at the same exam session. Time and available exam versions may limit the number of times you can try the exam at a single exam session. If you don’t pass after a couple of tries you will certainly benefit from more study of the question pools before you try again.

### *License Examinations*

The FCC allows Volunteer Examiners to select the questions for an amateur exam, but they must use the questions exactly as they are released by the VEC that coordinates the test session. If you attend a test session coordinated by the ARRL/VEC, your test will be designed by the ARRL/VEC or by a computer program created by the VEC. The questions and answers will be exactly as they are printed in this book.

Before you can take an FCC exam, you’ll have to fill out a copy of the National Conference of Volunteer Examiner Coordinators (NCVEC) Quick Form 605. This form is used as an application for a new license or an upgraded license. The NCVEC Quick Form 605 is only used at license exam sessions. This form includes some information that the Volunteer Examiner Coordinator’s office will need to process your application with the FCC. See **Figure 3**.

You should not use an NCVEC Quick Form 605 to apply for a license renewal or modification with the FCC. Never mail these forms to the FCC, because that will result in a rejection of the application. Likewise, an FCC Form 605 can’t be used for a license exam application.



NCVEC QUICK-FORM 605 APPLICATION
AMATEUR OPERATOR/PRIMARY STATION LICENSE

SECTION 1 - TO BE COMPLETED BY APPLICANT — PLEASE PRINT LEGIBLY!

| | |
|---|---|
| PRINT LAST NAME | Somma |
| FIRST NAME | Maria |
| STATION CALL SIGN (IF ANY) | KB1KJC |
| MAILING ADDRESS (Number and Street or P.O. Box) | 225 Main St. |
| FEDERAL REGISTRATION NUMBER (FRN) | 0009876543 |
| CITY | Newington |
| STATE CODE | CT |
| ZIP CODE (5 or 9 Numbers) | 06111 |
| DAYTIME TELEPHONE NUMBER (Include Area Code) | |
| E-MAIL ADDRESS (MANDATORY TO RECEIVE LICENSE NOTIFICATION EMAIL FROM FCC) | KB1KJC@arrl.org |

Basic Qualification Question: *ANSWER REQUIRED IN ORDER TO PROCESS YOUR APPLICATION*
Has the Applicant or any party to this application, or any party directly or indirectly controlling the Applicant, ever been convicted of a felony by any state or federal court? ☐ YES ☑ NO
If "YES", see "FCC BASIC QUALIFICATION QUESTION INSTRUCTIONS AND PROCEDURES" on the back of this form.

I HEREBY APPLY FOR (Make an X in the appropriate box(es)):
- ☐ EXAMINATION for a new license grant
- ☑ EXAMINATION for upgrade of my license class
- ☐ CHANGE my name on my license to my new name. Former Name: ______ (Last name) (Suffix) (First name) (MI)
- ☐ CHANGE my mailing address to above address
- ☐ CHANGE my station call sign systematically. Applicant's Initials: To confirm ______
- ☐ RENEWAL of my license grant. Exp. Date: ______

| Do you have another license application on file with the FCC which has not been acted upon? | PURPOSE OF OTHER APPLICATION | PENDING FILE NUMBER (FOR VEC USE ONLY) |
|---|---|---|

I certify that:
- I waive any claim to the use of any particular frequency regardless of prior use by license or otherwise;
- All statements and attachments are true, complete and correct to the best of my knowledge and belief and are made in good faith;
- I am not a representative of a foreign government;
- I am not subject to a denial of Federal benefits pursuant to Section 5301of the Anti-Drug Abuse Act of 1988, 21 U.S.C. § 862;
- The construction of my station will NOT be an action which is likely to have a significant environmental effect (See 47 CFR Sections 1.1301-1.1319 and Section 97.13(a));
- I have read and WILL COMPLY with Section 97.13(c) of the Commission's Rules regarding RADIOFREQUENCY (RF) RADIATION SAFETY and the amateur service section of OST/OET Bulletin Number 65.

Signature of Applicant: *By typing your name below, you are signing this form electronically. Understand that your electronic signature is legally binding, as if you had physically signed the document by hand.*
X Maria Somma Date Signed: 03/13/2022

SECTION 2 - TO BE COMPLETED BY ALL ADMINISTERING VEs

Applicant is qualified for operator license class:
- ☐ NO NEW LICENSE OR UPGRADE WAS EARNED
- ☐ TECHNICIAN Element 2
- ■ GENERAL Elements 2 and 3
- ☐ AMATEUR EXTRA Elements 2, 3 and 4

| | |
|---|---|
| DATE OF EXAMINATION SESSION | 03/13/2022 |
| EXAMINATION SESSION LOCATION | Newington, CT |
| VEC ORGANIZATION | ARRL VEC |
| VEC RECEIPT DATE | |

I CERTIFY THAT I HAVE COMPLIED WITH THE ADMINISTERING VE REQUIREMENTS IN PART 97 OF THE COMMISSION'S RULES AND WITH THE INSTRUCTIONS PROVIDED BY THE COORDINATING VEC AND THE FCC.
*By typing your name below, you are signing this form electronically. Understand that your electronic signature is legally binding, as if you had physically signed the document by hand.*

| VEs NAME (Print First, MI, Last, Suffix) | VEs STATION CALL SIGN | VEs SIGNATURE (Must match name) | DATE SIGNED |
|---|---|---|---|
| 1st: Penny Harts | N1NAG | Penny Harts | 03/13/2022 |
| 2nd: Rose-Ann Lawrence | KB1DMW | Rose-Ann Lawrence | 03/13/2022 |
| 3rd: Perry Green | WY1O | Perry Green | 03/13/2022 |

DO NOT SEND THIS FORM TO FCC – THIS IS NOT AN FCC FORM.
IF THIS FORM IS SENT TO FCC, FCC WILL RETURN IT TO YOU WITHOUT ACTION.
NCVEC FORM 605 - September 2017 (Updated March 2018) FOR VE/VEC USE ONLY - Page 1

**Figure 3—At the test session, the Volunteer Examiners will help you fill out an NCVEC Quick Form 605, which will be filed with the FCC.**

## *Finding an Exam Session*

You can locate upcoming exam sessions in your area by using ARRL's online Exam Search page. Browse to **www.arrl.org**, and click the "Licensing, Education & Training" button to find complete information about taking a licensing exam. Registration deadlines and the time and location of the exams, are mentioned prominently in publicity releases about upcoming sessions. You can also contact the ARRL/VEC office directly or watch for announcements in *QST* or on the ARRL website. Many local clubs sponsor exams, so they are another good source of information on exam opportunities.

## *Taking the Exam*

By the time examination day rolls around, you should have already prepared yourself. This means getting your schedule, supplies, and mental attitude ready. Plan your schedule so you'll get to the examination site with plenty of time to spare. There's no harm in being early. In fact, you might have time to meet and talk with another applicant which is a great way to calm pretest nerves.

What supplies will you need? While this is probably your first license, if you have any current amateur licenses or a Certificate of Successful Completion of Examination (CSCE), bring the original and a photocopy. Bring along several sharpened number 2 pencils and two pens (blue or black ink). Be sure to have a good eraser. A pocket calculator may also come in handy. You may use a programmable calculator if that is the kind you have, but take it into your exam "empty" (cleared of all programs and constants in memory). Don't program equations ahead of time, because you may be asked to demonstrate that there is nothing in the calculator memory. The examining team has the right to refuse a candidate the use of any calculator that they feel may contain information for the test or could otherwise be used to cheat on the exam.

The Volunteer Examiner team is required to check two forms of identification before you enter the test room. You can use a driver's license, a piece of mail addressed to you, a birth certificate, or a photo ID of some type. If you have an original amateur radio license, bring it — not a photocopy.

The following description of the testing procedure applies to exams coordinated by the ARRL/VEC, although many other VECs use a similar procedure.

## *Written Test*

The examiner will give each applicant a test booklet, an answer sheet and scratch paper. You'll be shown where to sign your name and after that, you're on your own. The first thing to do is read the instructions.

Next, check the examination to see that all pages and questions are there. If not, report this to the examiner immediately. When filling in your answer sheet make sure your answers are marked next to the numbers that correspond to each question.

Go through the entire exam, and answer the easy questions first. Next, go back to the beginning and try the harder questions. Leave the really tough questions for last.

If you don't know the answer to a question, make your best guess. There is no additional penalty for answering incorrectly. If you have to guess, do it intelligently: At first glance, you may find that you can eliminate one or more "distractors." Of the remaining responses, more than one may seem correct; only one is the best answer, however. To the applicant who is fully prepared, incorrect distractors to each question are obvious. Nothing beats preparation!

After you've finished, check the examination thoroughly. You may have read a question wrong or goofed in your arithmetic. Don't be overconfident. There's no rush, so take your time. Think and check your answer sheet. When you feel you've done your best, return the test booklet, answer sheet, and scratch pad to the examiner.

The Volunteer Examiner team will grade the exam while you wait. The passing grade is 74%. (That means 26 out of 35 questions correct with up to 9 incorrect answers on the Element 2 exam.) You will receive a Certificate of Successful Completion of Examination (CSCE — see **Figure 4**) showing all exam elements that you pass at that exam session. That certificate is valid for 365 days. Use it as proof that you passed those exam elements so you won't have to take them over again next time you take a license exam.

**Figure 4 — The CSCE (Certificate of Successful Completion of Examination) is your test session receipt that serves as proof that you have completed one or more exam elements. It can be used at other test sessions for 365 days.**

**American Radio Relay League VEC**
**Certificate of Successful Completion of Examination**

ARRL The National Association for Amateur Radio®

Test Site (City/State): Newington, CT Test Date: 03/13/2022

NOTE TO VE TEAM: COMPLETELY CROSS OUT ALL BOXES BELOW THAT DO NOT APPLY TO THIS CANDIDATE.

The applicant named herein has presented valid proof for the exam element credits indicated below
Element 3 credit
Element 4 credit

**CREDIT FOR ELEMENTS PASSED VALID FOR 365 DAYS**
You have passed the 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.

EXAM ELEMENTS EARNED
~~Passed written Element 2~~
Passed written Element 3
~~Passed written Element 4~~

**LICENSE UPGRADE NOTICE**
**If you hold a valid FCC-issued Amateur Radio license and call sign**, this certificate validates temporary operation with the operating privileges of your new operator class (see Section 97.9[b] of the FCC 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. See the back of the certificate for temporary operating instructions.

NEW LICENSE CLASS EARNED
~~TECHNICIAN~~
GENERAL
~~EXTRA~~
~~NONE~~

**APPLICATION STATUS AND FEES**
Visit **www.arrl.org/FCC-Application-Fee** for the instructions on how to pay the FCC application fee.
You can find out if a new license or upgrade has been issued by the FCC by visiting the FCC website at **http://www.fcc.gov/wireless/systems-utilities/universal-licensing-system** (Click on License Search); or by calling the FCC at 1-888-225-5322 or the ARRL at 1-860-594-0300 during business hours (8am-5pm).

**THIS CERTIFICATE IS NOT A LICENSE, PERMIT, OR ANY OTHER KIND OF OPERATING AUTHORITY IN AND OF ITSELF. THE ELEMENT CREDITS AND/OR OPERATING PRIVILEGES THAT MAY BE INDICATED IN THE LICENSE UPGRADE NOTICE ARE VALID FOR 365 DAYS FROM THE TEST DATE. THE HOLDER NAMED HEREIN MUST ALSO HAVE BEEN GRANTED AN AMATEUR RADIO LICENSE ISSUED BY THE FCC TO OPERATE ON THE AIR.**

Candidate's Signature Maria Somma Call Sign KB1KJC (If none, write none)
Candidate's Name Maria Somma
Address 225 Main Street
City Newington State CT ZIP 06111

VE #1 [illegible] N1NAG
Signature Call Sign
VE #2 [illegible] KB1DMW
Signature Call Sign
VE #3 [illegible] WY1O
Signature Call Sign

COPIES: **WHITE**–Candidate, **YELLOW**–VE Team, **PINK**–ARRL VEC
MVE 1/2022

**Figure 4 — The CSCE (Certificate of Successful Completion of Examination) is your test session receipt that serves as proof that you have completed one or more exam elements. It can be used at other test sessions for 365 days.**

## *Forms and Procedures*

To renew or modify a license, you can file a copy of FCC Form 605. In addition, hams who have held a valid license that has expired within the past two years may apply for reinstatement with an FCC Form 605.

Licenses are normally good for 10 years. Your application for a license renewal must be submitted to the FCC no more than 90 days before the license expires. (We recommend you submit the application for renewal between 90 and 60 days before your license expires.) If the FCC receives your renewal application before the license expires, you may continue to operate until your new license is granted and shows up in the FCC database, even if it is past the expiration date.

If you forget to apply before your license expires, you may still be able to renew your license without taking another exam. There is a two-year grace period, during which you may apply for renewal of your expired license. Use an FCC Form 605 to apply for reinstatement (and your old call sign). If you apply for reinstatement of your expired license under this two-year grace period, you may not operate your station until your new license is issued.

If you move or change addresses, you should use an FCC Form 605 to notify the FCC of the change. If your license is lost or destroyed, however, just write a letter to the FCC explaining why you are requesting a new copy of your license.

You can ask one of the Volunteer Examiner Coordinators' offices to file your renewal application electronically if you don't want to mail the form to the FCC. You must still mail the form to the VEC, however. The ARRL/VEC office will electronically file application forms. This service is free for any ARRL member.

### *Electronic Filing*

You can also file your license renewal or address modification using the FCC's Universal Licensing System (ULS) website, **www.fcc.gov/uls**. To use ULS, you must have an FCC Registration Number, or FRN. Obtain your FRN by registering with the Commission Registration System, known as CORES.

Described as an agency-wide registration system for anyone filing applications with or making payments to the FCC, CORES will assign a unique 10-digit FCC Registration Number (FRN) to all registrants. All Commission systems that handle financial, authorization of service, and enforcement activities will use the FRN. The FCC says use of the FRN will allow it to more rapidly verify fee payment. Amateurs mailing payments to the FCC — for example as part of a vanity call sign application — would include their FRN on FCC Form 159.

The online filing system and further information about CORES is available by visiting the FCC web home page, **www.fcc.gov**, and clicking on the Commission Registration System link. Follow the directions on the website. It is also possible to register on CORES using a paper Form 160.

When you register with CORES you must supply a Taxpayer Identification Number, or TIN. For individuals, this is usually a Social Security Number. Club stations that do not have an EIN register as exempt. Anyone can register on CORES and obtain an FRN. You don't need a license to be registered.

Once you have registered on CORES and obtained your FRN, you can proceed to renew or modify your license using the Universal Licensing System by clicking on the "Online Filing" button. Follow the directions provided on the web page to connect to the FCC's ULS database.

## Paper Filing

If you decide to “do the paperwork” on real paper instead of online, you’ll need to get a blank FCC 605 Main Form. This is not difficult! You can get FCC 605 Main Form with detailed instructions from the FCC Forms web page — **www.fcc.gov/licensing-databases/forms**.

The ARRL VEC offers an overview of the various FCC and VEC forms and their uses online at **www.arrl.org/fcc-forms**.

## And Now, Let’s Begin

The complete Technician question pool (Element 2) is printed in this book. Each chapter lists all the questions for a particular subelement (such as Operating Procedures — T2). A brief explanation about the correct answer is given after each question.

The correct answer (A, B, C or D) is given in bold at the beginning of an explanation section that follows the question and the possible responses. This convention will be used throughout this book. In addition, at the end of each explanation you’ll find the page number where this question is discussed in ARRL’s *Ham Radio License Manual*, like this: [*Ham Radio License Manual*, page 7-3].

You’ll often see a reference to Part 97 of the Federal Communications Commission rules set in brackets, like this: [97.3(a)(4)]. This tells you where to find the exact wording of the Rules as they relate to that question. You’ll find the complete Part 97 Rules on the ARRL website at www.arrl.org.

**Table 3** shows the study guide or syllabus for the Element 2 exam as released by the Volunteer Examiner Coordinators’ Question Pool Committee in March 2022. The syllabus lists the topics to be covered by the Technician exam, and so forms the basic outline for the remainder of this book. Use the syllabus to guide your study.

The question numbers used in the question pool refer to this syllabus. Each question number begins with a syllabus point number (for example, T0C or T1A). The question numbers end with a two-digit number. For example, question T3B09 is the ninth question about the T3B syllabus topics.

The Question Pool Committee designed the syllabus and question pool so there are the same number of topics in each subelement as there are exam questions from that subelement. For example, three exam questions on the Technician exam must be from the “Operating Procedures” subelement, so there are three groups for that topic. These are numbered T2A, T2B, and T2C. While not a requirement of the FCC Rules, the Question Pool Committee recommends that one question be taken from each group to make the best possible license exams.

Good luck with your studies!

**Table 3**

**Technician Class Syllabus**

Effective July 1, 2022 to June 30, 2026

**SUBELEMENT T1 —COMMISSION’S RULES [6 Exam Questions — 6 Groups]**

T1A Purpose and permissible use of the Amateur Radio Service; Operator/primary station license grant; Meanings of basic terms used in FCC rules; Interference; RACES rules; Phonetics; Frequency Coordinator

T1B Frequency allocations; Emission modes; Spectrum sharing; Transmissions near band edges; Contacting the International Space Station; Power output

T1C Licensing: classes, sequential and vanity call sign systems, places where the Amateur Radio Service is regulated by the FCC, name and address on FCC license database, term, renewal, grace period, maintaining mailing address; International communications

T1D Authorized and prohibited transmissions: communications with other countries, music, exchange of information with other services, indecent language, compensation for operating, retransmission of other amateur signals, encryption, sale of equipment, unidentified transmissions, one-way transmission

T1E Control operator: eligibility, designating, privileges, duties, location, required; Control point; Control types: automatic, remote

T1F Station identification; Repeaters; Third party communications; Club stations; FCC inspection

**SUBELEMENT T2 — OPERATING PROCEDURES [3 Exam Questions — 3 Groups]**

T2A Station operation: choosing an operating frequency, calling another station, test transmissions; Band plans: calling frequencies, repeater offsets

T2B VHF/UHF operating practices: FM repeater, simplex, reverse splits; Access tones: CTCSS, DTMF; DMR operation; Resolving operational problems; Q signals

T2C Public service: emergency operations, applicability of FCC rules, RACES and ARES, net and traffic procedures, operating restrictions during emergencies, use of phonetics in message handling

**SUBELEMENT T3 — RADIO WAVE PROPAGATION [3 Exam Questions — 3 Groups]**

T3A Radio wave characteristics: how a radio signal travels, fading, multipath, polarization, wavelength vs absorption; Antenna orientation

T3B Electromagnetic wave properties: wavelength vs frequency, nature and velocity of electromagnetic waves, relationship of wavelength and frequency; Electromagnetic spectrum definitions: UHF, VHF, HF

T3C Propagation modes: sporadic E, meteor scatter, auroral propagation, tropospheric ducting; F region skip; Line of sight and radio horizon

**SUBELEMENT T4 — AMATEUR RADIO PRACTICES [2 Exam Questions — 2 Groups]**

T4A Station setup: connecting a microphone, a power source, a computer, digital equipment, an SWR meter; bonding; Mobile radio installation

T4B Operating controls: frequency tuning, use of filters, squelch function, AGC, memory channels, noise blanker, microphone gain, receiver incremental tuning (RIT), bandwidth selection, digital transceiver configuration

**SUBELEMENT T5 — ELECTRICAL PRINCIPLES [4 Exam Questions — 4 Groups]**

T5A Current and voltage: terminology and units, conductors and insulators, alternating and direct current

T5B Math for electronics: conversion of electrical units, decibels

T5C Capacitance and inductance terminology and units; Radio frequency definition and units; Impedance definition and units; Calculating power

T5D Ohm’s Law; Series and parallel circuits

**SUBELEMENT T6 — ELECTRONIC AND ELECTRICAL COMPONENTS [4 Exam Questions — 4 Groups]**

T6A Fixed and variable resistors; Capacitors; Inductors; Fuses; Switches; Batteries

T6B Semiconductors: basic principles and applications of solid state devices, diodes and transistors

T6C Circuit diagrams: use of schematics, basic structure; Schematic symbols of basic components

T6D Component functions: rectifiers, relays, voltage regulators, meters, indicators, integrated circuits, transformers; Resonant circuit; Shielding

**SUBELEMENT T7 — PRACTICAL CIRCUITS [4 Exam Questions — 4 Groups]**

T7A Station equipment: receivers, transceivers, transmitter amplifiers, receive amplifiers, transverters; Basic radio circuit concepts and terminology: sensitivity, selectivity, mixers, oscillators, PTT, modulation

T7B Symptoms, causes, and cures of common transmitter and receiver problems: overload and overdrive, distortion, interference and consumer electronics, RF feedback

T7C Antenna and transmission line measurements and troubleshooting: measuring SWR, effects of high SWR, causes of feed line failures; Basic coaxial cable characteristics; Use of dummy loads when testing

T7D Using basic test instruments: voltmeter, ammeter, and ohmmeter; Soldering

**SUBELEMENT T8 — SIGNALS AND EMISSIONS [4 Exam Questions — 4 Groups]**

T8A Basic characteristics of FM and SSB; Bandwidth of various modulation modes: CW, SSB, FM, fast-scan TV; Choice of emission type: selection of USB vs LSB, use of SSB for weak signal work, use of FM for VHF packet and repeaters

T8B Amateur satellite operation: Doppler shift, basic orbits, operating protocols, modulation mode selection, transmitter power considerations, telemetry and telecommand, satellite tracking programs, beacons, uplink and downlink mode definitions, spin fading, definition of “LEO”, setting uplink power

T8C Operating activities: radio direction finding, contests, linking over the internet, exchanging grid locators

T8D Non-voice and digital communications: image signals and definition of NTSC, CW, packet radio, PSK, APRS, error detection and correction, amateur radio networking, Digital Mobile Radio, WSJT modes, Broadband-Hamnet

**SUBELEMENT T9 — ANTENNAS AND FEED LINES [2 Exam Questions — 2 Groups]**

T9A Antennas: vertical and horizontal polarization, concept of antenna gain, definition and types of beam antennas, antenna loading, common portable and mobile antennas, relationships between resonant length and frequency, dipole pattern

T9B Feed lines: types, attenuation vs frequency, selecting; SWR concepts; Antenna tuners (couplers); RF Connectors: selecting, weather protection

**SUBELEMENT T0 — SAFETY [3 Exam Questions — 3 Groups]**

T0A Power circuits and hazards: hazardous voltages, fuses and circuit breakers, grounding, electrical code compliance; Lightning protection; Battery safety

T0B Antenna safety: tower safety and grounding, installing antennas, antenna supports

T0C RF hazards: radiation exposure, proximity to antennas, recognized safe power levels, radiation types, duty cycle

# Subelement T1
# Commission's Rules

**[6 Exam questions — 6 Groups]**

## T1A — Purpose and permissible use of the Amateur Radio Service; Operator/primary station license grant; Meanings of basic terms used in FCC rules; Interference; RACES rules; Phonetics; Frequency Coordinator

**T1A01 Which of the following is part of the Basis and Purpose of the the Amateur Radio Service?**

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

**C** [97.1] — Part 97.1 of the FCC's rules is the Basis and Purpose for the Amateur Service:

The rules and regulations in this part are designed to provide an amateur radio service having a fundamental purpose as expressed in the following principles:

(a) Recognition and enhancement of the value of the amateur service to the public as a voluntary noncommercial communication service, particularly with respect to providing emergency communications.

(b) Continuation and extension of the amateur's proven ability to contribute to the advancement of the radio art.

(c) Encouragement and improvement of the amateur service through rules which provide for advancing skills in both the communication and technical phases of the art.

(d) Expansion of the existing reservoir within the amateur radio service of trained operators, technicians, and electronics experts.

(e) Continuation and extension of the amateur's unique ability to enhance international goodwill.

[*Ham Radio License Manual*, page 7-2]

**T1A02 Which agency regulates and enforces the rules for the Amateur Radio Service in the United States?**

A. FEMA
B. Homeland Security
C. The FCC
D. All of these choices are correct

**C** [97.1] — The *Federal Communications Commission* or *FCC* is responsible for regulating telecommunications in the United States and all of its possessions. [*Ham Radio License Manual*, page 7-1]

**T1A03 What do the FCC rules state regarding the use of a phonetic alphabet for station identification in the Amateur Radio Service?**

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

**B** [97.119(b)(2)] — You are required to identify in English, even if you are communicating in a language other than English. The FCC recommends the use of phonetics when you identify by voice — that avoids confusing letters that sound alike. The standard phonetics are words in the English language. You may also identify by CW even if using phone. [*Ham Radio License Manual*, page 8-3]

**ITU Phonetic Alphabet**

| *Letter* | *Word* | *Pronunciation* |
|---|---|---|
| A | Alfa | **AL** FAH |
| B | Bravo | **BRAH** VOH |
| C | Charlie | **CHAR** 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 | Juliet | **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 |

| ***Letter*** | ***Word*** | ***Pronunciation*** |
|---|---|---|
| S | Sierra | SEE **AIR** RAH |
| T | Tango | **TANG** GO |
| U | Uniform | **YOU** NEE FORM |
| V | Victor | **VIK** TAH |
| W | Whiskey | **WISS** KEY |
| X | X-Ray | **ECKS** RAY |
| Y | Yankee | **YANG** KEY |
| Z | Zulu | **ZOO** LOO |

**T1A04 How many operator/primary station license grants may be held by any one person?**

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

**A** [97.5(b)(1)] — An operator license gives you permission to operate an amateur station according to the rules of the amateur service. The station license authorizes you to have an amateur station. The combined license is an *amateur operator/primary station license*. Each person can have only one such license. [*Ham Radio License Manual*, page 7-3]

**T1A05 What proves that the FCC has issued an operator/primary license grant?**

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

**C** [97.7] — Once your information appears in the FCC ULS consolidated database, that’s proof you have been granted an operator/station license and are fully authorized to go on the air. The FCC no longer routinely issues printed licenses, although they are available upon request. [*Ham Radio License Manual*, page 7-5]

**T1A06 What is the FCC Part 97 definition of a beacon?**

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

**D** [97.3(a)(9)] — Beacon stations are restricted to certain sub-bands to keep them from causing interference since they transmit under automatic control and do not listen for other activity. [*Ham Radio License Manual*, page 7-11]

**T1A07 What is the FCC Part 97 definition of a space station?**

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

**C** [97.3(a)(41)] — The definition is for an amateur station operating in space, not the more common name of the International Space Station (ISS). There is an amateur station on the ISS, so there is a space station operating on the space station! [*Ham Radio License Manual*, page 6-23]

**T1A08 Which of the following entities recommends transmit/receive channels and other parameters for auxiliary and repeater stations?**

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

**B** [97.3(a)(22)] — A committee of volunteers known as a *frequency coordinator* recommends transmit and receive frequencies. The frequency coordinator representatives are selected by the local or regional amateurs whose stations are eligible to be auxiliary or repeater stations. [*Ham Radio License Manual*, page 7-13]

**T1A09 Who selects a Frequency Coordinator?**

A. The FCC Office of Spectrum Management and Coordination Policy

B. The local chapter of the Office of National Council of Independent Frequency Coordinators

C. Amateur operators in a local or regional area whose stations are eligible to be repeater or auxiliary stations

D. FCC Regional Field Office

**C** [97.3(a)(22)] — See question T1A08. [*Ham Radio License Manual*, page 7-13]

**T1A10 What is the Radio Amateur Civil Emergency Services (RACES)?**

A. A radio service using amateur frequencies for emergency management or civil defense communications
B. A radio service using amateur stations for emergency management or civil defense communications
C. An emergency service using amateur operators certified by a civil defense organization as being enrolled in that organization
D. All of these choices are correct

**D** [97.3(a)(38), 97.407] — RACES is a special part of the Amateur service created by the FCC to provide communications assistance to local, state, or federal government emergency management agencies during civil emergencies. See Part 97.407 of the FCC rules for more information on RACES. [*Ham Radio License Manual*, page 6-18]

**T1A11 When is willful interference to other amateur radio stations permitted?**

A. To stop another amateur station that is breaking the FCC rules
B. At no time
C. When making short test transmissions
D. At any time, stations in the Amateur Radio Service are not protected from willful interference

**B** [97.101(d)] — Intentionally creating harmful interference is called *willful interference* and is never allowed. [*Ham Radio License Manual*, page 8-5]

**T1B — Frequency allocations; Emission modes; Spectrum sharing; Transmissions near band edges; Contacting the International Space Station; Power output**

**T1B01 Which of the following frequency ranges are available for phone operation by Technician licensees?**

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

**C** The HF privileges for Technicians are listed in the table below. [*Ham Radio License Manual*, page 7-9]

**Technician HF Privileges**

200 watts PEP maximum output

| ***Band (Wavelength)*** | ***Frequency (MHz)*** |
|---|---|
| 80 meters | 3.525 – 3.600 (CW only) |
| 40 meters | 7.025 – 7.125 (CW only) |
| 15 meters | 21.025 – 21.200 (CW only) |
| 10 meters | 28.000 – 28.300 (CW, RTTY and data) |
| | 28.300 – 28.500 (CW and SSB) |

**T1B02 Which amateurs may contact the International Space Station (ISS) on VHF bands?**

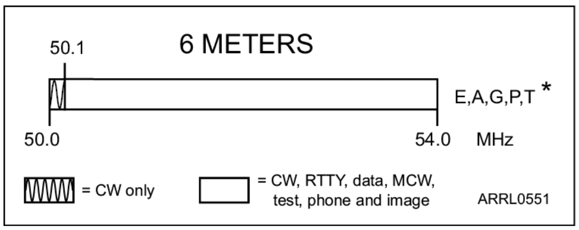
A. Any amateurs holding a General class or higher license
B. Any amateur holding a Technician or higher-class license
C. Any amateur holding a General class or higher license who has applied for and received approval from NASA
D. Any amateur holding a Technician class or higher license who has applied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

**B** [97.301, 97.207(c)] — It is only necessary to be licensed to transmit on the uplink frequencies to contact any space station. [*Ham Radio License Manual*, page 6-22]

**T1B03 Which frequency is in the 6 meter amateur band?**

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

**B** [97.301(a)] — The table below shows the Technician VHF/UHF frequency privileges that you are expected to know for your license exam. Remember that you can convert between frequency and wavelength using the following formula: frequency (in MHz) = 300 / wavelength (in meters) or wavelength (in meters) = 300 / frequency (in MHz). [*Ham Radio License Manual*, page 7-9]




**Most Popular VHF and UHF Technician Amateur Bands**

| *Band (Wavelength)* | *Frequency Limits* |
|---|---|
| **VHF Range** | |
| 6 meters | 50 – 54 MHz |
| 2 meters | 144 – 148 MHz |
| 1.25 meters | 219 – 220 MHz |
| 1.25 meters | 222 – 225 MHz |
| **UHF Range** | |
| 70 centimeters | 420 – 450 MHz |
| 33 centimeters | 902 – 928 MHz |
| 23 centimeters | 1240 – 1300 MHz |
| 13 centimeters | 2300 – 2310 MHz |
| 13 centimeters | 2390 – 2450 MHz |

**T1B04 Which amateur band includes 146.52 MHz?**

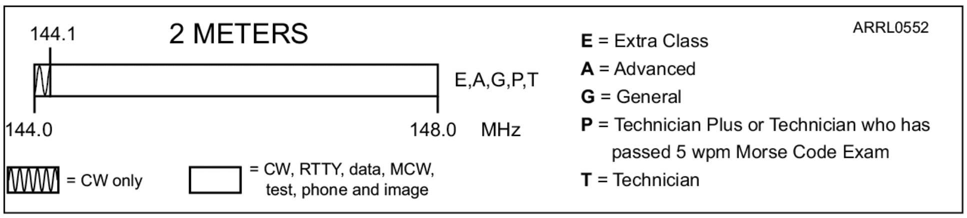
A. 6 meters

B. 20 meters

C. 70 centimeters

D. 2 meters

**D** [97.301(a)] — See question T1B03. [*Ham Radio License Manual,* page 7-9]



**T1B05 How may amateurs use the 219 to 220 MHz segment of 1.25 meter band?**

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

**D** [97.305(c)] — The segment of the 1.25 meter band from 219 to 220 MHz is restricted to digital message forwarding by fixed stations and systems. [*Ham Radio License Manual*, page 7-11]

**T1B06 On which HF bands does a Technician class operator have phone privileges?**

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

**B** [97.301(e), 97.305] [*Ham Radio License Manual*, page 7-9]

**Technician HF Privileges**

200 watts PEP maximum output

| *Band (Wavelength)* | *Frequency (MHz)* |
|---|---|
| 80 meters | 3.525 – 3.600 (CW only) |
| 40 meters | 7.025 – 7.125 (CW only) |
| 15 meters | 21.025 – 21.200 (CW only) |
| 10 meters | 28.000 – 28.300 (CW, RTTY and data) |
| | 28.300 – 28.500 (CW and SSB) |

**T1B07 Which of the following VHF/UHF band segments are limited to CW only?**

A. 50.0 MHz to 50.1 MHz and 144.0 MHz to 144.1 MHz
B. 219 MHz to 220 MHz and 420.0 MHz to 420.1 MHz
C. 902.0 MHz to 902.1 MHZ
D. All of these choices are correct

**A** [97.305(a), (c)] — There is a small CW-only sub-band occupying the bottom 100 kHz of the 6 and 2 meter bands. [*Ham Radio License Manual*, page 7-11]

**T1B08 How are US amateurs restricted in segments of bands where the Amateur Radio Service is secondary?**

A. U.S. amateurs may find non-amateur stations in those segments, and must avoid interfering with them

B. U.S. amateurs must give foreign amateur stations priority in those segments

C. International communications are not permitted in those segments

D. Digital transmissions are not permitted in those segments

**A** [97.303] — A primary service is *protected* from harmful interference by signals from secondary services. The secondary service gains access to the frequencies in the allocation with the understanding that it must not cause harmful interference to primary service users and it must accept interference from primary users. [*Ham Radio License Manual*, page 7-13]

**T1B09 Why should you not set your transmit frequency to be exactly at the edge of an amateur band or sub-band?**

A. To allow for calibration error in the transmitter frequency display
B. So that modulation sidebands do not extend beyond the band edge
C. To allow for transmitter frequency drift
D. All of these choices are correct

**D** [97.101(a), 97.301(a-e)] — Amateurs are allowed to use any frequency in a band, but have to be careful when operating near the edge of the band. All of the signal must be inside the band. Since radios display the *carrier frequency*, remember to leave room for the signal's sidebands. [*Ham Radio License Manual*, page 5-7]

**T1B10 Where may SSB phone be used in amateur bands above 50 MHz?**

A. Only in sub-bands allocated to General class or higher licensees
B. Only on repeaters
C. In at least some segment of all these bands
D. On any band if the power is limited to 25 watts

**C** [ 97.305(c)] — See the table with question T1B06. [*Ham Radio License Manual*, page 6-1]

**T1B11 What is the maximum peak envelope power output for Technician class operators in their HF band segments?**

A. 200 watts
B. 100 watts
C. 50 watts
D. 10 watts

**A** [97.313] — Below 30 MHz, Novice and Technician licensees are limited to 200 watts PEP on HF bands. With a few specific restrictions Technicians are allowed the full legal limit of 1500 watts PEP output above 30 MHz. [*Ham Radio License Manual*, page 7-12]

**T1B12 Except for some specific restrictions, what is the maximum peak envelope power output for Technician class operators using frequencies above 30 MHz?**

A. 50 watts
B. 100 watts
C. 500 watts
D. 1500 watts

**D** [97.313(b)] — See question T1B11. [*Ham Radio License Manual*, page 7-12]

**T1C — Licensing: classes, sequential and vanity call sign systems, places where the Amateur Radio Service is regulated by the FCC, name and address on FCC license database, term, renewal, grace period, maintaining mailing address; International communications**

**T1C01 For which license classes are new licenses currently available from the FCC?**

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

**D** [97.9(a), 97.17(a)] — There are three other license classes — the Novice, Technician Plus, and Advanced. No new licenses are being granted for these classes. [*Ham Radio License Manual*, page 7-3]

**T1C02 Who may select a desired call sign under the vanity call sign rules?**

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

**D** [97.19] — Licensed hams can pick any available call authorized for their license class. There are many available calls for Technician licensees to choose from in the Group C (1-by-3) and Group D (2-by-3) call sign formats. [*Ham Radio License Manual*, page 7-17]

**T1C03 What types of international communications is an FCC-licensed amateur radio station permitted to make?**

A. Communications incidental to the purposes of the Amateur Radio Service and remarks of a personal character

B. Communications incidental to conducting business or remarks of a personal nature

C. Only communications incidental to contest exchanges, all other communications are prohibited

D. Any communications that would be permitted by an international broadcast station

**A** [97.117] — Unless specifically prohibited by the government of either country, any ham can talk to any other ham. International communications must be limited to the purposes of the amateur service or remarks of a personal nature. [*Ham Radio License Manual*, page 7-15]

**T1C04 What may happen if the FCC is unable to reach you by email?**

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

**B** [97.23] — The FCC requires you to provide and maintain a valid current mail and email address in their database at all times. This is so you can be contacted by mail or email, if needed. If you move or even change P.O. boxes, be sure to update your information using the FCC ULS online system. If mail or email to you is returned to the FCC as undeliverable, your license can be suspended or revoked and removed from the database. [*Ham Radio License Manual*, page 7-8]

**T1C05 Which of the following is a valid Technician class call sign format?**

A. K1XXX
B. KA1X
C. W1XX
D. All of these choices are correct

**A** See question T1C02. [*Ham Radio License Manual*, page 7-17]

**T1C06 From which of the following locations may an FCC-licensed amateur station transmit?**

A. From within any country that belongs to the International Telecommunication Union
B. From within any country that is a member of the United Nations
C. From anywhere within International Telecommunication Union (ITU) Regions 2 and 3
D. From any vessel or craft located in international waters and documented or registered in the United States

**D** [97.5(a)(2)] — To operate at all, the foreign country must permit amateur operation. In addition, you must have permission and when you are inside a country's national boundaries, including territorial waters, you are required to operate according to their rules. You may also operate from any vessel or craft that is documented or registered in the United States. If the vessel is in territorial waters, regulations of the host country and those of the vessel's registry both apply. [*Ham Radio License Manual*, page 7-15]

**T1C07 Which of the following can result in revocation of the station license or suspension of the operator license?**

A. Failure to inform the FCC of any changes in the amateur station following performance of an RF safety environmental evaluation
B. Failure to provide and maintain a correct email address with the FCC
C. Failure to obtain FCC type acceptance prior to using a home-built transmitter
D. Failure to have a copy of your license available at your station

**B** [97.23] — See question T1C04. [*Ham Radio License Manual*, page 7-8]

**T1C08 What is the normal term for an FCC-issued amateur radio license?**

A. Five years
B. Life
C. Ten years
D. Twenty years

**C** [97.25] — Amateur Radio licenses are good for a 10-year term. You can renew them indefinitely without ever taking another exam. You can renew online by using the FCC’s Universal Licensing System (ULS). Up until 90 days before your license expires, you can also fill out a paper FCC Form 605 and mail it to the FCC. If your license expires, you have a two-year grace period to apply for a new license without taking the exam again. Until your license is renewed, stop transmitting because your license is not valid after it expires. [*Ham Radio License Manual*, page 7-5]

**T1C09 What is the grace period for renewal if an amateur license expires?**

A. Two years
B. Three years
C. Five years
D. Ten years

**A** [97.21(a)(b)] — See question T1C08. [*Ham Radio License Manual*, page 7-5]

**T1C10 How soon after passing the examination for your first amateur radio license may you transmit on the amateur radio bands?**

A. Immediately on receiving your Certificate of Successful Completion of Examination (CSCE)
B. As soon as your operator/station license grant appears on the ARRL website
C. As soon as your operator/station license grant appears in the FCC's license database
D. As soon as you receive your license in the mail from the FCC

**C** [97.5a] — See question T1A05. [*Ham Radio License Manual*, page 7-5]

**T1C11 If your license has expired and is still within the allowable grace period, may you continue to transmit on the amateur radio bands?**

A. Yes, for up to two years
B. Yes, as soon as you apply for renewal
C. Yes, for up to one year
D. No, you must wait until the license has been renewed

**D** [97.21(b)] — See question T1C08. [*Ham Radio License Manual*, page 7-5]

**T1D — Authorized and prohibited transmissions: communications with other countries, music, exchange of information with other services, indecent language, compensation for operating, retransmission of other amateur signals, encryption, sale of equipment, unidentified transmissions, one-way transmission**

**T1D01 With which countries are FCC-licensed amateur radio stations prohibited from exchanging communications?**

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

**A** [97.111(a)(1)] — Some countries do not recognize Amateur Radio, although the number is very small. The FCC can prohibit contacts between US citizens and those of specific other countries by notifying the ITU of its objections. [*Ham Radio License Manual*, page 7-15]

**T1D02 Under which of the following circumstances are one-way transmissions by an amateur station prohibited?**

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

**B** [97.113(b), 97.111(b)] — Broadcasting consists of *one-way transmissions* intended for reception by the general public. Hams are not permitted to make this type of transmission except for the purposes of transmitting code practice, information bulletins for other amateurs, or when necessary for emergency communications. The prohibition on broadcasting includes repeating and relaying transmissions from other communications services. Hams are also specifically prohibited from assisting and participating in news gathering by broadcasting organizations. [*Ham Radio License Manual*, page 8-11]

**T1D03 When is it permissible to transmit messages encoded to obscure their meaning?**

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

**C** [97.211(b), 97.215(b), 97.114(a)(4)] — Translating information into data for transmission is called *encoding.* Recovering the encoded information is called *decoding*. Reducing the size of a message to transmit it more efficiently is called *compression*. Most forms of encoding and compression are okay because they are done according to a published protocol. Any ham can look up the protocol and develop the appropriate capabilities to receive and decode data sent with that protocol. Encoding that uses codes or ciphers to hide the meaning of the transmitted message is called *encryption*. Recovering the encrypted information is called *decryption*. Amateurs may not use encryption techniques except for radio control and control transmissions to space stations where interception or unauthorized transmissions could have serious consequences. [*Ham Radio License Manual,* page 8-11]

**T1D04 Under what conditions is an amateur station authorized to transmit music using a phone emission?**

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

**A** [97.113(a)(4), 97.113(c)] — Music can only be rebroadcast as part of an authorized rebroadcast of space station transmissions — a rather unusual circumstance. This means that you should turn down a vehicle's audio system when you're transmitting from a mobile station. [*Ham Radio License Manual*, page 8-11]

**T1D05 When may amateur radio operators use their stations to notify other amateurs of the availability of equipment for sale or trade?**

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

**D** [97.113(a)(3)(ii)] — It is okay to advertise equipment for sale as long as it pertains to Amateur Radio and it's not your regular business. You can also order things over the air, as long as you don't do it regularly or as part of your normal income-making activities. No transmissions related to conducting your business or employer's activities are permitted. Your own personal activities don't count as "business" communications, though. One exception is that teachers can be a control operator of a ham station while using ham radio for instruction, but it must be incidental to their job and can't be the majority of their duties. [*Ham Radio License Manual*, page 8-10]

**T1D06 What, if any, are the restrictions concerning transmission of language that may be considered indecent or obscene?**

A. The FCC maintains a list of words that are not permitted to be used on amateur frequencies

B. Any such language is prohibited

C. The ITU maintains a list of words that are not permitted to be used on amateur frequencies

D. There is no such prohibition

**B** [97.113(a)(4)] — While you may encounter stations using such language, it's best to avoid controversial topics and expletives. [*Ham Radio License Manual*, page 8-10]

**T1D07 What types of amateur stations can automatically retransmit the signals of other amateur stations?**

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

**D** [97.113(d)] — Retransmitting the signals of another station is generally prohibited, except when you are relaying messages or digital data from another station. Some types of stations (repeaters, auxiliary stations and space stations) are allowed to automatically retransmit signals on different frequencies or channels. [*Ham Radio License Manual*, page 8-11]

**T1D08 In which of the following circumstances may the control operator of an amateur station receive compensation for operating that station?**

A. When the communication is related to the sale of amateur equipment by the control operator's employer

B. When the communication is incidental to classroom instruction at an educational institution

C. When the communication is made to obtain emergency information for a local broadcast station

D. All these choices are correct

**B** [97.113(a)(3)(iii)] — See question T1D05. [*Ham Radio License Manual*, page 8-10]

**T1D09 When may amateur stations transmit information in support of broadcasting, program production, or news gathering, assuming no other means is available?**

A. When such communications are directly related to the immediate safety of human life or protection of property
B. When broadcasting communications to or from the space shuttle
C. Where noncommercial programming is gathered and supplied exclusively to the National Public Radio network
D. Never

**A** [97.113(5)(b)] — See question T1D02. [*Ham Radio License Manual*, page 8-11]

**T1D10 How does the FCC define broadcasting for the Amateur Radio Service?**

A. Two-way transmissions by amateur stations
B. Any transmission made by the licensed station
C. Transmission of messages directed only to amateur operators
D. Transmissions intended for reception by the general public

**D** [97.3(a)(10)] — See question T1D02. [*Ham Radio License Manual*, page 8-11]

**T1D11 When may an amateur station transmit without identifying on the air?**

A. When the transmissions are of a brief nature to make station adjustments
B. When the transmissions are unmodulated
C. When the transmitted power level is below 1 watt
D. When transmitting signals to control model craft

**D** [97.119(a)] — Unidentified transmissions are not allowed. Unidentified means that no call sign was associated with a transmission. The only exceptions are for space stations, or for when your signals are controlling a model craft. [*Ham Radio License Manual*, page 8-3]

## T1E —Control operator: eligibility, designating, privileges, duties, location, required; Control point; Control types: automatic, remote

**T1E01 When may an amateur station transmit without a control operator?**

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

**D** [97.7(a)] — A *control operator* is the licensed amateur designated to be responsible for making sure that transmissions comply with FCC rules. That doesn't have to be the same person as the station owner. Any licensed amateur can be a control operator.

The *station licensee* is responsible for designating the control operator. A control operator must be named in the FCC amateur license database or have reciprocal operating authorization. All transmissions must be made under the supervision of a control operator and there can be only one control operator for a station at a time. [*Ham Radio License Manual*, page 8-1]

**T1E02 Who may be the control operator of a station communicating through an amateur satellite or space station?**

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

**D** [97.301, 97.207(c)] — Satellite contacts, including contacts with the amateur station on the International Space Station, can be made by any amateur licensed to transmit on the *uplink* frequency. [*Ham Radio License Manual*, page 6-23]

**T1E03 Who must designate the station control operator?**

A. The station licensee

B. The FCC

C. The frequency coordinator

D. Any licensed operator

**A** [97.103(b)] — See question T1E01. [*Ham Radio License Manual*, page 8-1]

**T1E04 What determines the transmitting frequency privileges of an amateur station?**

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

**D** [97.103(b)] — As the control operator, you may operate the station in any way permitted by the privileges of your license class. It doesn’t matter what the station owner’s privileges are, only the privileges of the control operator. When acting as a control operator, you are restricted to the privileges of your license class. [*Ham Radio License Manual*, page 8-2]

**T1E05 What is an amateur station**’s **control point?**

A. The location of the station’s transmitting antenna

B. The location of the station’s transmitting apparatus

C. The location at which the control operator function is performed

D. The mailing address of the station licensee

**C** [97.3(a)(14)] — See question T1E01. [*Ham Radio License Manual*, page 8-1]

**T1E06 When, under normal circumstances, may a Technician class licensee be the control operator of a station operating in an Amateur Extra class band segment?**

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

**A** [97.301] — See question T1E04. [*Ham Radio License Manual*, page 8-2]

**T1E07 When the control operator is not the station licensee, who is responsible for the proper operation of the station?**

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

**D** [97.103(a)] — The station owner is responsible for limiting access to the station only to responsible licensees who will follow the FCC rules. Note that the FCC will presume the station licensee to be the control operator unless there is a written record to the contrary. [*Ham Radio License Manual*, page 8-2]

**T1E08 Which of the following is an example of automatic control?**

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

**A** [97.3(a)(6), 97.205(d)] — There are three different ways that a operator can control a transmitter:

*Local control* — a control operator is physically present at the control point. This is the situation for nearly all amateur stations, including mobile operation. Any type of station can be locally controlled.

*Remote control* — the control point is located away from the transmitter and the control operator adjusts or operates the transmitter indirectly via some kind of control link. The control operator must be present at the control point during all transmission. Many stations operate under remote control over an Internet link. Any station can be remotely controlled.

*Automatic control* — the station operates completely under the control of devices and procedures that ensure compliance with FCC rules. A control operator is still required, but need not be at the control point when the station is transmitting. Repeaters, beacons and space stations are allowed to be automatically controlled. Digipeaters that relay messages, such as for the APRS network, are also automatically controlled.

[*Ham Radio License Manual*, page 8-9]

**T1E09 Which of the following are required for remote control operation?**

A. The control operator must be at the control point
B. A control operator is required at all times
C. The control operator must indirectly manipulate the controls
D. All of these choices are correct

**D** [97.109(c)] — See question T1E08. [*Ham Radio License Manual*, page 8-9]

**T1E10 Which of the following is an example of remote control as defined in Part 97?**

A. Repeater operation
B. Operating the station over the internet
C. Controlling a model aircraft, boat, or car by amateur radio
D. All of these choices are correct

**B** [97.3(a)(39)] — See question T1E08. [*Ham Radio License Manual*, page 8-9]

**T1E11 Who does the the FCC presume to be the control operator of an amateur station, unless documentation to the contrary is in the station records?**

A. The station custodian
B. The third-party participant
C. The person operating the station equipment
D. The station licensee

**D** [97.103(a)] — See question T1E07. [*Ham Radio License Manual*, page 8-2]

**T1F — Station identification; Repeaters; Third party communications; Club stations; FCC inspection**

**T1F01 When must the station and its records be available for FCC inspection?**

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

**B** [97.103(c)] — As a federal licensee, you are obligated to make your station available for inspection upon request by an FCC representative. By accepting the FCC rules and regulations for the amateur service, you agree that your station could be inspected any time. [*Ham Radio License Manual*, page 7-8]

**T1F02 How often must you identify with your FCC-assigned call sign when using tactical call signs such as “Race Headquarters”?**

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

**C** [97.119(a)] — Tactical call signs (or tactical IDs) are used to help identify where a station is and what it is doing. Tactical calls don’t replace regular call signs and the regular identification rules apply — give your FCC-assigned call sign every 10 minutes and at the end of the communication. [*Ham Radio License Manual*, page 8-4]

**T1F03 When are you required to transmit your assigned call sign?**

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

**D** [97.119(a)] — Give your call sign at least once every 10 minutes during a contact and when the communication is finished. The communication can include contacts with several stations, such as during a net or contest. [*Ham Radio License Manual*, page 8-3]

**T1F04 What language may you use for identification when operating in a phone sub-band?**

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

**C** [97.119(b)(2)] — See question T1A03. [*Ham Radio License Manual*, page 8-3]

**T1F05 What method of call sign identification is required for a station transmitting phone signals?**

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

**B** [97.119(b)(2)] — See question T1A03. [*Ham Radio License Manual*, page 8-3]

**T1F06 Which of the following self-assigned indicators are acceptable when using a phone transmission?**

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

**D** [97.119(c)] — FCC Part 97.119(c) says, "One or more indicators may be included with the call sign. Each indicator must be separated from the call sign by the slant mark (/) or by any suitable word that denotes the slant mark. If an indicator is self-assigned, it must be included before, after, or both before and after, the call sign." [*Ham Radio License Manual, page 8-4]*

**T1F07 Which of the following restrictions apply when a non-licensed person is allowed to speak to a foreign station using a station under the control of a licensed amateur operator?**

A. The person must be a U.S. citizen

B. The foreign station must be in a country with which the U.S. has a third-party agreement

C. The licensed control operator must do the station identification

D. All of these choices are correct

**B** [97.115(a)(2)] — The exact definition of third-party communication is a message from an amateur station control operator to another amateur station control operator on behalf of another person. That "other person" is the "third party." Simplifying the definition, any time that you send or receive information via ham radio on behalf of any unlicensed person or an organization, even if the person is right there in the station with you — that's third-party communications. [*Ham Radio License Manual*, page 8-7]

The table on page 45 shows which countries have *third-party agreements* with the United States. If the other country isn't on this list, third-party communication with that country is not permitted.

**T1F08 What is the definition of third party communications?**

A. A message from a control operator to another amateur station control operator on behalf of another person

B. Amateur radio communications where three stations are in communications with one another

C. Operation when the transmitting equipment is licensed to a person other than the control operator

D. Temporary authorization for an unlicensed person to transmit on the amateur bands for technical experiments

**A** [97.3(a)(47)] — See question T1F07. [*Ham Radio License Manual*, page 8-7]

**T1F09 What type of amateur station simultaneously retransmits the signal of another amateur station on a different channel or channels?**

A. Beacon station
B. Earth station
C. Repeater station
D. Message forwarding station

**C** [97.3(a)(40)] — Repeaters consist of a receiver and transmitter that re-transmit the information from a received signal simultaneously on another frequency or channel [*Ham Radio License Manual*, page 2-8]

**Third-Party Agreements**

## The United States has third-party agreements with the following nations.

| | |
|---|---|
| V2 | Antigua/Barbuda |
| LO-LW | Argentina |
| VK | Australia |
| V3 | Belize |
| CP | Bolivia |
| E7 | Bosnia-Herzegovina |
| PP-PY | Brazil |
| VE, VO, VY | Canada |
| CA-CE | Chile |
| HJ-HK | Colombia |
| D6 | Comoros (Federal Islamic Republic of) |
| TI, TE | Costa Rica |
| CM, CO | Cuba |
| J7 | Dominica |
| HI | Dominican Republic |
| HC-HD | Ecuador |
| YS | El Salvador |
| C5 | Gambia, The |
| 9G | Ghana |

| | |
|---|---|
| J3 | Grenada |
| TG | Guatemala |
| 8R | Guyana |
| HH | Haiti |
| HQ-HR | Honduras |
| 4X, 4Z | Israel |
| 6Y | Jamaica |
| JY | Jordan |
| EL | Liberia |
| V7 | Marshall Islands |
| XA-XI | Mexico |
| V6 | Micronesia, Federated States of |
| YN | Nicaragua |
| HO-HP | Panama |
| ZP | Paraguay |
| OA-OC | Peru |
| DU-DZ | Philippines |
| V4 | St. Kitts/Nevis |
| J6 | St. Lucia |
| J8 | St. Vincent and the Grenadines |
| 9L | Sierra Leone |
| ZR-ZU | South Africa |
| 3DA | Swaziland |
| 9Y-9Z | Trinidad/Tobago |
| TA-TC | Turkey |
| GB | United Kingdom |
| CV-CX | Uruguay |
| YV-YY | Venezuela |
| 4U1ITU | ITU — Geneva |
| 4U1VIC | VIC — Vienna |

**T1F10 Who is accountable if a repeater inadvertently retransmits communications that violate the FCC rules?**

A. The control operator of the originating station
B. The control operator of the repeater
C. The owner of the repeater
D. Both the originating station and the repeater owner

**A** [97.205(g)] — Repeater owners must ensure the repeater operates in compliance with FCC rules. Repeater users are responsible for proper operation via the repeater, however. [*Ham Radio License Manual*, page 8-9]

**T1F11 Which of the following is a requirement for the issuance of a club station license grant?**

A. The trustee must have an Amateur Extra class operator license grant

B. The club must have at least four members

C. The club must be registered with the American Radio Relay League

D. All of these choices are correct

**B** [97.5(b)(2)] — Each club must have a licensed *trustee* who actually holds the club license and is designated by a club officer. Clubs must have at least four members and be organized as in rule 97.5(b). [*Ham Radio License Manual*, page 7-3]

# Subelement T2
# Operating Procedures

**[3 Exam Questions — 3 Groups]**

**T2A — Station operation: choosing an operating frequency, calling another station, test transmissions; Band plans: calling frequencies, repeater offsets**

**T2A01 What is a common repeater frequency offset in the 2 meter band?**

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

**B** [*Ham Radio License Manual*, page 6-11]

## Standard Repeater Offsets by Band

| ***Band*** | ***Offset*** |
|---|---|
| 10 meters | –100 kHz |
| 6 meters | Varies by region: |
| | –500 kHz, –1 MHz, –1.7 MHz |
| 2 meters | + or –600 kHz |
| 1.25 meters | –1.6 MHz |
| 70 cm | + or –5 MHz |
| 902 MHz | 12 MHz |
| 1296 MHz | 12 MHz |

**T2A02 What is the national calling frequency for FM simplex operations in the 2 meter band?**

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

**A** 146.52 MHz is the standard 2 meter simplex calling frequency. 446.00 MHz is the simplex calling frequency on the 70 cm band. [*Ham Radio License Manual*, page 6-6]

**T2A03 What is a common repeater frequency offset in the 70 cm band?**

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

**A** See the table with question T2A01. [*Ham Radio License Manual*, page 6-11]

**T2A04 What is an appropriate way to call another station on a repeater if you know the other station's call sign?**

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

**B** If you want to respond to a station asking for a call or want to contact a station whose call sign you already know, just say the other station's call sign once, followed by "this is" or "from," then give your call sign. [*Ham Radio License Manual*, page 6-4]

**T2A05 How should you respond to a station calling CQ?**

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

**C** If you hear a station calling CQ, send the CQing station's call sign once then yours once or twice. Send your call clearly and distinctly so that it can be understood if there is noise or interference. [*Ham Radio License Manual*, page 6-6]

**T2A06 Which of the following is required when making on-the-air test transmissions?**

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

**A** Identification rules apply to on-the-air test transmissions, as well, no matter how brief. The call sign must be given once every 10 minutes and at the end of transmissions. [*Ham Radio License Manual*, page 8-5]

**T2A07 What is meant by "repeater offset"?**

A. The difference between a repeater's transmit and receive frequencies

B. The repeater has a time delay to prevent interference

C. The repeater station identification is done on a separate frequency

D. The number of simultaneous transmit frequencies used by a repeater

**A** The difference between repeater input and output frequencies is called the repeater's *offset* or *shift.* See also questions T2A01 and T2A03. [*Ham Radio License Manual,* page 6-11]

**T2A08 What is the meaning of the procedural signal “CQ”?**

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

**D** CQ is a procedural signal that means “I am calling any station.”
**[** *Ham Radio License Manual*, page 6-6]

**T2A09 Which of the following indicates that a station is listening on a repeater and looking for a contact?**

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

**B** Because repeaters usually have a strong signal on a known frequency, it’s not necessary to make a long transmission to attract listeners tuning by. The easiest way is to just give your call sign followed by “monitoring.” [*Ham Radio License Manual*, page 6-4]

**T2A10 What is a band plan, beyond the privileges established by the FCC?**

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

**A** Amateurs created band plans that help organize the different modes and activities. It’s important to keep in mind that band plans are voluntary agreements designed for normal conditions. They are not regulations and amateurs are expected to be flexible. [*Ham Radio License Manual*, page 6-1]

**T2A11 What term describes an amateur station that is transmitting and receiving on the same frequency?**

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

**C** *Simplex* and *duplex* refer to the type of communication taking place. Simplex communication is transmitting and receiving on the same frequency. Duplex communication uses one frequency for transmitting and another frequency for receiving. [*Ham Radio License Manual*, page 6-1]

**T2A12 What should you do before calling CQ?**

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

**D** Before you call CQ you should do three things:

• Be sure the frequency is one your license privileges authorize you to use!

• Listen to be sure the frequency is not already in use. If you don’t hear any signals in five to ten seconds the frequency may be available.

• Make a short transmission asking if the frequency is in use.

[*Ham Radio License Manual,* page 6-6]

## T2B — VHF/UHF operating practices: FM repeater, simplex, reverse splits; Access tones: CTCSS, DTMF; DMR operation; Resolving operational problems; Q signals

**T2B01 How is a VHF/UHF transceiver's "reverse" function used?**

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

**C** Many radios have a reverse split function that swaps the transmit and receive frequencies. This enables you to listen for the other station on the repeater's input frequency. [*Ham Radio License Manual*, page 6-6]

**T2B02 What term describes the use of a sub-audible tone transmitted along with normal voice audio to open the squelch of a receiver?**

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

**D** Repeater access tones are known by various names: Continuous Tone Coded Squelch System (CTCSS), PL (for Private Line, the Motorola trade name) or sub-audible. [*Ham Radio License Manual*, page 6-12]

**T2B03 Which of the following describes a linked repeater network?**

A. A network of repeaters in which signals received by one repeater are transmitted by all the repeaters in the network

B. A single repeater with more than one receiver

C. Multiple repeaters with the same control operator

D. A system of repeaters linked by APRS

**A** Repeaters can also be *linked* to other repeaters. That is, they share the signals each receives and retransmit them. This extends the coverage of any single repeater.. [*Ham Radio License Manual*, page 6-12]

**T2B04 Which of the following could be the reason you are unable to access a repeater whose output you can hear?**

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

**D** If you can hear a repeater's signal and you're sure you are using the right offset, but can't access the repeater, then you probably don't have your radio set up to use the right type or frequency of access tone. [*Ham Radio License Manual*, page 6-12]

**T2B05 What would cause your FM transmission audio to be distorted on voice peaks?**

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

**C** An overmodulated FM signal has excessive deviation and is said to be *overdeviating*. Overdeviation is usually caused by speaking too loudly into the microphone and may cause interference on adjacent channels. It often generates noise or distortion on voice peaks, called “breaking up.” To reduce overdeviation, speak more softly or move the microphone farther from your mouth. [*Ham Radio License Manual*, page 5-8]

**T2B06 What type of signaling uses pairs of audio tones?**

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

**A** To initiate a contact or exercise a control function on an IRLP-linked repeater, a control code is used. The code is a sequence of DTMF (Dual-tone Multi-Frequency) tones, like dialing a phone number. [*Ham Radio License Manual*, page 6-13]

**T2B07 How can you join a digital repeater's "talk group"?**

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

**C** The central DMR controller organizes users of the DMR network into talk groups. Each talk group has an ID or code. By programming your radio with those IDs and codes, you can join the group and your audio will be shared with all other members of the group. Talk groups allow groups of users to share a channel at different times without being heard by other users on the channel. [*Ham Radio License Manual*, page 6-13]

**T2B08 Which of the following applies when two stations transmitting on the same frequency interfere with each other?**

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

**A** If a transmission seriously degrades, obstructs or repeatedly interrupts the communications of a regulated service, that's considered harmful interference. Common courtesy should prevail but remember that no one has an absolute right to any frequency. [*Ham Radio License Manual*, page 8-5]

**T2B09 Why are simplex channels designated in the VHF/UHF band plans?**

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

**A** If you and the station you've contacted are in range of each other, why not give simplex a try? This avoids occupying or "tying up" a repeater. [*Ham Radio License Manual*, page 6-6]

**T2B10 Which Q signal indicates that you are receiving interference from other stations?**

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

**A** [*Ham Radio License Manual*, page 6-7]

# Q-Signals

These Q-signals are the ones used most often on the air. (Q abbreviations take the form of questions only when they are sent followed by a question mark.)

| | |
|---|---|
| QRG | Your exact frequency (or that of ______) is __________kHz.<br>Will you tell me my exact frequency (or that of ___________)? |
| QRL | I am busy (or I am busy with __________). Are you busy? Usually used to see if a frequency is busy. |
| QRM | Your transmission is being interfered with __________<br>(1. Nil; 2. Slightly; 3. Moderately; 4. Severely; 5. Extremely.)<br>Is my transmission being interfered with? |
| QRN | I am troubled by static __________. (1 to 5 as under QRM.)<br>Are you troubled by static? |
| QRO | Increase power. Shall I increase power? |
| QRP | Decrease power. Shall I decrease power? |
| QRQ | Send faster (__________wpm). Shall I send faster? |
| QRS | Send more slowly (__________wpm). Shall I send more slowly? |
| QRT | Stop sending. Shall I stop sending? |
| QRU | I have nothing for you. Have you anything for me? |
| QRV | I am ready. Are you ready? |
| QRX | I will call you again at ______hours (on ______kHz).<br>When will you call me again? Minutes are usually implied rather |

than hours.

| | |
|---|---|
| QRZ | You are being called by __________ (on ______kHz). |
| | Who is calling me? |
| QSB | Your signals are fading. Are my signals fading? |
| QSK | I can hear you between signals; break in on my transmission. |
| | Can you hear me between your signals and if so can I break in on your transmission? |
| QSL | I am acknowledging receipt. |
| | Can you acknowledge receipt (of a message or transmission)? |
| QSO | I can communicate with __________ direct (or relay through ______). |
| | Can you communicate with ______ direct or by relay? |
| QSP | I will relay to ______. Will you relay to ______? |
| QST | General call preceding a message addressed to all amateurs and ARRL members. This is in effect “CQ ARRL.” |
| QSX | I am listening to _____ on _____kHz. Will you listen to _____on _____kHz? |
| QSY | Change to transmission on another frequency (or on ______kHz). |
| | Shall I change to transmission on another frequency (or on ______kHz)? |
| QTC | I have ______messages for you (or for ______). |
| | How many messages have you to send? |
| QTH | My location is __________. What is your location? |
| QTR | The time is __________. What is the correct time? |

**T2B11 Which Q signal indicates that you are changing frequency?**

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

**B** See question T2B10. [*Ham Radio License Manual*, page 6-7]

**T2B12 What is the purpose of the color code used on DMR repeater systems?**

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

**A** Digital codes called *color codes* are used to access a specific repeater, similarly to CTCSS or PL access tones on an analog FM repeater. [*Ham Radio License Manual*, page 6-13]

**T2B13 What is the purpose of a squelch function?**

A. Reduce a CW transmitter’s key clicks

B. Mute the receiver audio when a signal is not present

C. Eliminate parasitic oscillations in an RF amplifier

D. Reduce interference from impulse noise

**B** The squelch circuit (sometimes called *carrier squelch*) mutes the receiver’s audio output when no signal is present. [*Ham Radio License Manual*, page 5-8]

**T2C — Public service: emergency operations, applicability of FCC rules, RACES and ARES, net and traffic procedures, operating restrictions during emergencies, use of phonetics in message handling**

**T2C01 When do the FCC rules NOT apply to the operation of an amateur station?**

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

**D** [97.103(a)] — You are bound by FCC rules at all times, even if using your radio in support of a public safety agency. [*Ham Radio License Manual*, page 6-19]

**T2C02 Which of the following are typical duties of a Net Control Station?**

A. Choose the regular net meeting time and frequency

B. Ensure that all stations checking into the net are properly licensed for operation on the net frequency

C. Call the net to order and direct communications between stations checking in

D. All of these choices are correct

**C** The *Net Control Station* (NCS) is in charge of net operation and directs the operation of other stations participating in the net. [*Ham Radio License Manual*, page 6-16]

**T2C03 What technique is used to ensure that voice messages containing unusual words are received correctly?**

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

**C** To help a receiving station copy a message exactly, proper names (such as “John Doe”) and unusual words (such as material names or model identifiers) are spelled out using standard phonetics. [*Ham Radio License Manual*, page 6-17]

**T2C04 What is RACES?**

A. An emergency organization combining amateur radio and citizens band operators and frequencies
B. An international radio experimentation society
C. A radio contest held in a short period, sometimes called a “sprint”
D. An FCC part 97 amateur radio service for civil defense communications during national emergencies

**D** RACES is a special part of the FCC Part 97 Amateur service to provide civil defense communications to local, state, or federal government emergency management agencies during national emergencies. [*Ham Radio License Manual*, page 6-18]

**T2C05 What does the term "traffic" refer to in net operation?**

A. Messages exchanged by net stations

B. The number of stations checking in and out of a net

C. Operation by mobile or portable stations

D. Requests to activate the net by a served agency

**A** Messages passed over the air that follow a set, formal structure are called *traffic*. Exchanging messages is called *traffic handling*. [*Ham Radio License Manual,* page 6-16]

**T2C06 What is the Amateur Radio Emergency Service (ARES)?**

A. A group of licensed amateurs who have voluntarily registered their qualifications and equipment for communications duty in the public service

B. A group of licensed amateurs who are members of the military and who voluntarily agreed to provide message handling services in the case of an emergency

C. A training program that provides licensing courses for those interested in obtaining an amateur license to use during emergencies

D. A training program that certifies amateur operators for membership in the Radio Amateur Civil Emergency Service

**C** ARES consists of licensed amateurs who have voluntarily registered their qualifications and equipment for communications duty in the public service. Its members support local and regional government and non-governmental agencies such as the Red Cross, Salvation Army, and National Weather Service. Any licensed amateur can participate in ARES. [*Ham Radio License Manual*, page 6-18]

**T2C07 Which of the following is standard practice when you participate in a net?**

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

**C** Once you have checked into a formal net under the direction of an NCS, it is important to not disrupt the net. Do not transmit unless you are specifically requested or authorized to do so or a request is made for capabilities or information that you can provide. [*Ham Radio License Manual*, page 6-16]

**T2C08 Which of the following is a characteristic of good traffic handling?**

A. Passing messages exactly as received
B. Making decisions as to whether messages are worthy of relay or delivery
C. Ensuring that any newsworthy messages are relayed to the news media
D. All of these choices are correct

**A** The most important job for traffic handlers during emergency and disaster net operation is the ability to accurately relay or “pass” messages exactly as written, spoken or received. [*Ham Radio License Manual*, page 6-17]

**T2C09 Are amateur station control operators ever permitted to operate outside the frequency privileges of their license class?**

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

**D** In an emergency situation where there is immediate risk to life or property and normal forms of communication are unavailable, you may use any means possible to address that risk, including operating outside the frequency privileges of your license. [*Ham Radio License Manual*, page 6-19]

**T2C10 What information is contained in the preamble of a formal traffic message?**

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

**D** The preamble is made up of several bits of information about the message. These establish a unique identity for each message so that it can be handled and tracked appropriately as it moves through the Amateur Radio traffic handling system.

• Number — a unique number assigned by the station that creates the radiogram

• Precedence — a description of the nature of the radiogram: Routine, Priority, Emergency and Welfare

• Handling Instructions (HX) — for special instructions in how to the handle the radiogram.

• Station of Origin — the call sign of the radio station from which the radiogram was first sent by Amateur Radio. (This allows information about the message to be returned to the sending station.)

• Check — the number of words and word equivalents in the radiogram text.

• Place of Origin — the name of the town from which the radiogram started

• Time and Date — the time and date the radiogram is received at the station that first sent it

• Address — the complete name, street and number, city and state to whom the radiogram is going

Following the preamble is the text of the radiogram.

[*Ham Radio License Manual*, page 6-17]

**T2C11 What is meant by “check” in a radiogram header?**

A. The number of words or word equivalents in the text portion of the message

B. The call sign of the originating station

C. A list of stations that have relayed the message

D. A box on the message form that indicates that the message was received and/or relayed

**A** See question T2C10. [*Ham Radio License Manual*, page 6-17]

# Subelement T3
# Radio Wave Propagation

**[3 Exam Questions — 3 Groups]**

## T3A — Radio wave characteristics: how a radio signal travels, fading, multipath, polarization, wavelength vs absorption; Antenna orientation

**T3A01 Why do VHF signal strengths sometimes vary greatly when the antenna is moved only a few feet?**

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

**C** Radio signals arriving at a receiver after taking different paths from the transmitter can interfere with each other if they are out of phase, even canceling completely! This phenomenon is known as *multipath* and can cause a signal to become weak and distorted. [*Ham Radio License Manual*, page 4-1]

**T3A02 What is the effect of vegetation on UHF and microwave signals?**

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

**B** Vegetation can absorb VHF and UHF radio waves. This can result in greater range in the winter. [*Ham Radio License Manual*, page 4-1]

**T3A03 What antenna polarization is normally used for long-distance CW and SSB contacts on the VHF and UHF bands?**

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

**C** Horizontal polarization is preferred for weak-signal contacts because it results in lower ground losses when the wave reflects from or travels along the ground. [*Ham Radio License Manual*, page 4-15]

**T3A04 What happens when antennas at opposite ends of a VHF or UHF line of sight radio link are not using the same polarization?**

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

**B** When the polarizations of transmit and receive antennas aren’t aligned the same, the received signal can be dramatically reduced. [*Ham Radio License Manual*, page 4-5]

**T3A05 When using a directional antenna, how might your station be able to communicate with a distant repeater if buildings or obstructions are blocking the direct line of sight path?**

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

**B** On VHF and UHF, if a direct signal path is blocked by building or other obstruction, a beam antenna can be used to aim the signal at a reflecting surface to bypass the obstruction. [*Ham Radio License Manual*, page 4-15]

**T3A06 What is the meaning of the term "picket fencing"?**

A. Alternating transmissions during a net operation

B. Rapid flutter on mobile signals due to multipath propagation

C. A type of ground system used with vertical antennas

D. Local vs long-distance communications

**B** Because "dead spots" from multipath are usually spaced about ½-wavelength apart, VHF or UHF signals from a station in motion can take on a rapid variation in strength known as *mobile flutter* or *picket-fencing*. [*Ham Radio License Manual*, page 4-1]

**T3A07 What weather condition might decrease range at microwave frequencies?**

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

**C** Precipitation such as fog and rain can absorb microwave and UHF radio waves although it has little effect at HF and on the lower VHF bands. [*Ham Radio License Manual*, page 4-1]

**T3A08 What is a likely cause of irregular fading of signals propagated by the ionosphere?**

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

**D** Multipath propagation of signals from distant stations results in irregular fading, even when reception is generally good, because signals taking different paths can interfere with each other at the receiving antenna. [*Ham Radio License Manual*, page 4-1]

**T3A09 Which of the following results from the fact that signals propagated by the ionosphere are elliptically polarized?**

A. Digital modes are unusable
B. Either vertically or horizontally polarized antennas may be used for transmission or reception
C. FM voice is unusable
D. Both the transmitting and receiving antennas must be of the same polarization

**B** Because as a radio wave travels through the ionosphere its polarization changes from vertical or horizontal to a combination of the two, both vertical and horizontal antennas are effective for receiving and transmitting on the HF bands where skip propagation is common. [*Ham Radio License Manual*, page 4-5]

**T3A10 What effect does multi-path propagation have on data transmissions?**

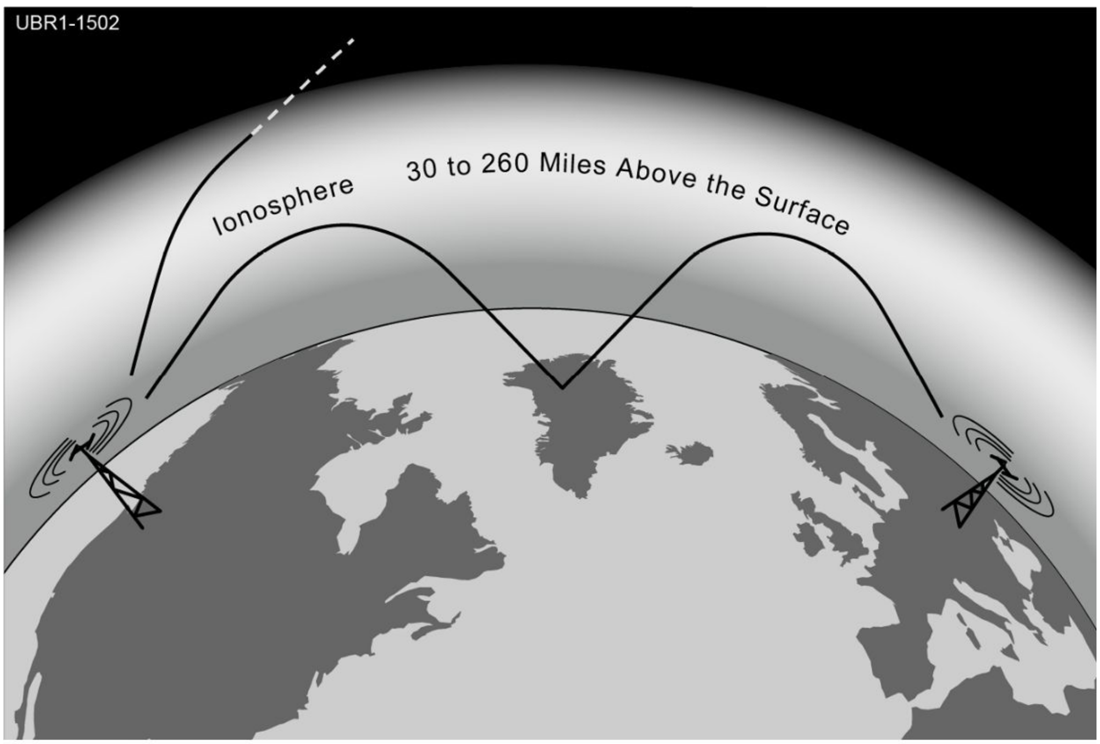
A. Transmission rates must be increased by a factor equal to the number of separate paths observed
B. Transmission rates must be decreased by a factor equal to the number of separate paths observed
C. No significant changes will occur if the signals are transmitted using FM
D. Error rates are likely to increase

**D** Distortion caused by multipath can cause VHF and UHF digital data signals to be received with a higher error rate, even though the signal may be strong. [*Ham Radio License Manual*, page 4-1]

**T3A11 Which region of the atmosphere can refract or bend HF and VHF radio waves?**

A. The stratosphere
B. The troposphere
C. The ionosphere
D. The magnetosphere

**C** Reflections from the ionosphere allow radio waves to be received hundreds or thousands of miles away. [*Ham Radio License Manual*, page 4-3]




**The ionosphere is formed by solar ultraviolet (UV) radiation. The UV rays knock electrons loose from air molecules, creating weakly charged layers at different heights. These layers can absorb or refract radio signals, sometimes bending them back to the Earth.**

**T3A12 What is the effect of fog and rain on signals in the 10 meter and 6 meter bands?**

A. Absorption
B. There is little effect
C. Deflection
D. Range increase

**B** See T3A07. [*Ham Radio License Manual*, page 4-1]

**T3B — Electromagnetic wave properties: wavelength vs frequency, nature and velocity of electromagnetic waves, relationship of wavelength and frequency; Electromagnetic spectrum definitions: UHF, VHF, HF**

**T3B01 What is the relationship between the electric and magnetic fields of an electromagnetic wave?**

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

**D** The electric and magnetic fields are at right angles to each other and oscillate at the same frequency as the RF current in the antenna. [*Ham Radio License Manual*, page 4-5]

**T3B02 What property of a radio wave defines its polarization?**

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

**A** *Polarization* refers to the orientation of the radio wave's electric field. [*Ham Radio License Manual*, page 4-5]

**T3B03 What are the two components of a radio wave?**

A. Impedance and reactance

B. Voltage and current

C. Electric and magnetic fields

D. Ionizing and non-ionizing radiation

**C** An *electromagnetic wave* is a combination of varying electric and magnetic fields. [*Ham Radio License Manual*, page 4-5]

**T3B04 What is the velocity of a radio wave traveling through free space?**

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

**A** All radio waves travel at the speed of light (represented by a lower-case *c*) in whatever medium they are traveling, such as air. [*Ham Radio License Manual*, page 2-5]

**T3B05 What is the relationship between wavelength and frequency?**

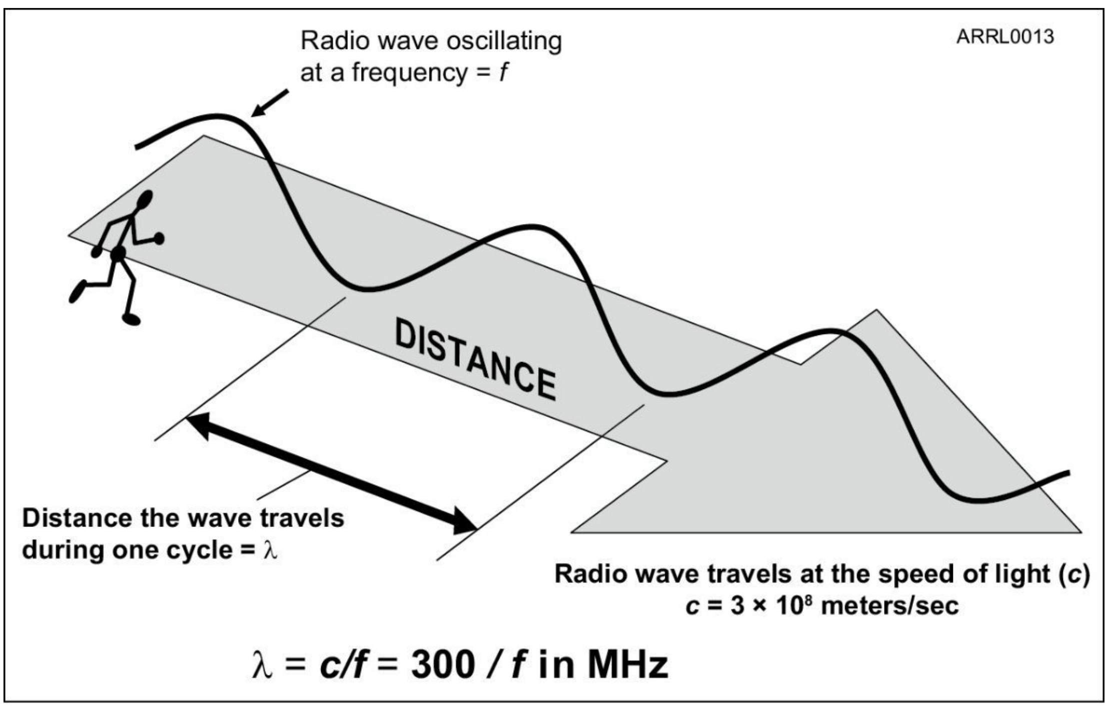
A. Wavelength gets longer as frequency increases
B. Wavelength gets shorter as frequency increases
C. Wavelength and frequency are unrelated
D. Wavelength and frequency increase as path length increases

**B** Because radio waves travel at a constant speed, $\lambda = c / f$ ($\lambda$ is one wavelength; $c$ is the speed of light; and $f$ is frequency). This means that as frequency increases, wavelength decreases and vice-versa.

$$\lambda \text{ in meters} = \frac{300}{f \text{ in MHz}}$$

Because of this relationship, amateur bands are often referred to by wavelength.

[*Ham Radio License Manual*, page 2-5]




**As a radio wave travels, it oscillates at the frequency of the signal. The distance covered by the wave during the time it takes for one complete cycle is its wavelength.**

**T3B06 What is the formula for converting frequency to approximate wavelength in meters?**

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

**D** See question T3B05. [*Ham Radio License Manual*, page 2-5]

**T3B07 In addition to frequency, which of the following is used to identify amateur radio bands?**

A. The approximate wavelength in meters

B. Traditional letter/number designators

C. Channel numbers

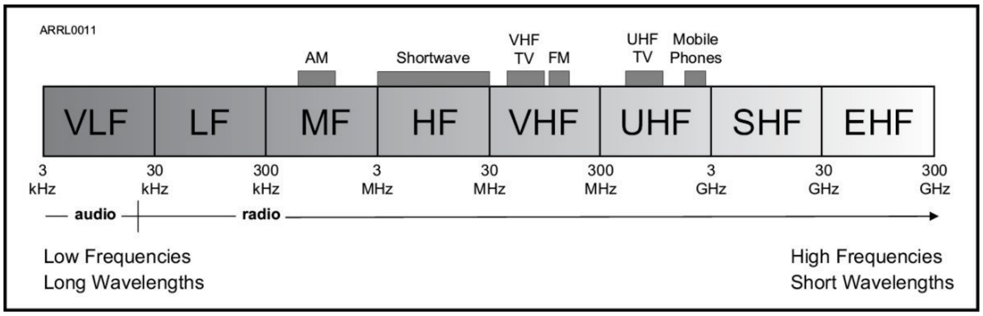
D. All these choices are correct

**A** See question T3B05. [*Ham Radio License Manual*, page 2-5]

**T3B08 What frequency range is referred to as VHF?**

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

**B** See table below. **[** *Ham Radio License Manual*, page 2-4]




**The radio spectrum extends over a very wide range of frequencies. The drawing shows the frequency ranges used by broadcast stations and mobile phones. Amateurs can use small frequency bands in the MF and higher frequency regions of the spectrum.**

**T3B09 What frequency range is referred to as UHF?**

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

**D** See the table below. [*Ham Radio License Manual*, page 2-4]

**T3B10 What frequency range is referred to as HF?**

A. 300 to 3000 MHz
B. 30 to 300 MHz
C. 3 to 30 MHz
D. 300 to 3000 kHz

**C** See the table below. [*Ham Radio License Manual*, page 2-4]

# RF Spectrum Ranges [T3B08 – T3B10]

| ***Range Name*** | ***Abbreviation*** | ***Frequency Range*** |
|---|---|---|
| Very Low Frequency | VLF | 3 kHz – 30 kHz |
| Low Frequency | LF | 30 kHz – 300 kHz |
| Medium Frequency | MF | 300 kHz – 3 MHz |
| High Frequency | HF | 3 MHz – 30 MHz |
| Very High Frequency | VHF | 30 MHz – 300 MHz |
| Ultra High Frequency | UHF | 300 MHz – 3 GHz |
| Super High Frequency | SHF | 3 GHz – 30 GHz |
| Extremely High Frequency | EHF | 30 GHz – 300 GHz |

**T3B11 What is the approximate velocity of a radio wave in free space?**

A. 150,000 kilometers per second
B. 300,000,000 meters per second
C. 300,000,000 miles per hour
D. 150,000 miles per hour

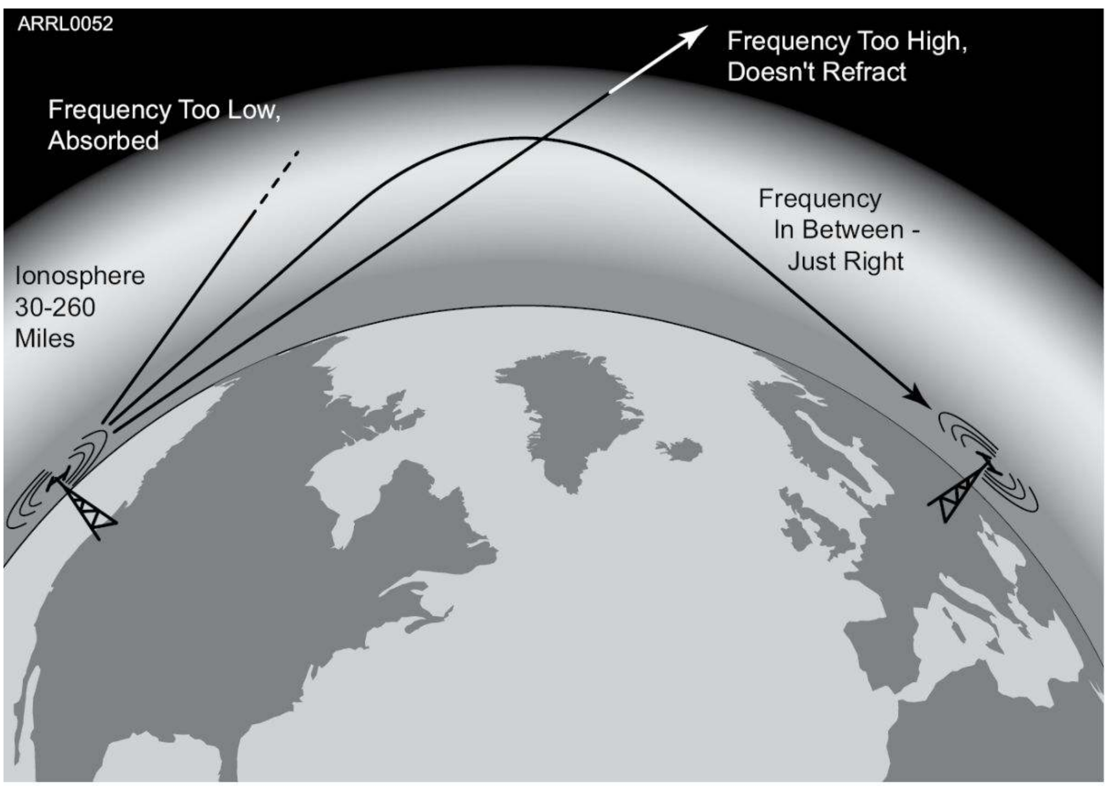
**B** The speed of light in space and air is very close to 300 million meters per second (300,000,000 or $3 \times 10^8$ meters per second). [*Ham Radio License Manual*, page 2-5]

## T3C — Propagation modes: sporadic E, meteor scatter, auroral propagation, tropospheric ducting; F region skip; Line of sight and radio horizon

**T3C01 Why are simplex UHF signals rarely heard beyond their radio horizon?**

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

**C** VHF and UHF signals usually pass through the ionosphere and are lost to space. Long-distance ionospheric propagation is the most common way for hams to make long-distance contacts on the HF bands. [*Ham Radio License Manual*, page 4-3]




**Signals that are too low in frequency are absorbed by the ionosphere and lost. Signals that are too high in frequency pass through the ionosphere and are also lost. Signals in the right range of frequencies are refracted back toward the Earth and are received hundreds or thousands of miles away.**

**T3C02 What is a characteristic of HF communication compared with communications on VHF and higher frequencies?**

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

**C** See question T3C01. [*Ham Radio License Manual*, page 4-3]

**T3C03 What is a characteristic of VHF signals received via auroral backscatter?**

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

**B** Because the aurora is constantly changing, the reflected signals change strength quickly and are often distorted. [*Ham Radio License Manual*, page 4-3]

**T3C04 Which of the following types of propagation is most commonly associated with occasional strong signals on the 10, 6, and 2 meter bands from beyond the radio horizon?**

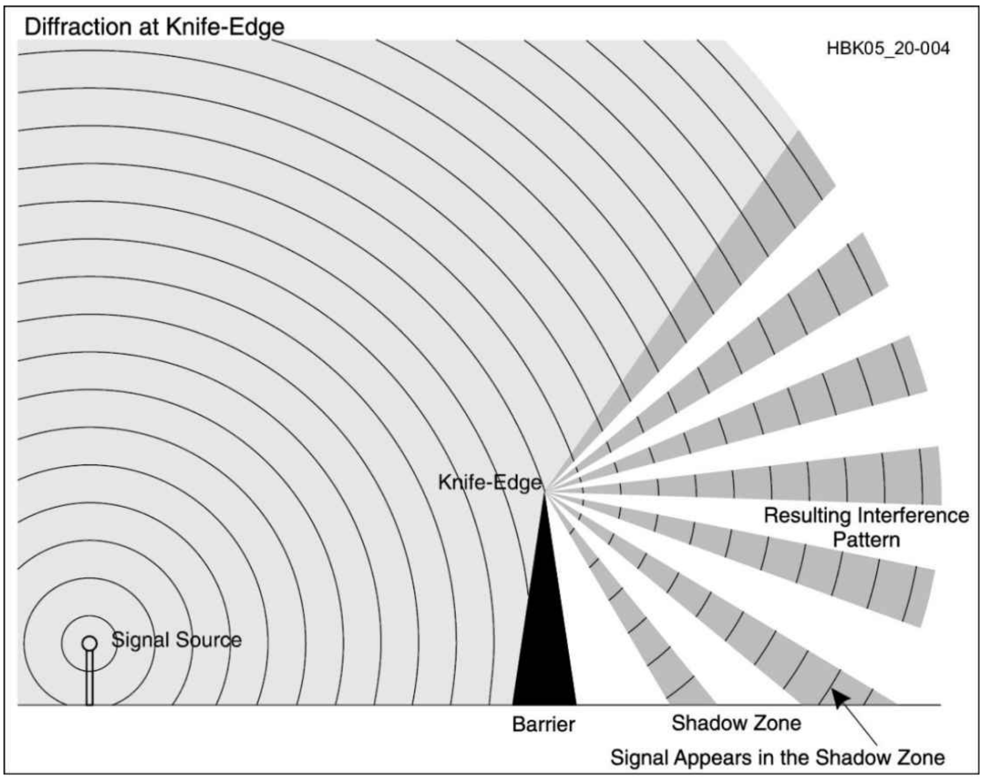
A. Backscatter
B. Sporadic E
C. D region absorption
D. Gray-line propagation

**B** Patches of the ionosphere's E layer can become sufficiently ionized to reflect VHF and UHF signals back to Earth. This is called *sporadic E*, *Es*, or *E-skip* propagation. [*Ham Radio License Manual*, page 4-3]

**T3C05 Which of the following effects may allow radio signals to travel beyond obstructions between the transmitting and receiving stations?**

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

**A** Radio waves can be *diffracted* as they travel past sharp edges of large objects. This type of propagation is called *knife-edge diffraction*. [*Ham Radio License Manual*, page 4-1]




**VHF and UHF radio waves are diffracted around the sharp edge of a solid object, such as a building, hill or other obstruction. Some signals appear behind the obstruction as a result of interference between waves at the edge and those farther away. The resulting interference pattern creates shadowed areas where little signal is present.**

**T3C06 What type of propagation is responsible for allowing over-the-horizon VHF and UHF communications to ranges of approximately 300 miles on a regular basis?**

A. Tropospheric ducting
B. D region refraction
C. F2 region refraction
D. Faraday rotation

**A** Tropospheric ducting is regularly used by amateurs to make VHF and UHF contacts that would otherwise be impossible by line-of-sight propagation. [*Ham Radio License Manual*, page 4-1]

**T3C07 What band is best suited for communicating via meteor scatter?**

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

**B** The best band for meteor scatter is 6 meters, and contacts can be made at distances up to 1200 to 1500 miles. [*Ham Radio License Manual*, page 4-3]

**T3C08 What causes tropospheric ducting?**

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

**D** Weather fronts and temperature inversions create layers of air next to each other form atmospheric *ducts* that can guide VHF, UHF, and microwave signals for long distances. [*Ham Radio License Manual*, page 4-2]

**T3C09 What is generally the best time for long-distance 10 meter band propagation via the F region?**

A. From dawn to shortly after sunset during periods of high sunspot activity

B. From shortly after sunset to dawn during periods of high sunspot activity

C. From dawn to shortly after sunset during periods of low sunspot activity

D. From shortly after sunset to dawn during periods of low sunspot activity

**A** During the years of maximum solar activity, the upper HF bands, such as 10 meters, are likely to be open from dawn until shortly after sunset. Occasionally, the F layers can even reflect 6 meter (50 MHz) signals at the sunspot cycle's peak. [*Ham Radio License Manual*, page 4-3]

**T3C10 Which of the following bands may provide long-distance communications via the ionosphere's F region during the peak of the sunspot cycle?**

A. 6 and 10 meters
B. 23 centimeters
C. 70 centimeters and 1.25 meters
D. All these choices are correct

**A** See question T3C09. [*Ham Radio License Manual*, page 4-3]

**T3C11 Why is the radio horizon for VHF and UHF signals more distant than the visual horizon?**

A. Radio signals move somewhat faster than the speed of light
B. Radio waves are not blocked by dust particles
C. The atmosphere refracts radio waves slightly
D. Radio waves are blocked by dust particles

**C** By bending signals slightly back toward the ground, refraction counteracts the curvature of the Earth and allows signals at these frequencies to be received at distances somewhat beyond the visual horizon. [*Ham Radio License Manual*, page 4-2]

# Subelement T4
# Amateur Radio Practices

**[2 Exam Questions — 2 Groups]**

## T4A — Station setup: connecting a microphone, a power source, a computer, digital equipment, an SWR meter; Bonding; Mobile radio installation

**T4A01 Which of the following is an appropriate power supply rating for a typical 50 watt output mobile FM transceiver?**

A. 24.0 volts at 4 amperes
B. 13.8 volts at 4 amperes
C. 24.0 volts at 12 amperes

**D** The current rating of a supply must be at least as much as the sum of the maximum current used by everything hooked up to the supply. To determine the maximum current rating needed for a transceiver, you must consider the transmitter's efficiency at full power output, how much current the receiver and control circuits require, and the power supply's regulation and ability to dissipate heat at full load. [*Ham Radio License Manual*, page 5-16]

**T4A02 Which of the following should be considered when selecting an accessory SWR meter?**

A. The frequency and power level at which the measurements will be made
B. The distance that the meter will be located from the antenna
C. The types of modulation being used at the station
D. All these choices are correct

**A** SWR is the same everywhere along a feed line, but it is usually measured at the transmitter's connection to the feed line. An SWR meter is used to measure SWR and is often built-in to the transceiver. If an external or standalone SWR meter is used, be sure it is specified for the frequency range in use so that it will make accurate measurements. [*Ham Radio License Manual*, page 4-10]

**T4A03 Why are short, heavy-gauge wires used for a transceiver's DC power connection?**

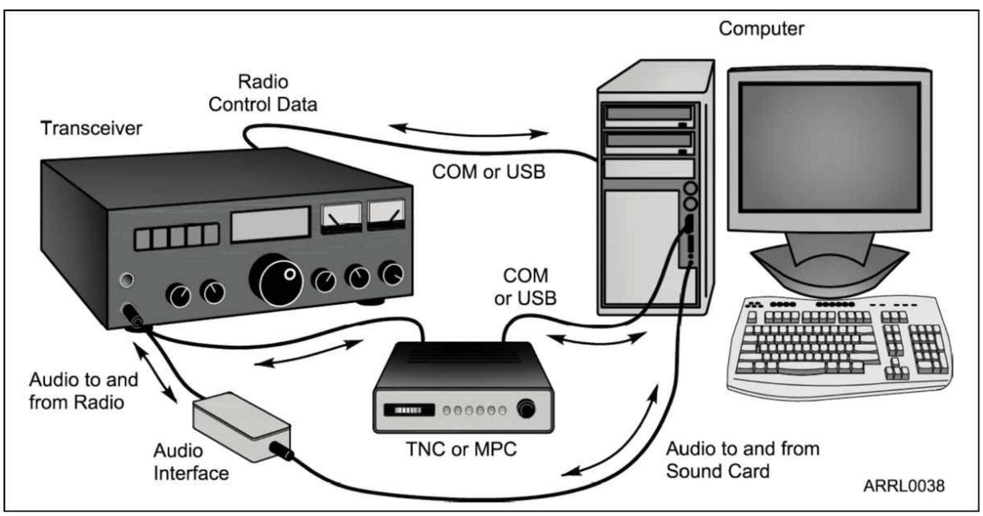
A. To minimize voltage drop when transmitting
B. To provide a good counterpoise for the antenna
C. To avoid RF interference
D. All of these choices are correct

**A** If the wire is too thin, its resistance (R) will create a *voltage drop*, $V = I \times R$. Longer wire lengths also increase resistance. The resulting lower voltage at the radio can cause it to operate improperly, possibly distorting your output signal or creating interference. [*Ham Radio License Manual*, page 5-17]

**T4A04 How are the transceiver audio input and output connected in a station configured to operate using FT8?**

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

**C** The figure shows an example of how a station is configured to use digital modes. If a standalone TNC is used, it is connected to one of the computer's digital data ports via a COM port or USB interface. The TNC is then connected to the radio's microphone input (for transmit audio) and speaker or headphone output (for receive audio). If a sound card is used instead, its output is connected to the radio's microphone input and the speaker or headphone output is connected to the sound card input. If you use a sound card, you may need a digital communications interface to supply the PTT (push-to-talk) signal for keying the transmitter. [*Ham Radio License Manual*, page 5-14]




**Data interfaces are connected between the transceiver's audio inputs and outputs and the computer's data connections (USB or COM ports) or sound card jacks. A TNC or MPC (multi-protocol controller) converts between data and audio. An audio interface isolates the computer sound card from the radio to prevent hum.**

**T4A05 Where should an RF power meter be installed?**

A. In the feed line, between the transmitter and antenna

B. At the power supply output

C. In parallel with the push-to-talk line and the antenna

D. In the power supply cable, as close as possible to the radio

**A** An SWR meter is placed in series with the feed line, usually right at the output of the radio. [*Ham Radio License Manual*, page 4-18]

**T4A06 What signals are used in a computer-radio interface for digital mode operation?**

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

**C** See question T4A04. [*Ham Radio License Manual*, page 5-14]

**T4A07 Which of the following connections is made between a computer and a transceiver to use computer software when operating digital modes?**

A. Computer “line out” to transceiver push-to-talk
B. Computer “line in” to transceiver push-to-talk
C. Computer “line in” to transceiver speaker connector
D. Computer “line out” to transceiver speaker connector

**C** See question T4A04. [*Ham Radio License Manual*, page 5-14]

**T4A08 Which of the following conductors is preferred for bonding at RF?**

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

**D** Use short, wide conductors such as copper flashing or strap or heavy solid wire (#8 AWG or larger). Solid strap is best because it presents the lowest impedance to RF. [*Ham Radio License Manual*, page 9-6]

**T4A09 How can you determine the length of time that equipment can be powered from a battery?**

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

**B** You can find out how long a fully-charged battery will power your equipment from the battery's energy rating. Divide the energy rating in ampere-hours (Ah) by the total current needs of the equipment. Remember to use average current draw for transceivers since you won't be transmitting all the time. [*Ham Radio License Manual*, page 5-17]

**T4A10 What function is performed with a transceiver and a digital mode hot spot?**

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

**A** Using the software and an internet connection, you can use your digital mode transceiver to make contacts on all of the popular digital voice systems in use today. [*Ham Radio License Manual*, page 6-13]

**T4A11 Where should the negative power return of a mobile transceiver be connected in a vehicle?**

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

**A** Connect the radio's negative lead to the negative battery terminal or where the battery ground lead is connected to the vehicle body. [*Ham Radio License Manual*, page 5-17]

**T4A12 What is an electronic keyer?**

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

**C** This device turns contact closures by a Morse *paddle* into a stream of dots and dashes. A keyer may be a standalone device or it can be built into a transceiver. Keyers and paddles can generate Morse code much faster than by using a straight key. [*Ham Radio License Manual*, page 5-7]

**T4B — Operating controls: frequency tuning, use of filters, squelch function, AGC, memory channels, noise blanker, microphone gain, receiver incremental tuning (RIT), bandwidth selection, digital transceiver configuration**

**T4B01 What is the effect of excessive microphone gain on SSB transmissions?**

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

**B** Excessive modulation results in distortion of transmitted speech and unwanted or *spurious* transmitter outputs on adjacent frequencies where they cause interference. *Overmodulation* of an AM or SSB signal is caused by speaking too loudly or by setting the microphone gain or speech compression too high, possibly resulting in distortion of the transmitted signal. [*Ham Radio License Manual*, page 5-8]

**T4B02 Which of the following can be used to enter a transceiver's operating frequency?**

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

**A** The control used for tuning is the *VFO*, an abbreviation for *variable frequency oscillator*. In older radios, the VFO knob changes the frequency of an oscillator circuit that in turn determines the radio's operating frequency. In most current radios, the VFO control is read by a microprocessor that controls the radio's frequency. Some radios also have a keypad that you can use to enter frequencies directly. [*Ham Radio License Manual*, page 5-5]

**T4B03 How is squelch adjusted so that a weak FM signal can be heard?**

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

**A** To keep from having to listen to continuous noise when no signal is present, the *squelch* circuit mutes the receiver's audio output when no signal is present. [*Ham Radio License Manual*, page 5-8]

**T4B04 What is a way to enable quick access to a favorite frequency or channel on your transceiver?**

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

**B** *Memories* or *memory channels* are used to store frequencies and modes for later recall. Memories are provided so that you can quickly tune to frequently used or favorite frequencies. [*Ham Radio License Manual*, page 5-5]

**T4B05 What does the scanning function of an FM transceiver do?**

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

**C** Repeater frequencies are evenly spaced in *channels*, so you know exactly what frequency to use when you do find or select a repeater. You can also use the *scanning* function of your radio to listen for activity on repeater or simplex channels. [*Ham Radio License Manual*, page 6-10]

**T4B06 Which of the following controls could be used if the voice pitch of a single-sideband signal returning to your CQ call seems too high or low?**

A. The AGC or limiter
B. The bandwidth selection
C. The tone squelch
D. The RIT or clarifier

**D** Receiver incremental tuning (RIT) is a fine-tuning control used for SSB or CW operation. RIT allows the operator to adjust the receiver frequency without changing the transmitter frequency. This allows you to tune in a station that is slightly off frequency or to adjust the pitch of an operator's voice that seems too high or low. [*Ham Radio License Manual*, page 5-9]

**T4B07 What does a DMR "code plug" contain?**

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

**B** A DMR transceiver must be set up with all of the necessary frequencies and IDs and codes to be used on the air. This information is contained in a computer file called a *code plug*, an old term from the days when a special component had to be plugged into the radio. Today, software is available to transfer the code plug file to the radio digitally. [*Ham Radio License Manual*, page 6-13]

**T4B08 What is the advantage of having multiple receive bandwidth choices on a multimode transceiver?**

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

**B** Having multiple filters available allows you to reduce noise or interference by selecting a filter with just enough bandwidth to pass the desired signal. [*Ham Radio License Manual*, page 5-9]

**T4B09 How is a specific group of stations selected on a digital voice transceiver?**

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

**C** Digital repeater systems such as WIRES II/System Fusion, D-STAR, DMR, P25, and NXDN all use talk groups in one form or another. To join a talk group, you'll need to know the group's identification code or number. Enter or select that code on your transceiver and the repeater system connects you to any ongoing communication with that group. Along with the talk group, you'll also have to enter your own identification code into the transceiver so the system knows who you are. For example, in the D-STAR system, your call sign must be programmed into the transceiver in order to be able to transmit. [*Ham Radio License Manual*, page 6-13]

**T4B10 Which of the following receiver bandwidths provides the best signal-to-noise ratio for SSB reception?**

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

**C** A receiver rejects unwanted signals through the use of filters. At the receiver input, a filter passes only signals from the selected band. Those signals then pass through filters narrow enough to reject all but the desired signal. ("Narrow" means smaller bandwidth and "wide" means greater bandwidth.) Wide filters (around 2.4 kHz) are used for SSB reception. [*Ham Radio License Manual*, page 5-9]

**T4B11 Which of the following must be programmed into a D-STAR digital transceiver before transmitting?**

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

**A** In the D-STAR system, your call sign must be programmed into the transceiver in order to be able to transmit. [*Ham Radio License Manual*, page 6-13]

**T4B12 What is the result of tuning an FM receiver above or below a signal’s frequency?**

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

**D** You will still hear the signal but the audio will be distorted. [*Ham Radio License Manual*, page 5-9]

# Subelement T5
# Electrical Principles

**[4 exam questions — 4 groups]**

## T5A — Current and voltage: terminology and units, conductors and insulators, alternating and direct current

**T5A01 Electrical current is measured in which of the following units?**

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

**D** Current is measured in units of *amperes* which is abbreviated as A or amps. [*Ham Radio License Manual*, page 3-1]

**T5A02 Electrical power is measured in which of the following units?**

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

**B** Power is measured in *watts* which are abbreviated as W. [*Ham Radio License Manual*, page 3-7]

**T5A03 What is the name for the flow of electrons in an electric circuit?**

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

**D** Electric *current* (represented in equations by the symbol *I* or *i*) is the flow of *electrons*. [*Ham Radio License Manual*, page 3-1]

**T5A04 What are the units of electrical resistance?**

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

**C** Resistance is measured in ohms, which are represented by the Greek letter omega, Ω. [*Ham Radio License Manual*, page 3-5]

**T5A05 What is the electrical term for the force that causes electron flow?**

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

**A** *Voltage* (represented in equations by the symbol *E* or *e*) is the *electromotive force* or *electric potential* that makes electrons move. [*Ham Radio License Manual*, page 3-1]

**T5A06 What is the unit of frequency?**

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

**A** The unit of measurement for frequency is *hertz*, abbreviated Hz. [*Ham Radio License Manual*, page 2-3]

**T5A07 Why are metals generally good conductors of electricity?**

A. They have relatively high density

B. They have many free electrons

C. They have many free protons

D. All these choices are correct

**B** Materials such as copper in which electrons flow easily in response to an applied voltage are *conductors*. [*Ham Radio License Manual*, page 3-5]

**T5A08 Which of the following is a good electrical insulator?**

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

**B** Materials such as glass and ceramics, dry wood and paper, most plastics, and other non-metals that resist or prevent the flow of electrons are *insulators*. [*Ham Radio License Manual*, page 3-5]

**T5A09 Which of the following describes alternating current?**

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

**C** Current that regularly reverses direction is a*lternating current*, abbreviated *ac*. [*Ham Radio License Manual*, page 3-1]

**T5A10 Which term describes the rate at which electrical energy is used?**

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

**C** *Power,* represented by the symbol *P*, is the rate at which electrical energy is used. [*Ham Radio License Manual*, page 3-7]

**T5A11 What type of current is opposed by resistance?**

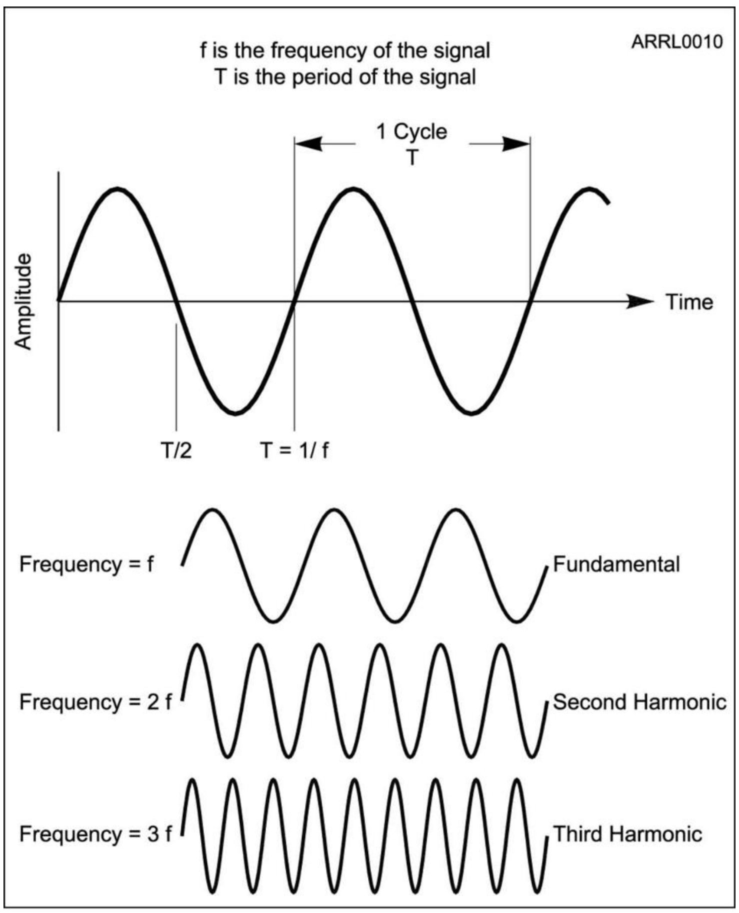
A. Direct current
B. Alternating current
C. RF current
D. All these choices are correct

**D** All materials oppose the flow of electrons through them, whether in the form of direct current (dc) or alternating current (ac) at power frequencies like 60 Hz or RF that we use for our radio signals. [*Ham Radio License Manual*, page 3-5]

**T5A12 What describes the number of times per second that an alternating current makes a complete cycle?**

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

**D** Like a water wave, a radio wave continually varies in strength or *amplitude* like the *sine wave* shown in the figure. This continual change is called *oscillating*. As the signal oscillates, each complete up-and-down sequence is called a *cycle*. The number of *cycles per second* is the signal's *frequency*, represented by a lower-case *f*. The unit of frequency is hertz (Hz). [*Ham Radio License Manual*, page 2-3]




**The frequency of a signal and its period are reciprocals. Higher frequency means shorter period and vice-versa.**

**T5B — Math for electronics: conversion of electrical units, decibels**

# International System of Units (SI) — Metric Units

| *Prefix* | *Symbol* | *Multiplication Factor* |
|---|---|---|
| Tera | T | $10^{12}$ = 1,000,000,000,000 |
| Giga | G | $10^{9}$ = 1,000,000,000 |
| Mega | M | $10^{6}$ = 1,000,000 |
| Kilo | k | $10^{3}$ = 1000 |
| Hecto | h | $10^{2}$ = 100 |
| Deca | da | $10^{1}$ = 10 |
| Deci | d | $10^{-1}$ = 0.1 |
| Centi | c | $10^{-2}$ = 0.01 |
| Milli | m | $10^{-3}$ = 0.001 |
| Micro | µ | $10^{-6}$ = 0.000001 |
| Nano | n | $10^{-9}$ = 0.000000001 |
| Pico | p | $10^{-12}$ = 0.000000000001 |

**T5B01 How many milliamperes is 1.5 amperes?**

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

**C** 1.5 A = 1.5 × 1,000 mA per A = 1,500 mA [*Ham Radio License Manual*, page 2-2]

**T5B02 Which is equal to 1,500,000 hertz?**

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

**A** 1,500,000 Hz = 1,500 kHz = 1.5 MHz [*Ham Radio License Manual*, page 2-2]

**T5B03 Which is equal to one kilovolt?**

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

**C** 1 kV = 1,000 × 1 V = 1,000 V [*Ham Radio License Manual*, page 2-2]

**T5B04 Which is equal to one microvolt?**

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

**A** 1 μV = 0.000001 V = one one-millionth of a volt [*Ham Radio License Manual*, page 2-2]

**T5B05 Which is equal to 500 milliwatts?**

A. 0.02 watts
B. 0.5 watts
C. 5 watts
D. 50 watts

**B** 500 mW = 500 × 0.001 W = 0.5 W [*Ham Radio License Manual*, page 2-2]

**T5B06 Which is equal to 3000 milliamperes?**

A. 0.003 amperes
B. 0.3 amperes
C. 3,000,000 amperes
D. 3 amperes

**D** 3,000 mA = 3 × 1,000 mA per A = 3 A [*Ham Radio License Manual*, page 2-2]

**T5B07 Which is equal to 3.525 MHz?**

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

**C** 3.525 MHz = 3.525 × 1,000 kHz per MHz = 3,525 kHz [*Ham Radio License Manual*, page 2-2]

**T5B08 What is equal to 1,000,000 picofarads?**

A. 0.001 microfarads
B. 1 microfarad
C. 1000 microfarads
D. 1,000,000,000 microfarads

**B** 1,000,000 pF = 1,000,000 × 0.000001 µF per pF = 1 µF [*Ham Radio License Manual*, page 2-2]

**T5B09 Which decibel value most closely represents a power increase from 5 watts to 10 watts?**

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

**B** 10 log (10 / 5) = 10 log (2) = 3 dB [*Ham Radio License Manual*, page 4-8]

**T5B10 Which decibel value most closely represents a power decrease from 12 watts to 3 watts?**

A. –1 dB
B. –3 dB
C. –6 dB
D. –9 dB

**C** 10 log (3 /12) = 10 log (0.25) = –6 dB [*Ham Radio License Manual*, page 4-8]

**T5B11 Which decibel value represents a power increase from 20 watts to 200 watts?**

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

**A** 10 log (200 / 20) = 10 log (10) = 10 dB [*Ham Radio License Manual*, page 4-8]

**T5B12 Which is equal to 28400 kHz?**

A. 28.400 kHz
B. 2.800 MHz
C. 284.00 MHz
D. 28.400 MHz

**D** 28400 kHz = 28400 × 0.001 MHz per kHz = 28.4 MHz [*Ham Radio License Manual*, page 2-2]

**T5B13 Which is equal to 2425 MHz?**

A. 0.002425 GHz
B. 24.25 GHz
C. 2.425 GHz
D. 2425 GHz

**C** 2425 MHz = 2425 × 0.001 GHz per MHz = 2.425 GHz. [*Ham Radio License Manual*, page 2-2]

**T5C — Capacitance and inductance terminology and units; Radio frequency definition and units; Impedance definition and units; Calculating power**

**T5C01 What describes the ability to store energy in an electric field?**

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

**D** Storing energy in an electric field is called *capacitance* and it is measured in farads (F). [*Ham Radio License Manual*, page 3-8]

**T5C02 What is the unit of capacitance?**

A. The farad

B. The ohm

C. The volt

D. The henry

**A** See question T5C01. [*Ham Radio License Manual*, page 3-8]

**T5C03 What describes the ability to store energy in a magnetic field?**

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

**D** Storing energy in a magnetic field is called *inductance* and it is measured in henrys (H). [*Ham Radio License Manual*, page 3-8]

**T5C04 What is the basic unit of inductance?**

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

**C** See question T5C03. [*Ham Radio License Manual*, page 3-8]

**T5C05 What is the unit of impedance?**

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

**D** See question T5C12. [*Ham Radio License Manual*, page 3-10]

**T5C06 What does the abbreviation "RF" mean?**

A. Radio frequency signals of all types
B. The resonant frequency of a tuned circuit
C. The real frequency transmitted as opposed to the apparent frequency
D. Reflective force in antenna transmission lines

**A** If connected to a speaker, signals below 20 kHz produce sound waves that humans can hear, so we call them *audio frequency* or *AF* signals. Signals that have a frequency greater than 20,000 Hz (or 20 kHz) are *radio frequency* or *RF* signals. [*Ham Radio License Manual*, page 2-4]

**T5C07 What is the abbreviation for megahertz?**

A. MH
B. mh
C. Mhz
D. MHz

**D** See the table of metric prefixes at the beginning of section T5B. [*Ham Radio License Manual*, page 2-3]

**T5C08 What is the formula used to calculate electrical power (P) in a DC circuit?**

A. $P = I \times E$
B. $P = E/I$
C. $P = E – 1$
D. $P = I + E$

**A** In a dc circuit, power is calculated as the product of current and voltage and current (*$P = I \times E$*). See question T5D01. [*Ham Radio License Manual*, page 3-7]

**T5C09 How much power is delivered by a voltage of 13.8 volts DC and a current of 10 amperes?**

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

**A** $P = E \times I = 13.8 \text{ V} \times 10 \text{ A} = 138 \text{ W}$ [*Ham Radio License Manual*, page 3-7]

**T5C10 How much power is delivered by a voltage of 12 volts DC and a current of 2.5 amperes?**

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

**B** $P = E \times I = 12\ \text{V} \times 2.5\ \text{A} = 30\ \text{W}$ [*Ham Radio License Manual*, page 3-7]

**T5C11 How much current is required to deliver 120 watts at a voltage of 12 volts DC?**

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

**B** *I* = *P / E* = 120 W / 12 V = 10 A [*Ham Radio License Manual*, page 3-7]

**T5C12 What is impedance?**

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

**A** The combination of resistance and reactance is called *impedance*, represented by the capital letter *Z*, and is also measured in ohms (Ω). *Impedance* is often used as a general term to mean the circuit's opposition to ac current flow. [*Ham Radio License Manual*, page 3-10]

**T5C13 What is the abbreviation for kilohertz?**

A. KHZ
B. khz
C. khZ
D. kHz

**D** See the table of metric prefixes at the beginning of section T5B. [*Ham Radio License Manual*, page 2-3]

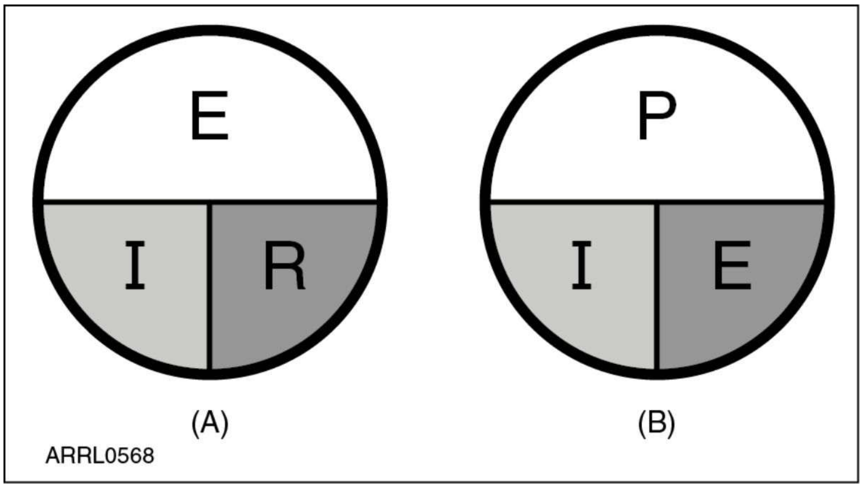
## T5D — Ohm's Law; Series and parallel circuits

**T5D01 What formula is used to calculate current in a circuit?**

A. I = E × R
B. I = E / R
C. I = E + R
D. I = E – R

**B** [*Ham Radio License Manual*, page 3-5]

*I = E / R*




**These simple diagrams will help you remember the Ohm's Law (A) and power (B) relationships. If you know any two of the quantities, the equation to find the third is shown by covering up the unknown quantity. The positions of the remaining two symbols show if you have to multiply (side-by-side) or divide (one above the other).**

**T5D02 What formula is used to calculate voltage in a circuit?**

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

**A** [*Ham Radio License Manual*, page 3-5]

$E = I \times R$

**T5D03 What formula is used to calculate resistance in a circuit?**

A. R = E × I
B. R = E / I
C. R = E + I
D. R = E – I

**B** [*Ham Radio License Manual*, page 3-5]

*R = E / I*

**T5D04 What is the resistance of a circuit in which a current of 3 amperes flows when connected to 90 volts?**

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

**B** $R = E / I = 90 \text{ V} / 3 \text{ A} = 30\ \Omega$ [*Ham Radio License Manual*, page 3-6]

**T5D05 What is the resistance of a circuit for which the applied voltage is 12 volts and the current flow is 1.5 amperes?**

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

**C** $R = E / I$ = 12 V / 1.5 A = 8 Ω [*Ham Radio License Manual*, page 3-6]

**T5D06 What is the resistance of a circuit that draws 4 amperes from a 12-volt source?**

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

**A** $R = E / I$ = 12 V / 4 A = 3 Ω [*Ham Radio License Manual*, page 3-6]

**T5D07 What is the current in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms?**

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

**D** $I = E / R = 120 \text{ V} / 80\ \Omega = 1.5 \text{ A}$ [*Ham Radio License Manual*, page 3-6]

**T5D08 What is the current through a 100-ohm resistor connected across 200 volts?**

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

**C** $I = E / R = 200 \text{ V} / 100\ \Omega = 2 \text{ A}$ [*Ham Radio License Manual*, page 3-6]

**T5D09 What is the current through a 24-ohm resistor connected across 240 volts?**

A. 24,000 amperes
B. 0.1 amperes
C. 10 amperes
D. 216 amperes

**C** $I = E / R = 240\ \text{V} / 24\ \Omega = 10\ \text{A}$ [*Ham Radio License Manual*, page 3-6]

**T5D10 What is the voltage across a 2-ohm resistor if a current of 0.5 amperes flows through it?**

A. 1 volt
B. 0.25 volts
C. 2.5 volts
D. 1.5 volts

**A** $E = I \times R = 0.5\text{ A} \times 2\ \Omega = 1\text{ V}$ [*Ham Radio License Manual*, page 3-6]

**T5D11 What is the voltage across a 10-ohm resistor if a current of 1 ampere flows through it?**

A. 1 volt
B. 10 volts
C. 11 volts
D. 9 volts

**B** $E = I \times R = 1\text{ A} \times 10\ \Omega = 10\text{ V}$ [*Ham Radio License Manual*, page 3-7]

**T5D12 What is the voltage across a 10-ohm resistor if a current of 2 amperes flows through it?**

A. 8 volts
B. 0.2 volts
C. 12 volts
D. 20 volts

**D** $E = I \times R = 2\text{ A} \times 10\ \Omega = 20\text{ V}$ [*Ham Radio License Manual*, page 3-7]

**T5D13 In which type of circut is DC current the same through all components?**

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

**A** If two or more components such as light bulbs are connected in a circuit so that the same current must flow through all of them, that is a *series* circuit. [*Ham Radio License Manual*, page 3-2]

**T5D14 In which type of circuit is voltage the same across all components?**

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

**B** If two or more components are connected so that the same voltage is present across all of them, that is a *parallel* circuit. [*Ham Radio License Manual*, page 3-2]

# Subelement T6

# Electronic and Electrical Components

**[4 exam questions — 4 groups]**

## T6A — Fixed and variable resistors; Capacitors; Inductors; Fuses; Switches; Batteries

**T6A01 What electrical component opposes the flow of current in a DC circuit?**

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

**B** *Resistors* oppose the flow of electrical current in an ac or dc circuit. [*Ham Radio License Manual*, page 3-8]

**T6A02 What type of component is often used as an adjustable volume control?**

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

**C** A variable resistor, also called a *potentiometer* or *pot*, is frequently used to adjust voltage or potential, such as for a volume control. [*Ham Radio License Manual*, page 3-8]

**T6A03 What electrical parameter is controlled by a potentiometer?**

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

**B** See question T6A02. [*Ham Radio License Manual*, page 3-8]

**T6A04 What electrical component stores energy in an electric field?**

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

**B** *Capacitors* store electrical energy in the *electric field* created by a voltage between two conducting surfaces or *electrodes* that are separated by an insulator called a *dielectric*. [*Ham Radio License Manual*, page 3-8]

**T6A05 What type of electrical component consists of conductive surfaces separated by an insulator?**

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

**D** See question T6A04. [*Ham Radio License Manual*, page 3-8]

**T6A06 What type of electrical component stores energy in a magnetic field?**

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

**C** *Inductors* store energy in the *magnetic field* created by current flowing in a wire. Inductors are sometimes wound around a *core* of magnetic material that concentrates the magnetic energy. [*Ham Radio License Manual*, page 3-8]

**T6A07 What electrical component is typically constructed as a coil of wire?**

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

**D** See question T6A06. [*Ham Radio License Manual*, page 3-8]

**T6A08 What is the function of an SPDT switch?**

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

**C** An SPDT switch selects one of two paths (double-throw) for one circuit (single pole). [*Ham Radio License Manual*, page 3-13]

**T6A09 What electrical component is used to protect other circuit components from current overloads?**

A. Fuse
B. Thyratron
C. Varactor
D. All these choices are correct

**A** *Fuses* interrupt current overloads by melting a short length of metal. [*Ham Radio License Manual*, page 3-12]

**T6A10 Which of the following battery chemistries is rechargeable?**

A. Nickel-metal hydride
B. Lithium-ion
C. Lead-acid
D. All of these choices are correct

**D** [*Ham Radio License Manual*, page 5-17]

# Battery Types and Characteristics

| *Battery Style* | *Chemistry Type* | *Fully-Charged Voltage* | *Energy Rating (average)* |
|---|---|---|---|
| AAA | Alkaline — Disposable | 1.5 V | 1100 mAh |
| AA | Alkaline — Disposable | 1.5 V | 2600 – 3200 mAh |
| AA | Carbon-Zinc — Disposable | 1.5 V | 600 mAh |
| AA | Nickel-Cadmium (NiCd) — Rechargeable | 1.2 V | 700 mAh |
| AA | Nickel-Metal Hydride (NiMH) — Rechargeable | 1.2 V | 1500 – 2200 mAh |
| C | Alkaline — Disposable | 1.5 V | 7500 mAh |
| D | Alkaline — Disposable | 1.5 V | 14,000 mAh |
| 9 V | Alkaline — Disposable | 9 V | 580 mAh |
| 9 V | Nickel-Cadmium (NiCd) — Rechargeable | 9 V | 110 mAh |
| 9 V | Nickel-Metal Hydride — Rechargeable | 9 V | 150 mAh |
| Coin Cells | Lithium — Disposable | 3 – 3.3 V | 25 – 1000 mAh |
| Packs | Lithium ion (Li-ion) — Rechargeable | 3.3 – 3.6 V | Varies per cell |
| Storage | Lead-acid — Rechargeable | 2 V per cell | Varies |

**T6A11 Which of the following battery chemistries is not rechargeable?**

A. Nickel-cadmium
B. Carbon-zinc
C. Lead-acid
D. Lithium-ion

**B** See the table for question T6A10. [*Ham Radio License Manual*, page 5-17]

**T6A12 What type of switch is represented by component 3 in [figure T-2]?**

A. Single-pole single-throw
B. Single-pole double-throw
C. Double-pole single-throw
D. Double-pole double-throw

**A** Switches and relays are described by their number of poles and the number of throws. Each pole controls the path of one current. For example, a single-pole (SP) switch controls a single current flow and a double-pole (DP) switch controls two separate currents. Each throw refers to a different path for the current. A double-throw (DT) switch can route current through either of two paths while a single-throw (ST) switch can only open or close a single path. [*Ham Radio License Manual*, page 3-13]

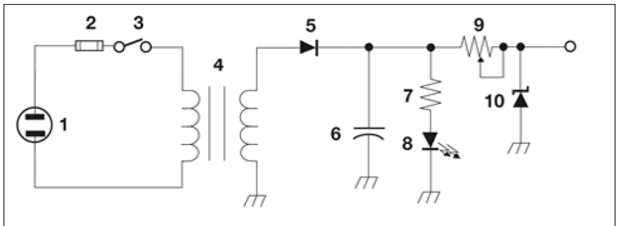


Figure T-2

## T6B — Semiconductors: basic principles and applications of solid state devices; diodes and transistors

**T6B01 Which is true about forward voltage drop in a diode?**

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

**A** When current flows through a diode, a small positive voltage develops from the anode to the cathode. This is called the diode's forward voltage drop and it is usually less than 1 V. The voltage depends on the type of diode and the materials it's made from. [*Ham Radio License Manual*, page 3-10]

**T6B02 What electronic component allows current to flow in only one direction?**

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

**C** A semiconductor that only allows current flow in one direction is called a *diode*. A diode has two electrodes, an *anode* and a *cathode.* On a diode the cathode is usually identified by a stripe marked on the component. Heavy-duty diodes that can handle large voltages and currents are called *rectifiers*. [*Ham Radio License Manual*, page 3-10]

**T6B03 Which of these components can be used as an electronic switch?**

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

**C** With the appropriate external circuit and a source of power, transistors can amplify or switch voltages and currents. Using small signals to control or amplify larger signals is called *gain*. [*Ham Radio License Manual*, page 3-10]

**T6B04 Which of the following components can consist of three regions of semiconductor material?**

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

**B** A transistor is made from up to three layers of P- and N-type semiconductor material. [*Ham Radio License Manual*, page 3-10]

**T6B05 Which type of transistor has a gate, drain, and source?**

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

**A** *Field effect transistors (FET)* contain three electrodes, they are the gate, drain, and source. [*Ham Radio License Manual*, page 3-12]

**T6B06 How is the cathode lead of a semiconductor diode often marked on the package?**

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

**B** See question T6B02. [*Ham Radio License Manual*, page 3-10]

**T6B07 What causes a light-emitting diode (LED) to emit light?**

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

**A** A special type of diode, the light-emitting diode or LED, gives off light when current flows through it in the forward direction from anode to cathode. The material from which the LED is made determines the color of light emitted. LEDs are most often used as visual indicators. [*Ham Radio License Manual*, page 3-10]

**T6B08 What does the abbreviation FET stand for?**

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

**D** There are two common types of transistors: *bipolar junction transistors (BJT)* and *field-effect transistors (FET)*. [*Ham Radio License Manual*, page 3-10]

**T6B09 What are the names for the electrodes of a diode?**

A. Plus and minus
B. Source and drain
C. Anode and cathode
D. Gate and base

**C** See question T6B02. [*Ham Radio License Manual*, page 3-10]

**T6B10 Which of the following can provide power gain?**

A. Transformer
B. Transistor
C. Reactor
D. Resistor

**B** RF power transistors are used as the primary gain-producing component in RF power amplifiers. [*Ham Radio License Manual*, page 3-11]

**T6B11 What is the term that describes a device’s ability to amplify a signal?**

A. Gain
B. Forward resistance
C. Forward voltage drop
D. On resistance

**A** See question T6B03. [*Ham Radio License Manual*, page 3-11]

**T6B12 What are the names of the electrodes of a bipolar junction transistor?**

A. Signal, bias, power
B. Emitter, base, collector
C. Input, output, supply
D. Pole one, pole two, output

**B** The three electrodes of a BJT are the base, collector, and emitter.
[*Ham Radio License Manual*, page 3-11]

**T6C — Circuit diagrams: use of schematics, basic structure; Schematic symbols of basic components**

**T6C01 What is the name of an electrical wiring diagram that uses standard component symbols?**

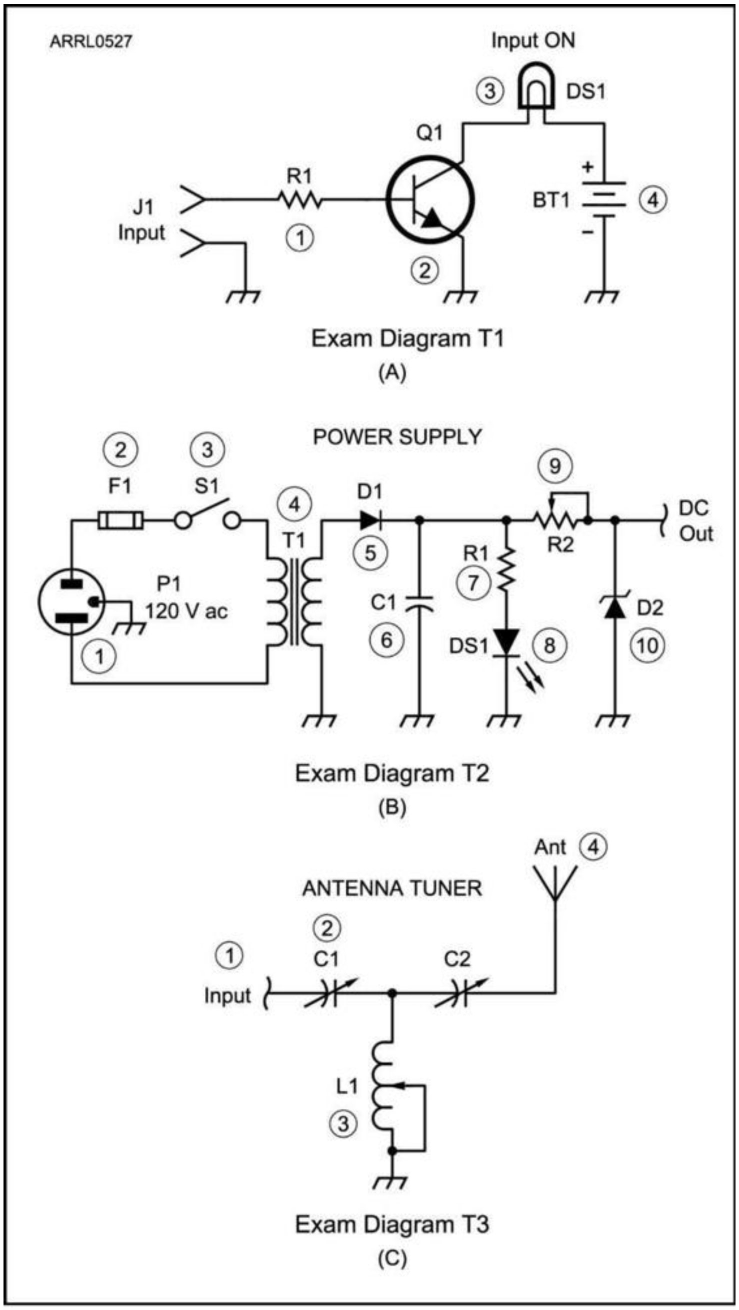
A. Bill of materials
B. Connector pinout
C. Schematic
D. Flow chart

**C** *Schematics* are a visual description of a circuit and its components that use standardized drawings called *circuit symbols*. [*Ham Radio License Manual*, page 3-14]

**T6C02 What is component 1 in figure T1?**

A. Resistor
B. Transistor
C. Battery
D. Connector

**A** For questions T6C02 through T6C11 and T6D10, refer to schematic diagrams T1, T2, and T3. These are the schematic diagrams used on the license exam. [*Ham Radio License Manual*, page 3-14]




**A schematic diagram describes complex circuits using symbols representing each type of component. Lines and dots show electrical connections between the components, but may not correspond to actual wires. Use diagrams T1 (A), T2 (B) and T3 (C) that are used on the Technician exam for questions T6C02 through T6C11 and T6D10.**

**T6C03 What is component 2 in [figure T1](#)?**

A. Resistor
B. Transistor
C. Indicator lamp
D. Connector

**B** [*Ham Radio License Manual*, page 3-14]

**T6C04 What is component 3 in figure T1?**

A. Resistor
B. Transistor
C. Lamp
D. Ground symbol

**C** [*Ham Radio License Manual*, page 3-14]

**T6C05 What is component 4 in figure T1?**

A. Resistor
B. Transistor
C. Ground symbol
D. Battery

**D** [*Ham Radio License Manual*, page 3-14]

**T6C06 What is component 6 in figure T2?**

A. Resistor
B. Capacitor
C. Regulator IC
D. Transistor

**B** [*Ham Radio License Manual*, page 3-14]

**T6C07 What is component 8 in figure T2?**

A. Resistor
B. Inductor
C. Regulator IC
D. Light emitting diode

**D** [*Ham Radio License Manual*, page 3-14]

**T6C08 What is component 9 in figure T2?**

A. Variable capacitor
B. Variable inductor
C. Variable resistor
D. Variable transformer

**C** [*Ham Radio License Manual*, page 3-14]

**T6C09 What is component 4 in figure T2?**

A. Variable inductor
B. Double-pole switch
C. Potentiometer
D. Transformer

**D** [*Ham Radio License Manual*, page 3-14]

**T6C10 What is component 3 in figure T3?**

A. Connector
B. Meter
C. Variable capacitor
D. Variable inductor

**D** [*Ham Radio License Manual*, page 3-14]

**T6C11 What is component 4 in [figure T3](#)?**

A. Antenna
B. Transmitter
C. Dummy load
D. Ground

**A** [*Ham Radio License Manual*, page 3-14]

**T6C12 Which of the following is accurately represented in electrical schematics?**

A. Wire lengths
B. Physical appearance of components
C. Component connections
D. All these choices are correct

**C** A schematic does not illustrate the actual physical layout of a circuit. It only shows how the components are connected electrically. The lines drawn from component to component represent those electrical connections. Each line does not necessarily correspond to a physical wire — it just indicates that an electrical connection exists between whatever is at each end of the line. [*Ham Radio License Manual*, page 3-14]

**T6D — Component functions: rectifiers, relays, voltage regulators, meters, indicators, integrated circuits, transformers; Resonant circuit; Shielding**

**T6D01 Which of the following devices or circuits changes an alternating current into a varying direct current signal?**

A. Transformer
B. Rectifier
C. Amplifier
D. Reflector

**B** If an ac voltage is applied to a diode, the result is a pulsing dc current. [*Ham Radio License Manual*, page 3-11]

**T6D02 What is a relay?**

A. An electrically-controlled switch
B. A current controlled amplifier
C. An optical sensor
D. A pass transistor

**A** A switch is operated manually while a relay is a switch controlled by an electromagnet. [*Ham Radio License Manual*, page 3-13]

**T6D03 Which of the following is a reason to use shielded wire?**

A. To decrease the resistance of DC power connections

B. To increase the current carrying capability of the wire

C. To prevent coupling of unwanted signals to or from the wire

D. To couple the wire to other signals

**C** Use shielded wire and shielded cables to prevent coupling with unwanted signals and undesired radiation. [*Ham Radio License Manual*, page 9-9]

**T6D04 Which of the following displays an electrical quantity as a numeric value?**

A. Potentiometer
B. Transistor
C. Meter
D. Relay

**C** An *indicator* is either ON or OFF, such as a power indicator or a label that appears when you are transmitting. A *meter* provides information as a value in the form of numbers or on a numeric scale. A *display* combines indicators, numbers, and labels. [*Ham Radio License Manual*, page 3-14]

**T6D05 What type of circuit controls the amount of voltage from a power supply?**

A. Regulator
B. Oscillator
C. Filter
D. Phase inverter

**A** A *regulated supply* uses a *regulator* circuit to minimize the amount of voltage change at different current levels. [*Ham Radio License Manual*, page 5-16]

**T6D06 What component changes 120V AC power to a lower AC voltage for other uses?**

A. Variable capacitor
B. Transformer
C. Transistor
D. Diode

**B** *Transformers* are made from two or more inductors that share their stored energy. This allows energy to be transferred from one inductor to another while changing the combination of voltage and current. [*Ham Radio License Manual*, page 3-8]

**T6D07 Which of the following is commonly used as a visual indicator?**

A. LED
B. FET
C. Zener diode
D. Bipolar transistor

**A** See question T6B07. [*Ham Radio License Manual*, page 3-11]

**T6D08 Which of the following is combined with an inductor to make a resonant circuit?**

A. Resistor
B. Zener diode
C. Potentiometer
D. Capacitor

**D** Circuits that contain both a capacitor and an inductor are called *resonant circuits* or *tuned circuits*. [*Ham Radio License Manual*, page 3-10]

**T6D09 What is the name of a device that combines several semiconductors and other components into one package?**

A. Transducer
B. Multi-pole relay
C. Integrated circuit
D. Transformer

**C** An *integrated circuit* (*IC* or *chip*) is made of many components connected together as a useful circuit and packaged as a single component. [*Ham Radio License Manual*, page 3-11]

**T6D10 What is the function of component 2 in Figure T1?**

A. Give off light when current flows through it
B. Supply electrical energy
C. Control the flow of current
D. Convert electrical energy into radio waves

**C** See question T6B03. [*Ham Radio License Manual*, page 3-11]

**T6D11 Which of the following is a resonant or tuned circuit?**

A. An inductor and a capacitor in series or parallel
B. A linear voltage regulator
C. A resistor circuit used for reducing standing wave ratio
D. A circuit designed to provide high-fidelity audio

**A** A tuned circuit acts as a filter, passing or rejecting signals at its resonant frequency. [*Ham Radio License Manual*, page 3-10]

# Subelement T7
# Practical Circuits

**[4 exam questions — 4 groups]**

## T7A — Station equipment: receivers, transceivers, transmitter amplifiers, receive amplifiers, transverters; Basic radio circuit concepts and terminology: sensitivity, selectivity, mixers, oscillators, PTT, modulation

**T7A01 Which term describes the ability of a receiver to detect the presence of a signal?**

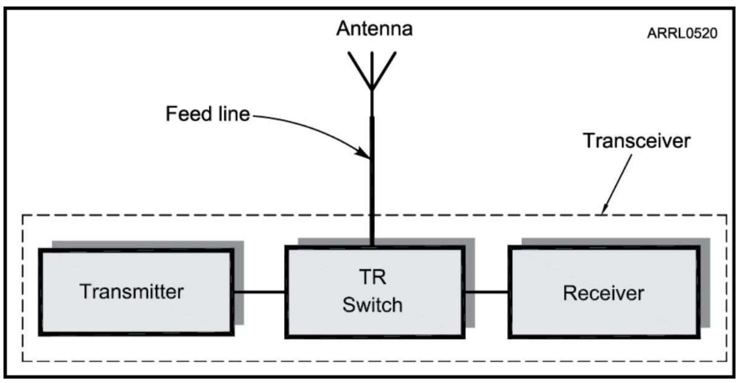
A. Linearity
B. Sensitivity
C. Selectivity
D. Total Harmonic Distortion

**B** A receiver's sensitivity determines its ability to detect signals. Higher sensitivity means a receiver can detect weaker signals. [Ham Radio License Manual, page 5-9]

**T7A02 What is a transceiver?**

A. A device that combines a receiver and transmitter
B. A device for matching feed line impedance to 50 ohms
C. A device for automatically sending and decoding Morse code
D. A device for converting receiver and transmitter frequencies to another band

**A** Most amateur equipment combines the transmitter and receiver into a single piece of equipment called a transceiver (abbreviated XCVR). A transmit-receive (TR) switch allows the transmitter and receiver to share a single antenna. [Ham Radio License Manual, page 2-7]




**A basic amateur station is made up of a transmitter and receiver connected to an antenna with a feed line. The transmit-receive (TR) switch allows the transmitter and receiver to share the antenna. A transceiver combines the transmitter, receiver, and TR switch in a single package.**

**T7A03 Which of the following is used to convert a radio signal from one frequency to another?**

A. Phase splitter
B. Mixer
C. Inverter
D. Amplifier

**B** Mixers combine two RF signals and shift one of them to a third frequency. [Ham Radio License Manual, page 3-18]

**T7A04 Which term describes the ability of a receiver to discriminate between multiple signals?**

A. Discrimination ratio
B. Sensitivity
C. Selectivity
D. Harmonic distortion

**C** Selectivity is the ability of a receiver to discriminate between signals, retrieving only the information from the desired signal in the presence of unwanted signals. High selectivity means that a receiver can operate properly even in the presence of strong signals on nearby frequencies. [Ham Radio License Manual, page 5-9]

**T7A05 What is the name of a circuit that generates a signal at a specific frequency?**

A. Reactance modulator
B. Phase modulator
C. Low-pass filter
D. Oscillator

**D** An oscillator produces a steady signal at one frequency. [Ham Radio License Manual, page 3-17]

**T7A06 What device converts the RF input and output of a transceiver to another band?**

A. High-pass filter
B. Low-pass filter
C. Transverter
D. Phase converter

**C** A transverter allows a transceiver to be used on one or more new bands. Low-power transmitter output signals are shifted to the new output frequency where they are amplified for transmission. A receiving converter mixer shifts input signals to the desired band where they are received as regular signals by the transceiver. [Ham Radio License Manual, page 5-11]

**T7A07 What is the function of a transceiver’s PTT input?**

A. Input for a key used to send CW
B. Switches transceiver from receive to transmit when grounded
C. Provides a transmit tuning tone when grounded
D. I nput for a preamplifier tuning tone

**B** Switching between receive and transmit on voice can be performed manually with a push-to-talk (PTT) switch or an automatic voice-operated transmitter control circuit (VOX). [Ham Radio License Manual, page 5-7]

**T7A08 Which of the following describes combining speech with an RF carrier signal?**

A. Impedance matching
B. Oscillation
C. Modulation
D. Low-pass filtering

**C** The process of combining data or voice signals with an RF signal is modulation. A circuit that performs the modulation function is therefore called a modulator. [Ham Radio License Manual, page 3-17]

**T7A09 What is the function of the SSB/CW-FM switch on a VHF power amplifier?**

A. Change the mode of the transmitted signal
B. Set the amplifier for proper operation in the selected mode
C. Change the frequency range of the amplifier to operate in the proper portion of the band
D. Reduce the received signal noise

**B** An RF power amplifier is used to increase the output power from low-power handheld transceivers and medium-power base or mobile rigs. Commercial amplifiers used on VHF can be used with SSB, FM, or CW signals but need to be set to the right mode to operate properly. This is controlled by a switch on the amplifier's front panel that changes the amplifier from the CW and FM setting to the SSB setting. [Ham Radio License Manual, page 5-10]

**T7A10 What device increases the transmitted output power from a transceiver?**

A. A voltage divider
B. An RF power amplifier
C. An impedance network
D. All of these choices are correct

**B** See question T7A09. [Ham Radio License Manual, page 5-10]

**T7A11 Where is an RF preamplifier installed?**

A. Between the antenna and receiver
B. At the output of the transmitter power amplifier
C. Between the transmitter and the antenna tuner
D. At the output of the receiver audio amplifier

**A** If a receiver is not sensitive enough, a preamplifier or “preamp” can be used. The preamp is connected between the antenna and receiver. [Ham Radio License Manual, page 5-9]

## T7B — Symptoms, causes, and cures of common transmitter and receiver problems: overload and overdrive, distortion, interference and consumer electronics, RF feedback

**T7B01 What can you do if you are told your FM handheld or mobile transceiver is over-deviating?**

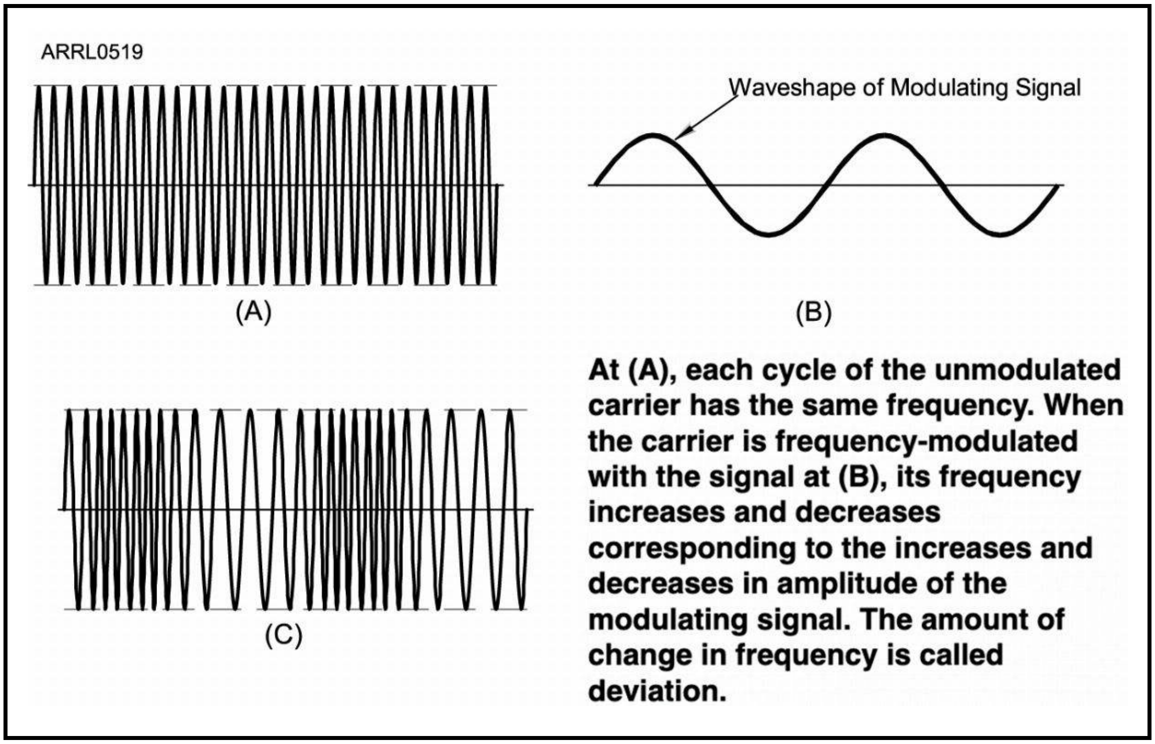
A. Talk louder into the microphone
B. Let the transceiver cool off
C. Change to a higher power level
D. Talk farther away from the microphone

**D** An overmodulated FM signal has excessive deviation and is said to be overdeviating. Overdeviation is usually caused by speaking too loudly into the microphone and may cause interference on adjacent channels. It often generates noise or distortion on voice peaks, called “breaking up.” To reduce overdeviation, speak more softly or move the microphone farther from your mouth. [Ham Radio License Manual, page 5-8]

**T7B02 What would cause a broadcast AM or FM radio to receive an amateur radio transmission unintentionally?**

A. The receiver is unable to reject strong signals outside the AM or FM band
B. The microphone gain of the transmitter is turned up too high
C. The audio amplifier of the transmitter is overloaded
D. The deviation of an FM transmitter is set too low

**A** See also question T7B03. [Ham Radio License Manual, page 9-8]



**T7B03 Which of the following can cause radio frequency interference?**

A. Fundamental overload
B. Harmonics
C. Spurious emissions
D. All of these choices are correct

**D** Very strong signals may overwhelm a receiver’s ability to reject them. This is called fundamental overload. Overload usually results in severe interference to all channels of a broadcast TV, AM, or FM receiver. A high-pass filter can be connected at the antenna input of FM and TV receivers to reject strong lower-frequency signals from amateur HF transmitters. A band-reject or notch filter can be used to reduce interference from amateur VHF or UHF signals. Due to minor imperfections, every transmitter’s RF output signal contains weak harmonics of the desired output signal and other spurious emissions that can cause interference to nearby equipment. To prevent harmonics from being radiated by your station, a low-pass or band-pass filter must be installed at the transmitter’s connection to the antenna feed line. [Ham Radio License Manual, page 9-8]

**T7B04 Which of the following could you use to cure distorted audio caused by RF current on the shield of a microphone cable?**

A. Band-pass filter
B. Low-pass filter
C. Preamplifier
D. Ferrite choke

**D** RF choke or common-mode filters made of ferrite material are used to reduce RF currents flowing on unshielded wires such as speaker cables, ac power cords, and telephone modular cords. Ferrite chokes are also used to reduce RF current on the outside of shielded audio, microphone, and computer cables. [Ham Radio License Manual, page 9-7]

**T7B05 How can fundamental overload of a non-amateur radio or TV receiver by an amateur signal be reduced or eliminated?**

A. Block the amateur signal with a filter at the antenna input of the affected receiver

B. Block the interfering signal with a filter on the amateur transmitter

C. Switch the transmitter from FM to SSB

D. Switch the transmitter to a narrow-band mode

**A** See question T7B03. [Ham Radio License Manual, page 9-9]

**T7B06 Which of the following actions should you take if a neighbor tells you that your station's transmissions are interfering with their radio or TV reception?**

A. Make sure that your station is functioning properly and that it does not cause interference to your own radio or television when it is tuned to the same channel

B. Immediately turn off your transmitter and contact the nearest FCC office for assistance

C. Install a harmonic doubler on the output of your transmitter and tune it until the interference is eliminated

D. All these choices are correct

**A** Regardless of the source, you can reduce or eliminate much interference by making sure your own station follows good amateur practices for grounding and filtering. Eliminate interference to your own home appliances and televisions first. [Ham Radio License Manual, page 9-9]

**T7B07 Which of the following can reduce overload to a VHF transceiver by a nearby commercial FM station?**

A. Installing an RF preamplifier
B. Using double-shielded coaxial cable
C. Installing bypass capacitors on the microphone cable
D. Installing a band-reject filter

**D** See question T7B03. [Ham Radio License Manual, page 9-8]

**T7B08 What should you do if something in a neighbor's home is causing harmful interference to your amateur station?**

A. Work with your neighbor to identify the offending device
B. Politely inform your neighbor that FCC rules prohibit the use of devices that cause interference
C. Make sure your station meets the standards of good amateur practice
D. All these choices are correct

**D** There are several simple steps to take:

• Make sure your station meets the standards of good amateur practices.

• You can offer to help determine the source of interference. Severe noise often indicates defective equipment that could be a safety or fire hazard.

• You may have to politely explain to the neighbor that FCC rules prohibit them from using a device that causes harmful interference.

Be diplomatic in dealing with your neighbors, even though it may be their responsibility to deal with interference to or from their devices. They are probably unaware of FCC rules.

[Ham Radio License Manual, page 9-10]

**T7B09 What should be the first step to resolve non-fiber optic cable TV interference caused by your amateur radio transmission?**

A. Add a low-pass filter to the TV antenna input
B. Add a high-pass filter to the TV antenna input
C. Add a preamplifier to the TV antenna input
D. Be sure all TV feed line coaxial connectors are installed properly

**D** A possible source of interference, both to hams and to cable TV customers, is leakage. Leakage refers to signals from inside the cable TV feed line getting out. This can cause interference to amateur signals. Leakage also refers to external signals getting into the cable TV feed line. An amateur transmission on a frequency used by the cable system can cause interference if it gets into the feed line. The most common cause of leakage in either direction is faulty coaxial connectors on the cable feed line. They might be improperly installed or simply loose. Be sure the connectors are installed correctly and attached tightly. [Ham Radio License Manual, page 9-10]

**T7B10 What might be a problem if you receive a report that your audio signal through an FM repeater is distorted or unintelligible?**

A. Your transmitter is slightly off frequency
B. Your batteries are running low
C. You are in a bad location
D. All of these choices are correct

**D** Being slightly off frequency sometimes happens when a radio control knob or key gets bumped, changing frequency by a small amount. You could also be causing excessive deviation by speaking too loudly into the microphone. Either lower your voice or hold the microphone farther away from your mouth. You could be transmitting from a bad location where your signal is distorted at the repeater input. Weak or low batteries can also cause distorted audio. [Ham Radio License Manual, page 6-4]

**T7B11 What is a symptom of RF feedback in a transmitter or transceiver?**

A. Excessive SWR at the antenna connection

B. The transmitter will not stay on the desired frequency

C Reports of garbled, distorted, or unintelligible voice transmissions

D. Frequent blowing of power supply fuses

**C** RF current flowing in sensitive audio cables or data cables can interfere with your station's normal function. Often called "RF feedback," this type of interference can cause distorted transmitted audio, for example. [Ham Radio License Manual, page 9-6]

**T7C — Antenna and transmission line measurements and troubleshooting: measuring SWR, effects of high SWR, causes of feed line failures; Basic coaxial cable characteristics; Use of dummy loads when testing**

**T7C01 What is the primary purpose of a dummy load?**

A. To prevent transmitting signals over the air when making tests
B. To prevent over-modulation of a transmitter
C. To improve the efficiency of an antenna
D. To improve the signal-to-noise ratio of a receiver

**A** To avoid interfering with other stations while you’re adjusting your transmitter or measuring its output power, it’s a good idea to use a dummy load. A dummy load is a heavy-duty resistor that can absorb and dissipate the output power from a transmitter. [Ham Radio License Manual, page 5-7]

**T7C02 Which of the following is used to determine if an antenna is resonant at the desired operating frequency?**

A. A VTVM
B. An antenna analyzer
C. A Q meter
D. A frequency counter

**B** An antenna analyzer contains a very low-power signal source with an adjustable frequency and one or more meters to show the impedance and SWR. [Ham Radio License Manual, page 4-18]

**T7C03 What does a dummy load consist of?**

A. A high-gain amplifier and a TR switch
B. A non-inductive resistor mounted on a heat sink
C. A low-voltage power supply and a DC relay
D. A 50-ohm reactance used to terminate a transmission line

**B** A dummy load is a heavy-duty resistor that can absorb and dissipate the output power from a transmitter. [Ham Radio License Manual, page 5-7]

**T7C04 What reading on an SWR meter indicates a perfect impedance match between the antenna and the feed line?**

A. 50:50
B. Zero
C. 1:1
D. Full Scale

**C** When there is no reflected power the SWR is 1:1. This condition is called a perfect match. [Ham Radio License Manual, page 4-10]

**T7C05 Why do most solid-state transmitters reduce output power as SWR increases beyond a certain level?**

A. To protect the output amplifier transistors

B. To comply with FCC rules on spectral purity

C. Because power supplies cannot supply enough current at high SWR

D. To lower the SWR on the transmission line

**A** Most amateur transmitting equipment is designed to work at full power with an SWR of 2:1 or lower. Higher SWR may cause the transmitter's protection circuits to reduce power to avoid damage to the output transistors. [Ham Radio License Manual, page 4-10]

**T7C06 What does an SWR reading of 4:1 indicate?**

A. Loss of -4 dB
B. Good impedance match
C. Gain of +4 dB
D. Impedance mismatch

**D** As more power is reflected, SWR increases. SWR greater than 1:1 is called an impedance mismatch or just mismatch. [Ham Radio License Manual, page 4-10]

**T7C07 What happens to power lost in a feed line?**

A. It increases the SWR
B. It is radiated as harmonics
C. It is converted into heat
D. It distorts the signal

**C** Power lost in a feed line is converted into and dissipated as heat.
[Ham Radio License Manual, page 4-9]

**T7C08 Which instrument can be used to determine SWR?**

A. Voltmeter
B. Ohmmeter
C. Iambic pentameter
D. Directional wattmeter

**D** Many amateurs use a directional wattmeter that can read power flowing in either direction in the feed line. The forward and reflected power readings can then be converted to SWR by using a table or formula. [Ham Radio License Manual, page 4-18]

**T7C09 Which of the following causes failure of coaxial cables?**

A. Moisture contamination
B. Solder flux contamination
C. Rapid fluctuation in transmitter output power
D. Operation at 100% duty cycle for an extended period

**A** Water in coaxial cable degrades the effectiveness of the braided shield and dramatically increases losses. Nicks, cuts and scrapes can all breach the jacket of coaxial cable allowing moisture contamination, the most common cause of coaxial cable failure. [Ham Radio License Manual, page 4-17]

**T7C10 Why should the outer jacket of coaxial cable be resistant to ultraviolet light?**

A. Ultraviolet resistant jackets prevent harmonic radiation
B. Ultraviolet light can increase losses in the cable’s jacket
C. Ultraviolet and RF signals can mix, causing interference
D. Ultraviolet light can damage the jacket and allow water to enter the cable

**D** Prolonged exposure to the ultraviolet (UV) in sunlight will cause the plastic in the jacket to degrade, causing small cracks that allow water into the cable. [Ham Radio License Manual, page 4-17]

**T7C11 What is a disadvantage of air core coaxial cable when compared to foam or solid dielectric types?**

A. It has more loss per foot
B. It cannot be used for VHF or UHF antennas
C. It requires special techniques to prevent moisture in the cable
D. It cannot be used at below freezing temperatures

**C** Connectors that can seal the coax core must be used with extra attention paid to waterproofing. Another technique is to pressurize the cable. [Ham Radio License Manual, page 4-17]

**T7D — Using basic test instruments: voltmeter, ammeter, and ohmmeter; Soldering**

**T7D01 Which instrument would you use to measure electric potential?**

A. An ammeter
B. A voltmeter
C. A wavemeter
D. An ohmmeter

**B** Voltage is measured with a voltmeter. [Ham Radio License Manual, |page 3-1]

**T7D02 How is a voltmeter connected to a component to measure applied voltage?**

A. In series
B. In parallel
C. In quadrature
D. In phase

**B** Voltmeters are connected in parallel with or “across” a component or circuit to measure voltage. [Ham Radio License Manual, page 3-2]

**T7D03 When configured to measure current, how is a multimeter connected to a component?**

A. In series
B. In parallel
C. In quadrature
D. In phase

**A** Ammeters and multimeters configured to measure current are connected in series with a component or circuit. [Ham Radio License Manual, page 3-2]

**T7D04 Which instrument is used to measure electric current?**

A. An ohmmeter
B. A wavemeter
C. A voltmeter
D. An ammeter

**D** An ammeter is used to measure current. [Ham Radio License Manual, page 3-1]

**T7D05 Question removed from the pool.**

**T7D06 Which of the following can damage a multimeter?**

A. Attempting to measure resistance using the voltage setting
B. Failing to connect one of the probes to ground
C. Attempting to measure voltage when using the resistance setting
D. Not allowing it to warm up properly

**C** Trying to measure voltage or connecting the probes to an energized circuit when the meter is set to measure resistance is a common way to damage a multimeter. [Ham Radio License Manual, page 3-4]

**T7D07 Which of the following measurements are made using a multimeter?**

A. Signal strength and noise
B. Impedance and reactance
C. Voltage and resistance
D. All these choices are correct

**C** The multimeter measures all three primary electrical values of voltage, current, and resistance. [Ham Radio License Manual, page 3-4]

**T7D08 Which of the following types of solder should not be used for radio and electronic applications?**

A. Acid-core solder
B. Lead-tin solder
C. Rosin-core solder
D. Tin-copper solder

**A** Avoid acid-core solder which is corrosive to electronics. [Ham Radio License Manual, page 4-17]

**T7D09 What is the characteristic appearance of a cold tin-lead solder joint?**

A. Dark black spots
B. A bright or shiny surface
C. A rough or lumpy surface
D. Excessive solder

**C** A cold tin-lead solder joint has a rough or lumpy surface. [Ham Radio License Manual, page 4-17]

**T7D10 What reading indicates that an ohmmeter is connected across a large, discharged capacitor?**

A. Increasing resistance with time
B. Decreasing resistance with time
C. Steady full-scale reading
D. Alternating between open and short circuit

**A** If you are measuring the resistance of a circuit and the reading starts out low, but gradually increases, that indicates the presence of a large value, discharged capacitor. [Ham Radio License Manual, page 3-4]

**T7D11 Which of the following precautions should be taken when measuring in-circuit resistance with an ohmmeter?**

A. Ensure that the applied voltages are correct
B. Ensure that the circuit is not powered
C. Ensure that the circuit is grounded
D. Ensure that the circuit is operating at the correct frequency

**B** See question T7D06. [Ham Radio License Manual, page 3-4]

# Subelement T8
# Signals and Emissions

**[4 exam questions — 4 groups]**

## T8A — Basic characteristics of FM and SSB; Bandwidth of various modulation modes: CW, SSB, FM, fast-scan TV; Choice of emission type: selection of USB vs LSB, use of SSB for weak signal work, use of FM for VHF packet and repeaters

**T8A01 Which of the following is a form of amplitude modulation?**

A. Spread spectrum
B. Packet radio
C. Single sideband
D. Phase shift keying (PSK)

**C** Single sideband or SSB is an amplitude modulation (AM) signal with the carrier and one sideband removed or *suppressed*. [*Ham Radio License Manual*, page 5-3]

**T8A02 What type of modulation is commonly used for VHF packet radio transmissions?**

A. FM or PM
B. SSB
C. AM
D. PSK

**A** Frequency modulation or FM is commonly used for packet radio on VHF and UHF. The data modulates the FM signal as audio tones. [*Ham Radio License Manual*, page 5-4]

**T8A03 Which type of voice mode is often used for long-distance (weak signal) contacts on the VHF and UHF bands?**

A. FM
B. DRM
C. SSB
D. PM

**C** Because an SSB signal's power is concentrated into a narrow bandwidth, it is possible to communicate with SSB over much longer ranges and in poorer conditions than with FM or AM, particularly on the VHF and UHF bands. See table for question T8A05. [*Ham Radio License Manual*, page 5-4]

**T8A04 Which type of modulation is commonly used for VHF and UHF voice repeaters?**

A. AM
B. SSB
C. PSK
D. FM or PM

**D** Because of FM's excellent noise-rejection qualities, it is the mode used by most VHF and UHF repeaters. [*Ham Radio License Manual*, page 5-4]

**T8A05 Which of the following types of signal has the narrowest bandwidth?**

A. FM voice
B. SSB voice
C. CW
D. Slow-scan TV

**C** [*Ham Radio License Manual*, page 5-4]

# Signal Bandwidths

| *Type of Signal* | *Typical Bandwidth* |
|---|---|
| CW | 150 Hz (0.15 kHz) |
| SSB digital | 500 to 3000 Hz (0.5 to 3 kHz) |
| SSB voice | 2 to 3 kHz |
| AM voice | 6 kHz |
| AM broadcast | 10 kHz |
| FM voice | 10 to 15 kHz |
| FM broadcast | 150 kHz |
| Fast-scan video broadcast | 6 MHz |

**T8A06 Which sideband is normally used for 10 meter HF, VHF, and UHF single-sideband communications?**

A. Upper sideband
B. Lower sideband
C. Suppressed sideband
D. Inverted sideband

**A** Above 10 MHz, including all of the VHF and UHF bands, upper sideband (USB) is the standard choice. USB must also be used on the 60 meter channels. LSB is used for voice below 10 MHz. [*Ham Radio License Manual*, page 5-4]

**T8A07 What is a characteristic of single sideband (SSB) compared to FM?**

A. SSB signals are easier to tune in correctly
B. SSB signals are less susceptible to interference
C. SSB signals have narrower bandwidth
D. All these choices are correct

**C** See the table for question T8A05. [*Ham Radio License Manual*, page 5-4]

**T8A08 What is the approximate bandwidth of a typical single sideband (SSB) voice signal?**

A. 1 kHz
B. 3 kHz
C. 6 kHz
D. 15 kHz

**B** See the table for question T8A05. [*Ham Radio License Manual*, page 5-4]

**T8A09 What is the approximate bandwidth of a VHF repeater FM voice signal?**

A. Less than 500 Hz
B. About 150 kHz
C. Between 10 and 15 kHz
D. Between 50 and 125 kHz

**C** See the table for question T8A05. [*Ham Radio License Manual*, page 5-4]

**T8A10 What is the approximate bandwidth of AM fast-scan TV transmissions?**

A. More than 10 MHz
B. About 6 MHz
C. About 3 MHz
D. About 1 MHz

**B** See the table for question T8A05. [*Ham Radio License Manual*, page 5-4]

**T8A11 What is the approximate bandwidth required to transmit a CW signal?**

A. 2.4 kHz
B. 150 Hz
C. 1000 Hz
D. 15 kHz

**B** See the table for question T8A05. [*Ham Radio License Manual*, page 5-4]

**T8A12 Which of the following is a disadvantage of FM compared with single sideband?**

A. Voice quality is poorer
B. Only one signal can be received at a time
C. FM signals are harder to tune
D. All these choices are correct

**B** Because of the way FM receivers work, only one signal can be received at a time. This is called the *capture effect* and if multiple signals are present, only the strongest will be heard in the receiver. [*Ham Radio License Manual*, page 5-4]

**T8B — Amateur satellite operation: Doppler shift, basic orbits, operating protocols, modulation mode selection, transmitter power considerations, telemetry and telecommand, satellite tracking programs, beacons, uplink and downlink mode definitions, spin fading, definition of "LEO", setting uplink power**

**T8B01 What telemetry information is typically transmitted by satellite beacons?**

A. The signal strength of received signals
B. Time of day accurate to plus or minus 1/10 second
C. Health and status of the satellite
D. All of these choices are correct

**C** The telemetry data from a satellite contains information on the health and status of the satellite. [*Ham Radio License Manual*, page 6-24]

**T8B02 What is the impact of using excessive effective radiated power on a satellite uplink?**

A. Possibility of commanding the satellite to an improper mode
B. Blocking access by other users
C. Overloading the satellite batteries
D. Possibility of rebooting the satellite control computer

**B** Always use the minimum amount of transmitter power to contact satellites, since their relay transmitter power is limited by their solar panels and batteries. If your signal on the satellite downlink is about the same strength as that of the satellite's beacon, you're using the right amount of power. [*Ham Radio License Manual*, page 6-24]

**T8B03 Which of the following are provided by satellite tracking programs?**

A. Maps showing the real-time position of the satellite track over Earth
B. The time, azimuth, and elevation of the start, maximum altitude, and end of a pass
C. The apparent frequency of the satellite transmission, including effects of Doppler shift
D. All of these choices are correct

**D** Tracking software provides real-time maps of the satellite's location, the trajectory the satellite will follow across the sky, and even the amount of Doppler shift the signals will experience. You will need to enter data about the satellite's orbit called the *Keplerian elements*. [*Ham Radio License Manual*, page 6-24]

**T8B04 What mode of transmission is commonly used by amateur radio satellites?**

A. SSB
B. FM
C. CW/data
D. All of these choices are correct

**D** Satellites can use any amateur signal mode. The most common are SSB, FM, CW, and data. See question T8B08. [*Ham Radio License Manual*, page 6-24]

**T8B05 What is a satellite beacon?**

A. The primary transmit antenna on the satellite
B. An indicator light that shows where to point your antenna
C. A reflective surface on the satellite
D. A transmission from a satellite that contains status information

**D** [*Ham Radio License Manual*, page 6-23]

Common satellite terms include:

- Apogee — The point of a satellite's orbit that is farthest from Earth
- Beacon — A signal from the satellite containing information about a satellite
- Doppler shift — A shift in a signal's frequency due to relative motion between the satellite and the Earth station
- Elliptical orbit — An orbit with a large difference between apogee and perigee
- LEO — A satellite in Low Earth Orbit
- Perigee — The point of a satellite's orbit that is nearest the Earth
- Space station — Defined by the FCC as an amateur station located more than 50 km above the Earth's surface
- Spin fading — Signal fading caused by rotation of the satellite and its antennas

**T8B06 Which of the following are inputs to a satellite tracking program?**

A. The satellite transmitted power
B. The Keplerian elements
C. The last observed time of zero Doppler shift
D. All of these choices are correct

**B** See question T8B03. [*Ham Radio License Manual*, page 6-24]

**T8B07 What is Doppler shift in reference to satellite communications?**

A. A change in the satellite orbit

B. A mode where the satellite receives signals on one band and transmits on another

C. An observed change in signal frequency caused by relative motion between the satellite and Earth station

D. A special digital communications mode for some satellites

**C** See question T8B05. [*Ham Radio License Manual*, page 6-23]

**T8B08 What is meant by the statement that a satellite is operating in U/V mode?**

A. The satellite uplink is in the 15 meter band and the downlink is in the 10 meter band
B. The satellite uplink is in the 70 centimeter band and the downlink is in the 2 meter band
C. The satellite operates using ultraviolet frequencies
D. The satellite frequencies are usually variable

**B** A satellite's mode specifies the bands on which it is transmitting and receiving. Mode is specified as two letters separated by a slash. The first letter indicates the uplink band and the second letter indicates the downlink band. For example, the uplink for a satellite in U/V mode is in the UHF band (70 cm) and a downlink is in the VHF band (2 meters). [*Ham Radio License Manual*, page 6-24]

**T8B09 What causes spin fading of satellite signals?**

A. Circular polarized noise interference radiated from the sun
B. Rotation of the satellite and its antennas
C. Doppler shift of the received signal
D. Interfering signals within the satellite uplink band

**B** See question T8B05. [*Ham Radio License Manual*, page 6-23]

**T8B10 What is a LEO satellite?**

A. A sun synchronous satellite
B. A highly elliptical orbit satellite
C. A satellite in low energy operation mode
D. A satellite in low earth orbit

**D** A satellite in low-Earth orbit. [*Ham Radio License Manual*, page 6-23]

**T8B11 Who may receive telemetry from a space station?**

A. Anyone
B. A licensed radio amateur with a transmitter equipped for interrogating the satellite
C. A licensed radio amateur who has been certified by the protocol developer
D. A licensed radio amateur who has registered for an access code from AMSAT

**A** Anyone can receive the stream of telemetry data from a space station, even if they don’t have an amateur license. [*Ham Radio License Manual*, page 6-24]

**T8B12 Which of the following is a way to determine whether your satellite uplink power is neither too low nor too high?**

A. Check your signal strength report in the telemetry data
B. Listen for distortion on your downlink signal
C. Your signal strength on the downlink should be about the same as the beacon
D. All of these choices are correct

**C** See question T8B02. [*Ham Radio License Manual*, page 6-24]

**T8C — Operating activities: radio direction finding, contests, linking over the internet, exchanging grid locators**

**T8C01 Which of the following methods is used to locate sources of noise interference or jamming?**

A. Echolocation
B. Doppler radar
C. Radio direction finding
D. Phase locking

**C** Locating a hidden transmitter (the fox) or *foxhunting* has been a popular ham activity for many years. It has its practical side, too, training hams to find downed aircraft, lost hikers, and sources of interference or jamming. It doesn't require much in the way of equipment. You can get started with a portable radio with a signal strength indicator and a handheld or portable directional antenna, such as a small Yagi beam. [*Ham Radio License Manual*, page 6-10]

**T8C02 Which of these items would be useful for a hidden transmitter hunt?**

A. Calibrated SWR meter
B. A directional antenna
C. A calibrated noise bridge
D. All of these choices are correct

**B** See question T8C01. [*Ham Radio License Manual*, page 6-10]

**T8C03 What operating activity involves contacting as many stations as possible during a specified period?**

A. Simulated emergency exercises
B. Net operations
C. Public service events
D. Contesting

**D** Radio *contests* are held in which the competitors try to make as many short contacts as possible in a fixed period of time. [*Ham Radio License Manual*, page 6-7]

**T8C04 Which of the following is good procedure when contacting another station in a radio contest?**

A. Sign only the last two letters of your call if there are many other stations calling
B. Contact the station twice to be sure that you are in his log
C. Send only the minimum information needed for proper identification and the contest exchange
D. All of these choices are correct

**C** When making a contest contact, send only the minimum information needed to identify your station and send the complete information required, called the *exchange*. [*Ham Radio License Manual*, page 6-7]

**T8C05 What is a grid locator?**

A. A letter-number designator assigned to a geographic location
B. A letter-number designator assigned to an azimuth and elevation
C. An instrument for neutralizing a final amplifier
D. An instrument for radio direction finding

**A** The Maidenhead Locator System is named for the town outside London, England where the method was first created. In this system, the Earth's surface is divided into a system of rectangles based on latitude and longitude known as *grid locators* or *grid squares*. Each grid square is identified with a combination of letters and numbers. [*Ham Radio License Manual*, page 6-8]

**T8C06 How is over the air access to IRLP nodes accomplished?**

A. By obtaining a password that is sent via voice to the node
B. By using DTMF signals
C. By entering the proper internet password
D. By using CTCSS tone codes

**B** To initiate a contact or exercise a control function on an IRLP-linked repeater, a control code is used. The code is a sequence of DTMF (Dual-tone Multi-Frequency) tones, like dialing a phone number. [*Ham Radio License Manual*, page 6-13]

**T8C07 What is Voice Over Internet Protocol (VoIP)?**

A. A set of rules specifying how to identify your station when linked over the internet to another station

B. A technique employed to "spot" DX stations via the internet

C. A technique for measuring the modulation quality of a transmitter using remote sites monitored via the internet

D. A method of delivering voice communications over the internet using digital techniques

**D** VoIP is a type of digital protocol used to deliver voice and audio over the internet. It is used by the IRLP and EchoLink repeater systems. [*Ham Radio License Manual*, page 6-13]

**T8C08 What is the Internet Radio Linking Project (IRLP)?**

A. A technique to connect amateur radio systems, such as repeaters, via the internet using Voice Over Internet Protocol (VoIP)
B. A system for providing access to websites via amateur radio
C. A system for informing amateurs in real time of the frequency of active DX stations
D. A technique for measuring signal strength of an amateur transmitter via the internet

**A** The IRLP and EchoLink systems use VoIP (Voice over Internet Protocol) technology to link repeaters. [*Ham Radio License Manual*, page 6-13]

**T8C09 Which of the following protocols enables an amateur station to transmit through a repeater without using a radio to initiate the transmission?**

A. IRLP
B. D-STAR
C. DMR
D. EchoLink

**D** The EchoLink system uses VoIP to enable amateur stations to transmit through an internet-connected repeater without using a radio to initiate the transmission. [*Ham Radio License Manual*, page 6-14]

**T8C10 What is required before using the EchoLink system?**

A. Complete the required EchoLink training
B. Purchase a license to use the EchoLink software
C. Register your call sign and provide proof of license
D. All these choices are correct

**D** You must be a licensed amateur to use EchoLink repeaters. EchoLink allows audio to come from a PC and microphone, so a radio is not necessary but hams are required to send a copy of their license to the EchoLink system administrators to be authorized to use the system. [*Ham Radio License Manual*, page 6-14]

**T8C11 What is an amateur radio station that connects other amateur stations to the internet?**

A. A gateway
B. A repeater
C. A digipeater
D. A beacon

**A** A *gateway* is a special kind of digital station that provides a connection to the internet via Amateur Radio. Most gateways are set up to *forward* messages. The most common examples are APRS gateways and the Winlink RMS stations. [*Ham Radio License Manual*, page 5-15]

**T8D — Non-voice and digital communications: image signals and definition of NTSC, CW, packet radio, PSK, APRS, error detection and correction, amateur radio networking, Digital Mobile Radio, WSJT modes, Broadband-Hamnet**

**T8D01 Which of the following is a digital communications mode?**

A. Packet radio
B. IEEE 802.11
C. FT8
D. All of these choices are correct

**D** On VHF/UHF, the popular digital modes include:

- Packet radio based on the AX.25 protocol
- B2F protocol for Winlink system messaging
- JT65 for moonbounce and MSK144 for scatter paths
- IEEE 802.11 (WiFi) adapted to amateur use on microwave bands and known as *Broadband-Hamnet* or *high-speed multimedia* (HSMM)

[*Ham Radio License Manual*, page 5-11]

**T8D02 What is a “talkgroup” on a DMR repeater?**

A. A group of operators sharing common interests
B. A way for groups of users to share a channel at different times without hearing other users on the channel
C. A protocol that increases the signal-to-noise ratio when multiple repeaters are linked together
D. A net that meets at a specified time

**B** Talk groups allow groups of users to share a channel at different times without being heard by other users on the channel. [*Ham Radio License Manual*, page 6-14]

**T8D03 What kind of data can be transmitted by APRS?**

A. GPS position data
B. Text messages
C. Weather data
D. All these choices are correct

**D** The *Automatic Packet Reporting System* (APRS) uses packet radio to transmit the position information from a moving or portable station. An APRS station is basically a packet radio station combined with a *Global Positioning System* (GPS) receiver, and as such can transmit GPS position data. The GPS receiver outputs a stream of position data that is then transmitted in packet form. Along with position information, you can also transmit weather information and short text messages. [*Ham Radio License Manual*, page 5-13]

**T8D04 What type of transmission is indicated by the term "NTSC?"**

A. A Normal Transmission mode in Static Circuit
B. A special mode for satellite uplink
C. An analog fast-scan color TV signal
D. A frame compression scheme for TV signals

**C** NTSC refers to a type of television signal. NTSC (National Television System Committee) fast-scan color television signals are the same as were used for analog broadcast TV signals. [*Ham Radio License Manual*, page 6-9]

**T8D05 Which of the following is an application of APRS?**

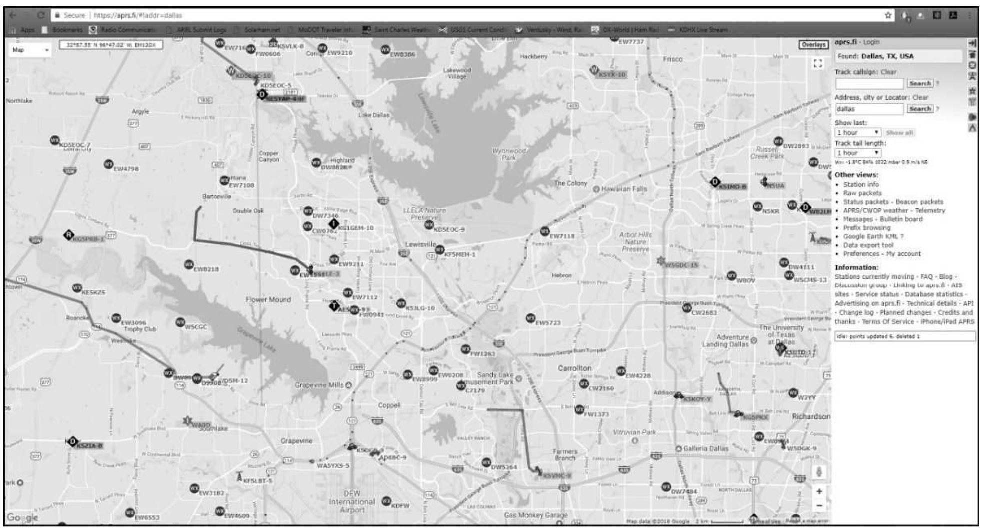
A. Providing real-time tactical digital communications in conjunction with a map showing the locations of stations

B. Showing automatically the number of packets transmitted via PACTOR during a specific time interval

C. Providing voice over internet connection between repeaters

D. Providing information on the number of stations signed into a repeater

**A** A common public service application of APRS is to provide maps of station locations while they are providing realtime tactical communications. [*Ham Radio License Manual*, page 5-13]



**APRS, the Automatic Packet Reporting System, uses packet radio signals to display the positions of fixed and mobile stations on a computer-generated map.**

**T8D06 What does the abbreviation "PSK" mean?**

A. Pulse Shift Keying
B. Phase Shift Keying
C. Packet Short Keying
D. Phased Slide Keying

**B** The most popular keyboard-to-keyboard mode today is PSK31, which stands for *phase shift keying, 31 baud*. [*Ham Radio License Manual*, page 5-13]

**T8D07 Which of the following describes DMR?**

A. A technique for time-multiplexing two digital voice signals on a single 12.5 kHz repeater channel

B. An automatic position tracking mode for FM mobiles communicating through repeaters

C. An automatic computer logging technique for hands-off logging when communicating while operating a vehicle

D. A digital technique for transmitting on two repeater inputs simultaneously for automatic error correction

**A** The DMR system was developed for the Land Mobile Radio service. Over the air, DMR is a technique for time-multiplexing two digital voice signals on a single 12.5 kHz repeater channel. [*Ham Radio License Manual*, page 6-14]

**T8D08 Which of the following is included in packet transmissions?**

A. A check sum that permits error detection
B. A header that contains the call sign of the station to which the information is being sent
C. Automatic repeat request in case of error
D. All of these choices are correct

**D** Each packet consists of a *header* and *data*. The header contains information about the packet and the call sign of the destination station. The header also includes a *checksum* that allows the receiver to detect errors. If an error is detected, the receiver automatically requests that the packet be retransmitted until the data is received properly. This is called ARQ for *automatic repeat request*. [*Ham Radio License Manual*, page 5-12]

**T8D09 What is CW?**

A. A type of electromagnetic propagation
B. A digital mode used primarily on 2 meter FM
C. A technique for coil winding
D. Another name for a Morse code transmission

**D** International Morse is the standard form of code for amateur CW operation. [*Ham Radio License Manual*, page 5-2]

**T8D10 Which of the following operating activities is supported by digital mode software in the WSJT-X suite?**

A. Earth-Moon-Earth
B. Weak-signal propagation beacons
C. Meteor scatter
D. All of these choices are correct

**D** Many popular digital modes are part of the *WSJT Suite*, a package of open-source software initially developed by Joe Taylor, K1JT. A team maintains and extends the software today, including modes designed for special types of communication such as JT65 for moonbounce (or Earth-Moon-Earth, EME), weak-signal propagation beacons (WSPR), and meteor scatter (MSK144). The latest invention, FT8, is capable of operating in low signal-to-noise conditions by transmitting special code sequences on 15-second intervals. [*Ham Radio License Manual*, page 5-12]

**T8D11 What is an ARQ transmission system?**

A. A special transmission format limited to video signals
B. A system used to encrypt command signals to an amateur radio satellite
C. An error correction method in which the receiving station detects errors and sends a request for retransmission
D. A method of compressing data using autonomous reiterative Q codes prior to final encoding

**C** See question T8D08. [*Ham Radio License Manual*, page 5-12]

**T8D12 Which of the following best describes an amateur radio mesh network?**

A. An amateur-radio-based data network using commercial Wi-Fi gear with modified firmware
B. A wide-bandwidth digital voice mode employing DRM protocols
C. A satellite communications network using modified commercial satellite TV hardware
D. An internet linking protocol used to network repeaters

**A** See question T8D01. [*Ham Radio License Manual*, page 5-12]

**T8D13 What is FT8?**

A. A wideband FM voice mode
B. A digital mode capable of low signal-to-noise operation
C. An eight-channel multiplex mode for FM repeaters
D. A digital slow scan TV mode with forward error correction and automatic color compensation

**B** See question T8D10. [*Ham Radio License Manual*, page 5-12]

# Subelement T9
# Antennas and Feed Lines

**[2 exam questions — 2 groups]**

## T9A — Antennas: vertical and horizontal polarization, concept of antenna gain, definition and types of beam antennas, antenna loading, common portable and mobile antennas, relationships between resonant length and frequency, dipole pattern

**T9A01 What is a beam antenna?**

A. An antenna built from aluminum I-beams
B. An omnidirectional antenna invented by Clarence Beam
C. An antenna that concentrates signals in one direction
D. An antenna that reverses the phase of received signals

**C** Beam antennas use multiple elements or reflecting surfaces to focus the transmitted signal or receiving ability in a specific direction. [*Ham Radio License Manual*, page 4-15]

**T9A02 Which of the following describes a type of antenna loading?**

A. Electrically lengthening by inserting inductors in radiating elements

B. Inserting a resistor in the radiating portion of the antenna to make it resonant

C. Installing a spring in the base of a mobile vertical antenna to make it more flexible

D. Strengthening the radiating elements of a beam antenna to better resist wind damage

**A** Inserting an inductor into an antenna element is called *inductive loading* and it makes the antenna longer electrically than it is physically. [*Ham Radio License Manual*, page 4-12]

**T9A03 Which of the following describes a simple dipole oriented parallel to the Earth's surface?**

A. A ground-wave antenna
B. A horizontally polarized antenna
C. A travelling-wave antenna
D. A vertically polarized antenna

**B** A dipole radiates a signal with a polarization that is the same as that of the orientation of the dipole. [*Ham Radio License Manual*, page 4-12]

**T9A04 What is a disadvantage of the short, flexible antenna supplied with most handheld radio transceivers, compared to a full-sized quarter-wave antenna?**

A. It has low efficiency
B. It transmits only circularly polarized signals
C. It is mechanically fragile
D. All these choices are correct

**A** The flexible antenna used with most handheld radios is called a *rubber duck*. It's a ground-plane antenna shortened by coiling the conductor inside a plastic coating. The body of the radio and the operator form the antenna's ground plane. The rubber duck is conveniently sized, but doesn't transmit or receive as well as a full-sized ground-plane antenna. [*Ham Radio License Manual*, page 4-12]

**T9A05 Which of the following increases the resonant frequency of a dipole antenna?**

A. Lengthening it
B. Inserting coils in series with radiating wires
C. Shortening it
D. Adding capacitive loading to the ends of the radiating wires

**C** Use an SWR meter or antenna analyzer to determine the resonant frequency. If the resonant frequency is too low, the dipole is too long: shorten it until it is resonant at the desired frequency. If the resonant frequency is too high, you will have to lengthen the dipole. [*Ham Radio License Manual*, page 4-12]

**T9A06 Which of the following types of antenna offers the greatest gain?**

A. 5/8 wave vertical
B. Isotropic
C. J pole
D. Yagi

**D** Compared to the theoretical isotropic antenna or practical omnidirectional antennas like the J-pole or 5/8-wave vertical, Yagi beam antennas have much more gain in their preferred direction. [*Ham Radio License Manual*, page 4-15]

**T9A07 What is a disadvantage of using a handheld VHF transceiver, with a flexible antenna inside a vehicle?**

A. Signal strength is reduced due to the shielding effect of the vehicle
B. The bandwidth of the antenna will decrease, increasing SWR
C. The SWR might decrease, decreasing the signal strength
D. All these choices are correct

**A** When using a handheld transceiver inside a vehicle, the standard flexible “rubber duck” antenna may not be an effective antenna. The vehicle’s metal roof and doors act like shields, trapping the radio waves inside. Some of the signal gets out through the windows (unless they’re tinted with a thin metal coating), but it’s as much as 10 to 20 times weaker than an external mobile antenna. [*Ham Radio License Manual*, page 4-12]

**T9A08 What is the approximate length, in inches, of a quarter-wavelength vertical antenna for 146 MHz?**

A. 112
B. 50
C. 19
D. 12

**C** The length of a ground-plane antenna is half that of a dipole so use the formula:

Length (in feet) = 234 / frequency (in MHz)

At 146 MHz, a $\lambda/4$ ($\frac{1}{4}\lambda$) ground-plane is 234 / 146 = 1.6 feet = 19¼ inches long.

[*Ham Radio License Manual*, page 4-12]

**T9A09 What is the approximate length, in inches, of a half-wavelength 6 meter dipole antenna?**

A. 6
B. 50
C. 112
D. 236

**C** [*Ham Radio License Manual*, page 4-12]

Use the formula:

Length (in feet) = 468 / frequency (in MHz)

At 50.1 MHz (in the 6 meter band), dipole length is calculated as 468 / 50.1 = 9.33 feet = 112 inches long

**T9A10 In which direction does a half-wave dipole antenna radiate the strongest signal?**

A. Equally in all directions
B. Off the ends of the antenna
C. In the direction of the feed line
D. Broadside to the antenna

**D** A dipole radiates strongest broadside to the antenna and weakest off the ends. [*Ham Radio License Manual*, page 4-12]

**T9A11 What is antenna gain?**

A. The additional power that is added to the transmitter power

B. The additional power that is required in the antenna when transmitting on a higher frequency

C. The increase in signal strength in a specified direction compared to a reference antenna

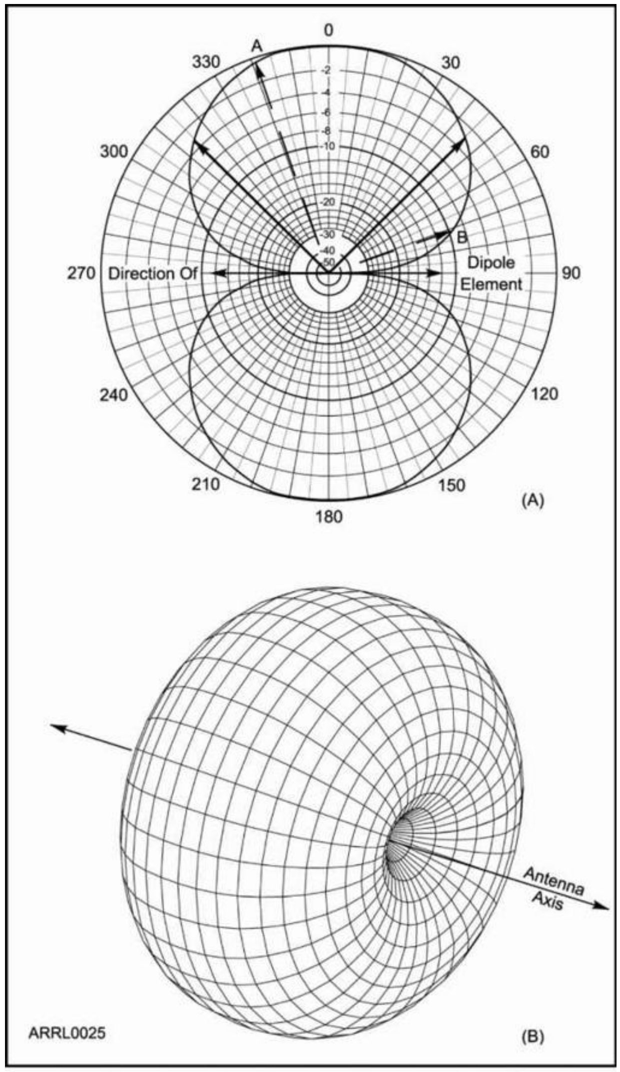
D. The increase in impedance on receive or transmit compared to a reference antenna

**C** Concentrating an antenna's radiated signals in a specific direction is called *gain*. Antenna gain increases signal strength in a specified direction when compared to a reference antenna. [*Ham Radio License Manual*, page 4-7]

**T9A12 What is an advantage of a 5/8 wavelength whip antenna for VHF or UHF mobile service?**

A. It has more gain than a 1/4-wavelength antenna
B. It radiates at a very high angle
C. It eliminates distortion caused by reflected signals
D. It has 10 times the power gain of a 1/4 wavelength whip

**A** Due to its extended length compared to a ¼-λ antenna, the ⅝-λ antenna focuses a bit more energy toward the horizon, improving range. [*Ham Radio License Manual*, page 4-12]




**The radiation pattern of a dipole far from ground (in free-space). At (A) the pattern is shown in a plane containing the dipole. The lengths of the arrows indicate the relative strength of the radiated power in that direction. The dipole radiates best broadside to its length. At (B) the 3-D pattern shows radiated strength in all directions.**

### T9B — Feed lines: types, attenuation vs frequency, selecting; SWR concepts; Antenna tuners (couplers); RF Connectors: selecting, weather protection

**T9B01 What is a benefit of low SWR?**

A. Reduced television interference
B. Reduced signal loss
C. Less antenna wear
D. All these choices are correct

**B** Low SWR reduces losses in the feed line from reflected power in the feed line traveling back and forth between the antenna and transmitter. [*Ham Radio License Manual*, page 4-10]

**T9B02 What is the most common impedance of coaxial cables used in amateur radio?**

A. 8 ohms
B. 50 ohms
C. 600 ohms
D. 12 ohms

**B** Most coaxial cable used in ham radio has a characteristic impedance ($Z_0$) of 50 ohms. Coaxial cables used for video and cable television have a $Z_0$ of 75 ohms. Open-wire feed lines have a $Z_0$ of 300 to 600 ohms. [*Ham Radio License Manual*, page 4-9]

**T9B03 Why is coaxial cable the most common feed line for amateur radio antenna systems?**

A. It is easy to use and requires few special installation considerations

B. It has less loss than any other type of feed line

C. It can handle more power than any other type of feed line

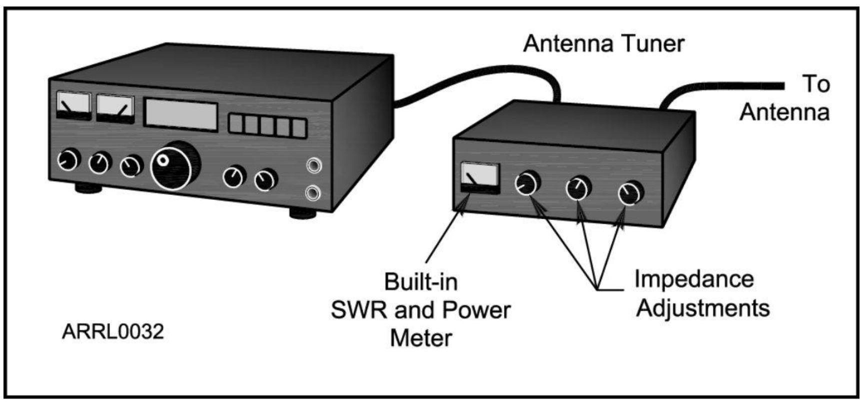
D. It is less expensive than any other type of feed line

**A** “Coax” is flexible, is unaffected by weather, and can be routed in bundles and next to insulating or conducting supports. [*Ham Radio License Manual*, page 4-9]

**T9B04 What is the major function of an antenna tuner (antenna coupler)?**

A. It matches the antenna system impedance to the transceiver's output impedance
B. It helps a receiver automatically tune in weak stations
C. It allows an antenna to be used on both transmit and receive
D. It automatically selects the proper antenna for the frequency band being used

**A** An antenna tuner is used to transform the antenna system's impedance to match that of the transceiver's output amplifier. [*Ham Radio License Manual*, page 4-18]




**An antenna tuner acts like an electrical version of a mechanical gearbox. By adjusting the tuner's controls, the impedance present at the end of the feed line can be converted to the impedance that best suits the transceiver's output circuits, usually 50 Ω.**

**T9B05 What happens as the frequency of a signal in coaxial cable is increased?**

A. The characteristic impedance decreases
B. The loss decreases
C. The characteristic impedance increases
D. The loss increases

**D** Feed line loss increases with frequency for all types of feed lines. [*Ham Radio License Manual*, page 4-9]

**T9B06 Which of the following RF connector types is most suitable for frequencies above 400 MHz?**

A. UHF (PL-259/SO-239)
B. Type N
C. RS-213
D. DB-25

**B** Above 400 MHz, the Type N connectors are used because of their low loss and controlled impedance. [*Ham Radio License Manual*, page 4-17]

**T9B07 Which of the following is true of PL-259 type coax connectors?**

A. They are preferred for microwave operation
B. They are watertight
C. They are commonly used at HF and VHF frequencies
D. They are a bayonet type connector

**C** The UHF series of connectors — PL-259 plugs and SO-239 receptacles — are the most widely-used for HF equipment. [*Ham Radio License Manual*, page 4-17]

**T9B08 Which of the following is a source of loss in coaxial feed line?**

A. Water intrusion into coaxial connectors
B. High SWR
C. Multiple connectors in the line
D. All these choices are correct

**A** Water in coaxial cable degrades the effectiveness of the braided shield and dramatically increases losses. See question T7C09. [*Ham Radio License Manual*, page 4-17]

**T9B09 What can cause erratic changes in SWR?**

A. Local thunderstorm
B. Loose connection in the antenna or feed line
C. Over-modulation
D. Overload from a strong local station

**B** A faulty feed line or feed line connectors can raise SWR as an intermittent connection creates large mismatches in impedance. Erratic SWR usually indicates a loose connection in the feed line or antenna. [*Ham Radio License Manual*, page 4-10]

**T9B10 What is the electrical difference between RG-58 and RG-213 coaxial cable?**

A. There is no significant difference between the two types
B. RG-58 cable has two shields
C. RG-213 cable has less loss at a given frequency
D. RG-58 cable can handle higher power levels

**C** In general, a larger diameter cable such as RG-213 will have less loss than a small cable such as RG-58. [*Ham Radio License Manual*, page 4-17]

**T9B11 Which of the following types of feed line has the lowest loss at VHF and UHF?**

A. 50-ohm flexible coax
B. Multi-conductor unbalanced cable
C. Air-insulated hard line
D. 75-ohm flexible coax

**C** A special type of coaxial feed line is called *hardline* because its shield is made from a semi-flexible solid tube of aluminum or copper. It has the lowest loss of any type of coaxial feed line. [*Ham Radio License Manual*, page 4-9]

**T9B12 What is standing wave ratio (SWR)?**

A. A measure of how well a load is matched to a transmission line
B. The ratio of amplifier power output to input
C. The transmitter efficiency ratio
D. An indication of the quality of your stations ground connection

**A** Because SWR is determined by the amounts of forward and reflected power, SWR in an antenna system is also a measure of how well the antenna (or load) and feed line impedances are matched. [*Ham Radio License Manual*, 4-10]

# Subelement T0
# Safety

**[3 exam questions — 3 groups]**

## T0A — Power circuits and hazards: hazardous voltages, fuses and circuit breakers, grounding, electrical code compliance; Lightning protection; Battery safety

**T0A01 Which of the following is a safety hazard of a 12-volt storage battery?**

A. Touching both terminals with the hands can cause electrical shock
B. Shorting the terminals can cause burns, fire, or an explosion
C. RF emissions from a nearby transmitter can cause the electrolyte to emit poison gas
D. All of these choices are correct

**B** Storage batteries release a lot of energy if shorted, leading to burns, fire, or an explosion. Keep metal objects such as tools and sheet metal clear of battery terminals and avoid working on equipment with the battery connected. [*Ham Radio License Manual*, page 9-2]

**T0A02 What health hazard is presented by electrical current flowing through the body?**

A. It may cause injury by heating tissue
B. It may disrupt the electrical functions of cells
C. It may cause involuntary muscle contractions
D. All of these choices are correct

**D** The severity of the hazard varies with the amount of current as shown in the table on the next page. [*Ham Radio License Manual*, page 9-2]

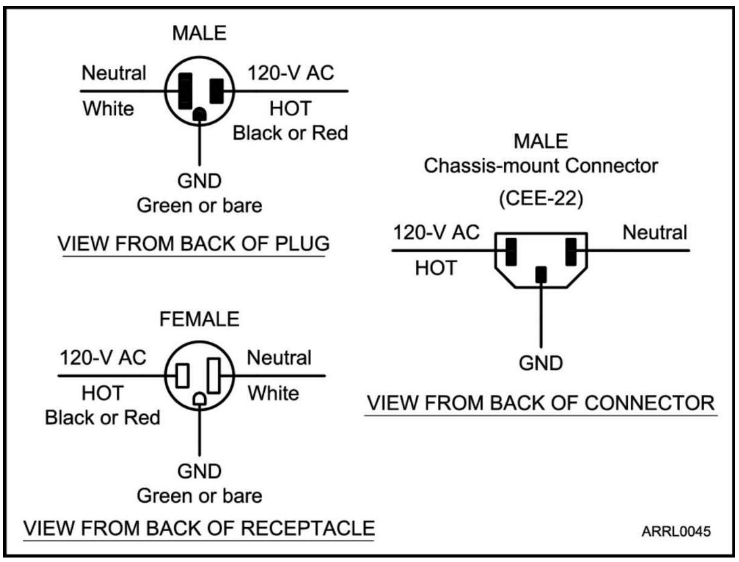
# Effects of Electric Current in the Human Body

| *Current* | *Reaction* |
|---|---|
| Below 1 milliampere | Generally not perceptible |
| 1 milliampere | Faint tingle |
| 5 milliamperes | Slight shock felt; not painful but disturbing. Average individual can let go. Strong involuntary reactions can lead to other injuries. |
| 6-25 milliamperes (women) | Painful shock, loss of muscular control; the freezing current or “can’t let-go” range. |
| 9-30 milliamperes (men) | |
| 50-150 milliamperes | Extreme pain, respiratory arrest, severe muscular contractions. Death is possible. |
| 1000-4300 milliamperes | Rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur; death likely. |
| 10,000 milliamperes | Cardiac arrest, severe burns; death probable. |

**T0A03 In the United States, what circuit does black wire insulation indicate in a three-wire 120 V cable?**

A. Neutral
B. Hot
C. Equipment ground
D. Black insulation is never used

**C** The US standard is hot – black wire (occasionally red); neutral – white wire; and safety or equipment ground – green or bare wire. [*Ham Radio License Manual*, page 9-4]




**The correct wiring technique for 120 V ac power cords and receptacles. The white wire is neutral and the green wire is the safety ground. The hot wire can be either black or red. These receptacles are shown from the back, or wiring side.**

**T0A04 What is the purpose of a fuse in an electrical circuit?**

A. To prevent power supply ripple from damaging a component
B. To remove power in case of overload
C. To limit current to prevent shocks
D. All of these choices are correct

**B** When the metal in a fuse melts or “blows,” the current path is broken and power is removed from circuits supplied by the fuse. [*Ham Radio License Manual*, page 3-12]

**T0A05 Why should a 5-ampere fuse never be replaced with a 20-ampere fuse?**

A. The larger fuse would be likely to blow because it is rated for higher current
B. The power supply ripple would greatly increase
C. Excessive current could cause a fire
D. All of these choices are correct

**C** Replacing a blown fuse with one having a higher current rating, even temporarily, could allow the fault to permanently damage the equipment or start a fire. Do not use a device with a higher current rating, even temporarily. [*Ham Radio License Manual*, page 3-12]

**T0A06 What is a good way to guard against electrical shock at your station?**

A. Use three-wire cords and plugs for all AC powered equipment
B. Connect all AC powered station equipment to a common safety ground
C. Install mechanical interlocks in high-voltage circuits
D. All of these choices are correct

**D** Follow these simple rules in your station:

• Use three-wire power cords and plugs for all ac-powered equipment.

• Make sure all of your equipment has a connection to the ac safety ground.

• Use *ground fault circuit interrupter (GFCI)* circuit breakers or circuit breaker outlets.

• Verify ac wiring is done properly by using an ac circuit tester.

• Never replace a fuse or circuit breaker with one of a larger size.

• Don't overload single outlets.

[*Ham Radio License Manual*, page 9-4]

**T0A07 Where should a lightning arrester be installed in a coaxial feed line?**

A. At the output connector of a transceiver
B. At the antenna feed point
C. At the ac power service panel
D. On a grounded panel near where feed lines enter the building

**D** See question T0B10. [*Ham Radio License Manual*, page 9-5]

**T0A08 Where should a fuse or circuit breaker be installed in a 120V AC power circuit?**

A. In series with the hot conductor only
B. In series with the hot and neutral conductors
C. In parallel with the hot conductor only
D. In parallel with the hot and neutral conductors

**A** Fuses or circuit breakers must be installed in series with the hot conductor or conductors so that if activated or *tripped*, power is removed from the protected equipment. [*Ham Radio License Manual*, page 9-4]

**T0A09 What should be done to all external ground rods or earth connections?**

A. Waterproof them with silicone caulk or electrical tape
B. Keep them as far apart as possible
C. Bond them together with heavy wire or conductive strap
D. Tune them for resonance on the lowest frequency of operation

**C** See question T0B10. [*Ham Radio License Manual*, page 9-5]

**T0A10 What hazard is caused by charging or discharging a battery too quickly?**

A. Overheating or out-gassing
B. Excess output ripple
C. Half-wave rectification
D. Inverse memory effect

**A** Storage batteries hold a lot of energy and must be treated with respect. They contain strong acids that can be hazardous if spilled or allowed to leak. Storage batteries can also release or vent flammable hydrogen gas, and that can cause an explosion. [*Ham Radio License Manual*, page 5-17]

**T0A11 What hazard exists in a power supply immediately after turning it off?**

A. Circulating currents in the dc filter
B. Leakage flux in the power transformer
C. Voltage transients from kickback diodes
D. Charge stored in filter capacitors

**D** Capacitors in a power supply can store charge after a charging circuit is turned off, presenting a hazardous voltage for a long time. This includes small-value capacitors charged to a high voltage. Make sure capacitors are discharged by testing them with a meter or use a *grounding stick* to shunt their charge to ground. [*Ham Radio License Manual*, page 9-2]

**T0A12 Which of the following precautions should be taken when measuring high voltages with a voltmeter?**

A. Ensure that the voltmeter has very low impedance
B. Ensure that the voltmeter and leads are rated for use at the voltages to be measured
C. Ensure that the circuit is grounded through the voltmeter
D. Ensure that the voltmeter is set to the correct frequency

**D** Ensure that the voltmeter and leads are rated for use at the voltages to be measured. [*Ham Radio License Manual*, page 3-4]

**T0B — Antenna safety: tower safety and grounding, installing antennas, antenna supports**

**T0B01 Which of the following is good practice when installing ground wires on a tower for lightning protection?**

A. Put a drip loop in the ground connection to prevent water damage to the ground system
B. Make sure all ground wire bends are right angles
C. Ensure that connections are short and direct
D. All these choices are correct

**C** Ground connections should be as short and direct as possible — avoid sharp bends. [*Ham Radio License Manual*, page 9-5]

**T0B02 What is required when climbing an antenna tower?**

A. Have sufficient training on safe tower climbing techniques
B. Use appropriate tie-off to the tower at all times
C. Always wear an approved climbing harness
D. All these choices are correct

**D** Starting with personal preparation, both climbers and ground crew should wear appropriate protective gear any time work is under way on the tower. Each member of the crew should wear a hard hat, goggles or safety glasses and heavy duty gloves suitable for working with ropes. If you are the climber be sure to get sufficient training on safe tower climbing techniques before beginning, use appropriate tie-off to the tower at all times, and always wear an approved climbing harness. Don’t use a leather “lineman’s belt” as they are unsafe and no longer approved for tower work. Many climbers prefer footwear with a steel shank that supports the foot while standing on a narrow rung. [*Ham Radio License Manual*, page 9-19]

**T0B03 Under what circumstances is it safe to climb a tower without a helper or observer?**

A. When no electrical work is being performed
B. When no mechanical work is being performed
C. When the work being done is not more than 20 feet above the ground
D. Never

**D** Having a ground crew is important; avoid climbing alone whenever possible because it’s never safe. [*Ham Radio License Manual*, page 9-19]

**T0B04 Which of the following is an important safety precaution to observe when putting up an antenna tower?**

A. Wear a ground strap connected to your wrist at all times
B. Insulate the base of the tower to avoid lightning strikes
C. Look for and stay clear of any overhead electrical wires
D. All of these choices are correct

**C** Power lines are the enemy of antenna installers. Place all antennas and feed lines well clear of power lines, including the utility service drop to your home. Be sure that if the any part of the antenna or support structure falls, it cannot fall onto power lines. A good guideline is to separate the antenna from the nearest power line by 150% of total height of tower or mast plus antenna — a minimum of 10 feet of clearance during a fall is a must. Never attach an antenna or guy wire to a utility pole, since a mechanical failure could result in contact with high-voltage power lines. [*Ham Radio License Manual*, page 9-17]

**T0B05 What is the purpose of a safety wire through a turnbuckle used to tension guy lines?**

A. Secure the guy line if the turnbuckle breaks
B. Prevent loosening of the turnbuckle from vibration
C. Provide a ground path for lightning strikes
D. Provide an ability to measure for proper tensioning

**B** Guy wires must be installed according to the tower manufacturer's instructions. Place a safety wire through any turnbuckles used to tension guy lines. This prevents them from loosening due to vibration and twisting. [*Ham Radio License Manual*, page 9-17]

**T0B06 What is the minimum safe distance from a power line to allow when installing an antenna?**

A. Add the height of the antenna to the height of the power line and multiply by a factor of 1.5

B. The height of the power line above ground

C. 1/2 wavelength at the operating frequency

D. Enough so that if the antenna falls, no part of it can come closer than 10 feet to the power wires

**D** See question T0B04. [*Ham Radio License Manual*, page 9-17]

**T0B07 Which of the following is an important safety rule to remember when using a crank-up tower?**

A. This type of tower must never be painted
B. This type of tower must never be grounded
C. This type of tower must not be climbed unless it is retracted, or mechanical safety locking devices have been installed
D. All of these choices are correct

**C** Crank-up towers must be fully retracted or mechanical safety locking devices must have been installed. Never climb a crank-up tower supported only by the cable that supports the sections. [*Ham Radio License Manual*, page 9-19]

**T0B08 Which is a proper grounding method for a tower?**

A. A single four-foot ground rod, driven into the ground no more than 12 inches from the base
B. A ferrite-core RF choke connected between the tower and ground
C. A connection between the tower base and a cold water pipe
D. Separate eight-foot long ground rods for each tower leg, bonded to the tower and each other

**D** Grounding rules for antennas and supports must be followed according to your local electrical code. Towers should be grounded with separate 8-foot long ground rods for each tower leg, bonded to the tower and each other. [*Ham Radio License Manual*, page 9-17]

**T0B09 Why should you avoid attaching an antenna to a utility pole?**

A. The antenna will not work properly because of induced voltages
B. The 60 Hz radiations from the feed line may increase the SWR
C. The antenna could contact high-voltage power lines
D. All of these choices are correct

**C** See question T0B04. [*Ham Radio License Manual*, page 9-17]

**T0B10 Which of the following is true when installing grounding conductors used for lightning protection?**

A. Use only non-insulated wire
B. Wires must be carefully routed with precise right-angle bends
C. Sharp bends must be avoided
D. Common grounds must be avoided

**C** Starting at your antennas, all towers, masts, and antenna mounts should be grounded according to your local building and electrical codes. These connections are made at the tower base, or in the case of roof mounts, though a large-diameter wire to a ground rod. Ground connections should be as short and direct as possible — avoid sharp bends. Where cables and feed lines enter the house, use lightning arrestors grounded to a common plate that is in turn connected to a nearby external ground such as a ground rod. All ground rods and earth connections must be bonded together with heavy wire, as well. [*Ham Radio License Manual*, page 9-5]

**T0B11 Which of the following establishes grounding requirements for an amateur radio tower or antenna?**

A. FCC Part 97 Rules
B. Local electrical codes
C. FAA tower lighting regulations
D. UL recommended practices

**B** See question T0B10. [*Ham Radio License Manual*, page 9-5]

## T0C — RF hazards: radiation exposure, proximity to antennas, recognized safe power levels, radiation types, duty cycle

**T0C01 What type of radiation are radio signals?**

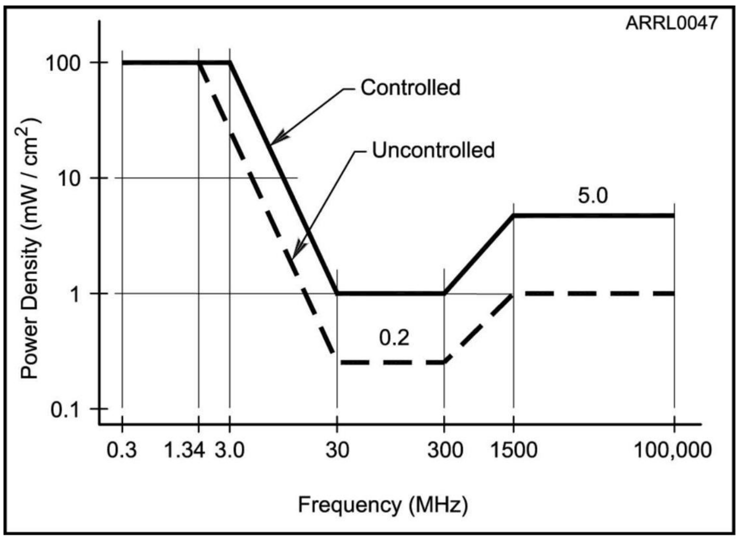
A. Gamma radiation
B. Ionizing radiation
C. Alpha radiation
D. Non-ionizing radiation

**D** RF radiation is not the same as *ionizing radiation* from radioactivity because the energy in signals at radio frequencies is far too low to cause an electron to leave an atom (ionize) and therefore cannot cause genetic damage. With its relatively low frequency, RF energy is *non-ionizing radiation*. [*Ham Radio License Manual*, page 9-11]

**T0C02 At which of the following frequencies does maximum permissible exposure have the lowest value?**

A. 3.5 MHz
B. 50 MHz
C. 440 MHz
D. 1296 MHz

**B** Using the following graph to compare MPE for amateur bands at 3.5, 50, 440, and 1296 MHz, you can see that MPE is lowest at 50 MHz and highest at 3.5 MHz. [*Ham Radio License Manual*, page 9-12]




**Maximum Permissible Exposure (MPE) limits vary with frequency because the body responds differently to energy at different frequencies. The controlled and uncontrolled limits refer to the environment in which people are exposed to the RF energy.**

# Maximum Permissible Exposure (MPE) Limits

# Controlled Exposure (6-Minute Average)

| *Frequency Range (MHz)* | *Power Density (mW/cm$^2$)* |
|---|---|
| 0.3 – 3.0 | (100)* |
| 3.0 – 30 | (900/f$^2$)* |
| 30 – 300 | 1.0 |

| *Frequency Range (MHz)* | *Power Density (mW/cm²)* |
|---|---|
| 300 – 1500 | f/300 |
| 1500 – 100,000 | 5 |

## Uncontrolled Exposure (30-Minute Average)

| *Frequency Range (MHz)* | *Magnetic Field Power Density (mW/cm²)* |
|---|---|
| 0.3 – 1.34 | (100)* |
| 1.34 – 30 | $(180/f^2)$* |
| 30 – 300 | 0.2 |
| 300 – 1500 | f/1500 |
| 1500 – 100,000 | 1.0 |

f = frequency in MHz
* = Plane-wave equivalent power density

**T0C03 How does the allowable power density for RF safety change if duty cycle changes from 100 percent to 50 percent?**

A. It increases by a factor of 3
B. It decreases by 50 percent
C. It increases by a factor of 2
D. There is no adjustment allowed for lower duty cycle

**C** The lower the duty cycle (less transmitting), the higher the transmitter output can be and still have an average value within the exposure limits. For example, what is the result if a transmitted signal in a controlled environment is present for 3 minutes and then absent for the remaining 3 minutes of the averaging period? Because the signal is only present for ½ of the time (50% duty cycle), the signal power can be twice as high and still have the same average power as it would if transmitted continuously with a duty cycle of 100%. [*Ham Radio License Manual*, page 9-13]

# Power Thresholds for RF Exposure Evaluation

| *Band* | *Power (W)* |
|---|---|
| 160 meters | 500 |
| 80 | 500 |
| 40 | 500 |
| 30 | 425 |
| 20 | 225 |
| 17 | 125 |
| 15 | 100 |
| 12 | 75 |
| 10 | 50 |

| *Band* | *Power (W)* |
|---|---|
| 6 | 50 |
| 2 | 50 |
| 1.25 | 50 |
| 70 cm | 70 |
| 33 | 150 |

| *Band* | *Power (W)* |
| --- | --- |
| 23 | 200 |
| 13 | 250 |
| SHF (all bands) | 250 |
| EHF (all bands) | 250 |

**T0C04 What factors affect the RF exposure of people near an amateur station antenna?**

A. Frequency and power level of the RF field
B. Distance from the antenna to a person
C. Radiation pattern of the antenna
D. All of these choices are correct

**D** When performing an RF exposure evaluation, you'll need information on the RF signal's frequency and power level, distance from the antenna, and the antenna's radiation pattern. Once you've done an evaluation, you don't need to re-evaluate unless you change equipment in your station that affects average output power, such as increasing transmitter power or antenna gain. You'll also need to re-evaluate if you add a new frequency band. [*Ham Radio License Manual*, page 9-14]

**T0C05 Why do exposure limits vary with frequency?**

A. Lower frequency RF fields have more energy than higher frequency fields
B. Lower frequency RF fields do not penetrate the human body
C. Higher frequency RF fields are transient in nature
D. The human body absorbs more RF energy at some frequencies than at others

**D** Heating as a result of exposure to RF fields is caused by the body absorbing RF energy. Absorption varies with frequency because the body absorbs more RF energy at some frequencies than others. [*Ham Radio License Manual*, page 9-11]

**T0C06 Which of the following is an acceptable method to determine that your station complies with FCC RF exposure regulations?**

A. By calculation based on FCC OET Bulletin 65
B. By calculation based on computer modeling
C. By measurement of field strength using calibrated equipment
D. All of these choices are correct

**D** By far the most common evaluation uses the techniques outlined in the FCC's OET Bulletin 65 (OET stands for *Office of Engineering Technology*). This method uses tables and simple formulas to evaluate whether your station has the potential of causing an exposure hazard. You could also obtain RF power density instrumentation and actually measure the power density of your transmissions. It is also acceptable to make computer models of your station and use those results. Both of these methods are rarely used due to the expense or effort required. [*Ham Radio License Manual*, page 9-14]

**T0C07 What hazard is created by touching an antenna during a transmission?**

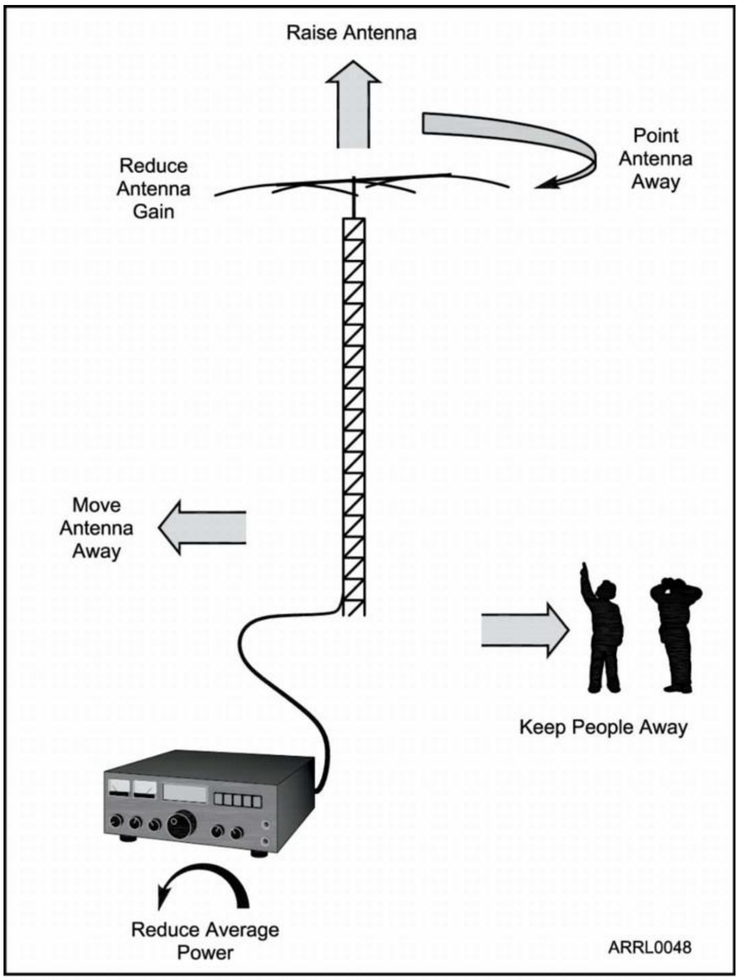
A. Electrocution
B. RF burn to skin
C. Radiation poisoning
D. All of these choices are correct

**B** RF burns caused by touching or coming close to conducting surfaces with a high RF voltage present are also an effect of heating. While these are sometimes painful, they are rarely hazardous. RF burns can be eliminated by proper bonding techniques or by preventing access to an antenna. [*Ham Radio License Manual*, page 9-11]

**T0C08 Which of the following actions can reduce exposure to RF radiation?**

A. Relocate antennas
B. Relocate the transmitter
C. Increase the duty cycle
D. All of these choices are correct

**A** Locate antennas away from where people can get close to them and away from property lines. [*Ham Radio License Manual*, page 9-14]




**There are many ways to reduce RF exposure to nearby people. Whatever lowers the power density in areas where people are will work. Raising the antenna will even benefit your signal strength to other stations as it lowers power density on the ground!**

**T0C09 How can you make sure your station stays in compliance with RF safety regulations?**

A. By informing the FCC of any changes made in your station

B. By re-evaluating the station whenever an item of equipment is changed

C. By making sure your antennas have low SWR

D. All of these choices are correct

**B** See question T0C04. [*Ham Radio License Manual*, page 9-14]

**T0C10 Why is duty cycle one of the factors used to determine safe RF radiation exposure levels?**

A. It affects the average exposure to radiation
B. It affects the peak exposure to radiation
C. It takes into account the antenna feed line loss
D. It takes into account the thermal effects of the final amplifier

**A** Duty cycle is the ratio of the transmitted signal's on-the-air time to the total operating time during the measurement period and has a maximum of 100%. Stated simply, duty cycle is the percentage of time a transmitter is transmitting. Since duty cycle affects the average power level of transmissions, it must be considered when evaluating exposure. [*Ham Radio License Manual*, page 9-13]

**T0C11 What is the definition of duty cycle during the averaging time for RF exposure?**

A. The difference between the lowest power output and the highest power output of a transmitter

B. The difference between the PEP and average power output of a transmitter

C. The percentage of time that a transmitter is transmitting

D. The percentage of time that a transmitter is not transmitting

**C** See question T0C10. [*Ham Radio License Manual*, page 9-13]

**T0C12 How does RF radiation differ from ionizing radiation (radioactivity)?**

A. RF radiation does not have sufficient energy to cause checmical changes in cells and damage DNA
B. RF radiation can only be detected with an RF dosimeter
C. RF radiation is limited in range to a few feet
D. RF radiation is perfectly safe

**A** See question T0C01. [*Ham Radio License Manual*, page 9-11]

**T0C13 Who is responsible for ensuring that no person is exposed to RF energy above the FCC exposure limits?**

A. The FCC
B. The station licensee
C. Anyone who is near an antenna
D. The local zoning board

**B** To abide by these rules without requiring expensive testing, hams are expected to evaluate their stations to see if their operation has the potential to exceed MPE levels. The rules make the station licensee responsible for ensuring that no one is exposed to RF energy above the FCC exposure limits. [*Ham Radio License Manual*, page 9-11]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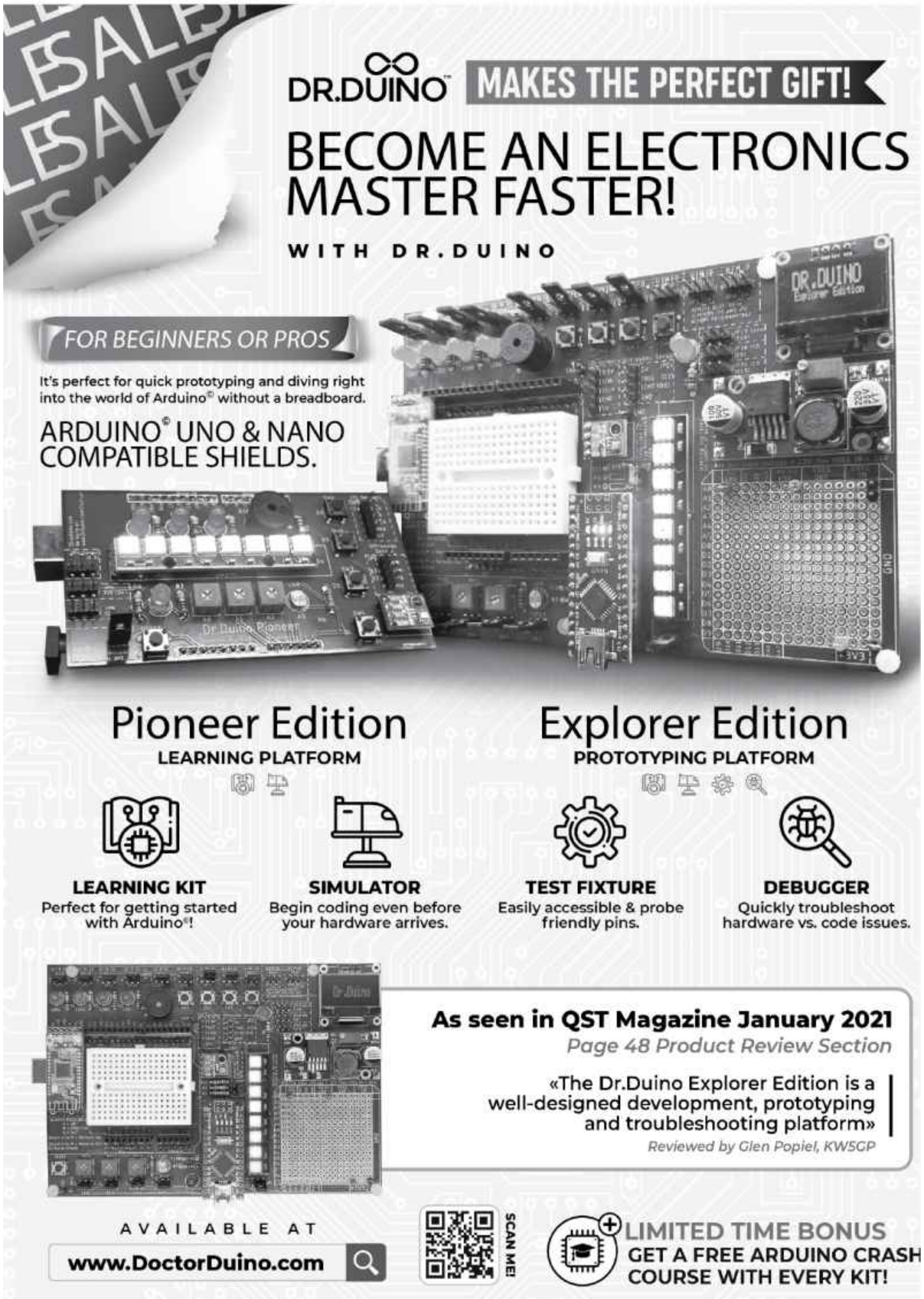
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