

Amateur Radio Technician Exam Self-Paced Study Guide

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Developed By

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For

[WCARS-Murphy](#) & [W4VEC](#)

For use with Technician Class exams taken between July 1, 2022 and June 30, 2026

Primary Reference: Code of Federal Regulations Part 97 -- AMATEUR RADIO SERVICE

<https://www.ecfr.gov/current/title-47/chapter-1/subchapter-D/part-97>

READ ME FIRST ... You have received a fully-functional copy the Technician Exam Self-Paced Study Guide. The entire exam has 10 sub-elements or sections of questions. This version of the study guide contains all 10 sections, plus all ancillary materials (instructions, useful websites, test taking tips, etc.).

This study guide is specifically designed to be used on a computer. If you choose to print it out, be aware that this version exceed 180 pages. And, it's not very user-friendly in print ... you've been warned!

Please notify me of ANYTHING you find incorrect, misleading, confusing, and (most importantly) suggestions for improvement. Be sure to reference the version date located on the title page.

Contact me at: KOILP.NC@gmail.com (the 0 is a zero)

So, good luck! Scroll forward to the next page to begin!

LINKS TO VARIOUS SECTIONS

Click [blue underlined font](#) to navigate to that section

Click [LINKS](#) to return to this page

- A. [Overview & Instructions](#) (READ ME FIRST)
- B. [Reading Materials \(and links to questions\)](#) (this is the link to begin studying)
- C. [Useful Websites for Hams](#)
- D. [Test-Taking Tips](#)
- E. Scroll Through Questions & Answers (do this AFTER Section B; it's a good idea to go through these 2-3 times the week prior to the exam)
[Show Only The Correct Answer](#) (my recommendation is to look ONLY at the correct answer)
[Show All Answer Choices](#)
- F. [Where Do I Go From Here?](#)

Technician Exam Self-Paced Study Guide

Overview & Instructions

[LINKS](#)

The purpose of this guide is to prepare test candidates for the Technician Class (Element 2) Amateur Radio Licensing Examination. Each question in the Technician Question Pool is explained within this guide. The Technician Exam consists of 35 questions, randomly selected from a pool of approximately 400 questions. A passing score is 74% (26 of 35 correct). When you pass the exam, you will be allowed to take the General Exam on the same day at no additional charge. Similarly, if you pass the General Exam, you may take the Extra Exam. For this reason, we include links to the General and Extra Question Pools (see **Useful Websites** from the [LINKS](#) page).

How to use the guide ... NOTE: *Blue underlined font indicates links ... click the link to navigate to that point.*

1. Read through the material (start at the Table of Contents ... [TOC](#)). As you read, you will see an exam question (maybe even two or three) at the beginning of each paragraph in *italicized green font*.
2. The response is explained in that paragraph. Key information for the answer is underlined. You may also see internet links to reference materials in the paragraph. It's not necessary to read these references to pass the exam – they're there for future reference. After you pass the exam, you will want to come back to these.
3. At or near the end of the paragraph, you'll see question numbers in brackets, followed by a 2-letter abbreviation. It will look like this ... [\[T1A01 – CO\]](#)
4. T1A01 is the question number. The letters (CO or AA) indicate how the question is presented:
 - CO means that you will only see the correct answer (short for *Correct Only*). If the correct answer is **All the Above**, then all responses will be listed, even on *Correct Only* formatted questions.
 - AA means that you will see *All Answers*. The correct answer is **highlighted**.
5. Click your choice of question format (CO or AA) and the program will display the question. The selected question will appear at the TOP of the page.
6. At the end of each question, you will see the word **BACK**. Click this and the program will return to the beginning of the paragraph containing the question you just came from.
7. Click the [TOC](#) symbol to return to the first page of the **Reading Materials and Links to Questions**.
8. Click [LINKS](#) to return to the **Links to Various Sections** page (this is the main menu screen).

Throughout the document, you'll see references to 47 CFR Part 97 (*Federal Communications Commission, Title 47, Amateur Radio Service*). You will specifically see references marked as ... **§97.xxx**. The internet link is:

<https://www.ecfr.gov/current/title-47/chapter-I/subchapter-D/part-97>

Once you're through the material, you'll want to find an exam location. There are links to help you (**Useful Websites**). Alternatively, search the internet for a local amateur radio (ham radio) club, and they'll point you in the right direction. If all else fails, send me an email. There will usually be a nominal fee for testing (\$12 to \$20 ... some are free), and the FCC will charge you \$35 for issuing a call sign (renewable every 10 years).

One final note ... You're probably aware that you must be connected to the Internet for external links (websites) to work. However, all the internal links (between questions) will work without the Internet.

If you have questions or comments, feel free to contact me at: Jerry D. Kilpatrick, KOILP.NC@gmail.com

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

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- 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

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LINKS

| Site Name | URL |
|-------------------------------|--|
| Amateur Radio Frequencies | https://en.wikipedia.org/wiki/Amateur_radio_frequency_allocations |
| Amateur Radio Rules (Part 97) | www.ecfr.gov/current/title-47/chapter-I/subchapter-D/part-97 |
| Antennas 101 | https://w4bfb.org/wordpress/wp-content/uploads/presentations/antennas_101.pdf |
| ARES | www.arrrl.org/ares |
| ARRL | www.arrrl.org |
| Band Plan, Chart | www.arrrl.org/files/file/Regulatory/Band%20Chart/Band%20Chart%208_5%20X%2011%20Color.pdf |
| Band Plan, Text | www.arrrl.org/band-plan |
| Call Sign Lookup | https://wireless2.fcc.gov/UlsApp/UlsSearch/searchLicense.jsp |
| DMR For Dummies | www.dmrfordummies.com |
| EchoLink | www.echolink.org |
| Exam Locations | www.arrrl.org/find-an-amateur-radio-license-exam-session |
| Extra Exam Question Pool | www.ncvec.org/page.php?id=356 |
| FCC Obtain FRN# | https://apps2.fcc.gov/fccUserReg/pages/createAccount.htm |
| General Exam Question Pool | www.ncvec.org/page.php?id=364 |
| Ham Radio for Non-Techies | https://hamradiofornontechies.com/ham-radio-tips/ |
| Ham Radio Glossary (by KNØJI) | https://noji.com/hamradio/glossary.php |
| Ham Radio School | www.hamradioschool.com |
| HAMSTUDY | www.hamstudy.org |
| Learn Morse Code (CW) | https://lcwo.net |
| Practice Exams | https://hamradioprep.com/free-ham-radio-practice-tests |
| Q Codes | www.giangrandi.org/electronics/radio/qcode.shtml |
| RACES | www.usraces.org |
| Radio Propagation | www.electronics-notes.com/articles/antennas-propagation/propagation-overview/basics.php |
| Radio Waves | https://en.wikipedia.org/wiki/Radio_wave |
| Repeater Book | www.repeaterbook.com |
| Tech Exam Question Pool | www.ncvec.org/page.php?id=373 |
| W4VEC Testing | www.w4vec.org |
| WCARS-Murphy Radio Club | www.wcars-murphy.org |
| What Is Ham Radio? | https://radiofidelity.com/what-is-ham-radio-ham-radio-for-beginners/ |
| | |

1. First, you'll hear all sorts of strategies for taking multiple choice tests, specifically, the amateur radio exams. My advice is to **ignore them**. I'll share a few with you and explain why they're flawed.
 - a. *If you're not sure of the right answer, choose the longest response.* I calculated statistics for this suggestion, after a long discussion with someone who sticks by it. There is NO BENEFIT to using this.
 - b. *If you're not sure of the right answer, always GUESS the same letter.* I calculated stats on this, as well. The question pool has an equal number of A, B, C, and D responses, meaning there is no benefit, but no detriment to using this.
 - c. *If one of the responses is "All these choices are correct," select it.* Again, I've calculated stats. This suggestion is a BIG mistake ... it provides the **wrong** answer more than correct ones.
2. The exams are not designed to be difficult. They are designed to test your basic knowledge of radio. There are NO trick questions, so don't over-think it.
3. The test is multiple choice. Determine the correct answer **before** reading the answer choices. Don't even look at the answer choices until after you've read the entire question. Then, read the answer choices carefully. Not all answers are a perfect fit ... sometimes you'll need to settle for the best option.
4. Regarding Tips 2 and 3, you WILL run into a set of answer choices where there is no EXACT match with the correct answer. A good example is a math question. You might work out a math problem and come up with an answer of 3.1415. But, there is no answer matching this. However, there is an answer choice of 3, and nothing else is close to what you calculated. The point is to find the BEST answer from the choices provided.
5. Go through the exam the first time answering ONLY those questions of which you're absolutely certain. Reason: Some questions will be near duplicates. In other words, it's possible that one question may provide a tip (or even a direct answer) for a previous question. If you guess early on, you may overlook this opportunity. Keep a list of those questions you skipped on your scratch paper (you can't write in the test booklet) ... mark these out as you answer them.
6. The second time through the exam, only look at those questions you skipped. Try to eliminate as many incorrect choices as possible before making an educated guess. Do NOT leave questions unanswered. Some exams (like the Scholastic Aptitude Test ... college prep exam) penalize you for guessing. This is not the case on the Amateur Radio exam.
7. Don't stay up all night studying the night before the exam. Get a reasonable amount of sleep. And, eat breakfast!
8. You're not allowed to bring notes, books, etc. to the exam. However, you WILL be given scratch paper. Take advantage of this. Immediately prior to the exam (about an hour or two ahead of time) go over the following diagrams, charts, and tables and commit them to memory. As soon as you get your scratch paper, draw these diagrams on it and refer to them during the exam. You will likely see 5-6 questions from these diagrams on the exam.
 - a. Ohm's Law diagrams (for Voltage and Power, at the beginning of SUBELEMENT T5)
 - b. Chart/tables at questions in section T1B
 - c. Measurements table at T5B
 - d. Measurements table at question T3B08
 - e. Signal Bandwidths table at question T8A05
 - f. Table of Satellite Definitions at T8B
9. Take your time! You will have 2 hours ... more than enough.
10. If you don't pass the first time, you will be allowed to try again. While most VECs charge for this 2nd attempt, a few may allow you to try again at no charge. If you only miss by 1-2 questions, it's worth it to try again, even if you must pay. When you do pass, you will be allowed to take the General Exam at the same time for free. In other words, once you're comfortable with the Technician material, it will benefit you to at least read through the General questions 1-2 times the week prior to exam. There's a link to the General (and Extra) exam questions on the Useful Websites page. Approximately 25% of test candidates pass the Technician & General exams at the same time, and a few pass all three! Trust me ... you will eventually want access to the frequencies allowed by a General Class license! But, even if you haven't studied AT ALL for General, you have absolutely nothing to lose by taking a shot at it!
11. Finally, email me at KOILP.NC@gmail.com and let me know how you did!

Ok, now that you're licensed, what are you going to do next? Don't just be satisfied with upgrading your license or talking on the weekly net. Find your niche. There are literally hundreds of things to do with your new skill. And, don't just have a single focus. If you haven't done so by now, here are some rather simple AND useful things to do that won't break your budget.

- Build your own antenna, from scratch. A good 2m Yagi will come in handy to hit those repeaters just out of range.
- Take a shot at digital communications. Most local clubs have experts willing to help.
- Learn CW (Morse Code). I know it's not required, but ARRL gives certificates for different levels of achievement.
- Try a moon bounce.
- Earn a WAS or Century award.
- Become a VE and actually participate in testing.
- Help teach a radio class. Don't wait to be asked ... volunteer!
- Purchase a kit and build your own HF QRP rig, and make a contact with it.
- Participate (actively) in Field Day. Arrive early to help set up!
- Help out with club community events, such as 22 Hump.

If you're interested in any of these and can't find resources to help, shoot me an email at K0ILP.NC@gmail.com. But, fair warning, I not going to do it for you! Time to get those hands dirty. RF burns aren't permanent!

Thanks, Kevin (KD4UYR), for the inspiration for this page.
Jerry / KØILP

Technician Exam Self-Paced Study Guide

SUBELEMENT T1 — COMMISSION'S RULES

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

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

Per CFR §97.1, the Basis and Purpose of Amateur Radio is:

- 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
- Continuation and extension of the amateur's proven ability to contribute to the advancement of the radio art
- Encouragement and improvement of the amateur service through rules which provide for advancing skills in both the communications and technical phases of the art [\[T1A01 – CO\]](#) [\[T1A01 – AA\]](#)
- Expansion of the existing reservoir within the amateur radio service of trained operators, technicians, and electronics experts
- Expansion of the existing reservoir within the amateur radio service of trained operators, technicians, and electronics experts

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

The amateur service is defined by and operates according to the rules in Part 97 of the FCC's rules. FCC is the abbreviation for Federal Communications Commission. The FCC also grants amateur radio licenses.

[\[T1A02 – CO\]](#) [\[T1A02 – AA\]](#)

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

The FCC requires that you periodically give your call sign when transmitting (discussed later in Operating Regulations). This may be done using voice, Morse Code, or image. When using voice, the FCC recommends this be done phonetically (see table below) to avoid confusion by letters that sound alike. [\[T1A03 – CO\]](#) [\[T1A03 – AA\]](#)

Amateur Radio Phonetic Alphabet

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

Your phonetic call sign would sound like this: [KØILP] ... *Kilo – Zero – India – Lima – Papa*

Even if you're communicating in voice, you may give your call sign in Morse Code: -.- - - - - . . . -.- - - - .

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

Per §97.5(b)(1) only one operator/primary station license grant may be held by any one person. The primary station license is granted together with the amateur operator license. [\[T1A04 – CO\]](#) [\[T1A04 – AA\]](#)

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

Evidence that you have an amateur radio license is that your name appears in the FCC ULS consolidated license database.

This is required before the station may transmit on any amateur service frequency defined in §97.5(a). [\[T1A05 – CO\]](#)

[\[T1A05 – AA\]](#) You may look up your call sign at: <https://wireless2.fcc.gov/ULsApp/ULsSearch/searchLicense.jsp>

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

Amateur radio operators are restricted by FCC regulations to operate on specific frequencies or bands. There are additional restrictions by mode or emission type. And, there are other types of stations, each with their own restrictions. One example is a beacon station. Beacons are used for conducting various amateur radio transmission experiments for observing propagation (how radio waves travel from one point to another). [\[T1A06 – CO\]](#) [\[T1A06 – AA\]](#)

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

Another type of station is a space station. A holder of any class operator license may be the control operator of a space station. The official definition of a space station is ... “A station located on an object which is beyond, is intended to go beyond, or has been beyond, the major portion of the Earth’s atmosphere.” However, for testing purposes, the definition is slightly different ... “An amateur station located more than 50 km above Earth’s surface.” [\[T1A07 – CO\]](#) [\[T1A07 – AA\]](#)

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

T1A09: Who selects a Frequency Coordinator?

Another type of station is a repeater. A repeater receives transmissions on one frequency and retransmits it (usually at much higher power) on another frequency. This allows radio operators much greater range than they would have from just using their radio. As a result of this, the repeater ties up two frequencies. As you might imagine, this poses the potential for conflict/interference. Therefore, ham radio operators developed a system of cooperation/coordination by creating a committee of volunteers known as frequency coordinators who recommend transmit and receive frequencies. [\[T1A08 – CO\]](#) [\[T1A08 – AA\]](#) These frequency coordinators are recognized and selected in a local or regional area by amateur operators whose stations are eligible to be auxiliary or repeater stations. [\[T1A09 – CO\]](#) [\[T1A09 – AA\]](#)

T1A10: What is the Radio Amateur Civil Emergency Service (RACES)?

Amateur radio provides an important public service. The federal government recognized this, and RACES was created as a special part of the FCC Part 97 Amateur service to provide civil defense communications to local, state, or federal government emergency management agencies. RACES stands for *Radio Amateur Civil Emergency Service*. From www.usraces.org, RACES volunteer operators are:

- Licensed Radio Amateurs
- Certified by a civil defense agency
- Able to communicate on Amateur Radio frequencies during drills, exercises, and emergencies
- Activated by local, county and state jurisdictions and are the only Amateur Radio operators authorized to transmit during declared emergencies when the President of the United States specifically invokes the War Powers Act.

[\[T1A10 – CO\]](#) [\[T1A10 – AA\]](#)

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

The FCC requires that each amateur station be operated following good engineering and good amateur practice. The General Standards are:

- a. In all respects not specifically covered by FCC Rules each amateur station must be operated in accordance with good engineering and good amateur practice.
- b. Each station licensee and each control operator must cooperate in selecting transmitting channels and in making the most effective use of the amateur service frequencies. No frequency will be assigned for the exclusive use of any station.
- c. At all times and on all frequencies, each control operator must give priority to stations providing emergency communications, except to stations transmitting communications for training drills and tests in RACES.
- d. No amateur operator shall willfully or maliciously interfere with or cause interference to any radio communication or signal. [\[T1A11 – CO\]](#) [\[T1A11 – AA\]](#)

TOC

[NEXT SECTION](#)

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

Amateur Radio is about communications. And, frequency allocations is our most important privilege. The Communications Act of 1934 combined federal regulation of telephone, telegraph, and radio communications, and created the Federal Communications Commission (FCC). To understand frequencies, let's talk about modes of communications. Morse code (or CW or Continuous Wave) is the original *digital* mode. Analog voice modes (which include SSB or single-side band, AM or amplitude modulation, FM or frequency modulation, PM or phase modulation) all came along after CW. Then came digital voice modes (D-Star, DMR, System Fusion, etc.). And, there are even more (RTTY, image modes, PSK, etc.). We'll discuss these later. What's important to know is that the various bands and frequencies allocated to amateur operators also have mode restrictions. The Amateur Radio Band Plan

| Band (Wavelength) | Frequency (MHz) | Mode |
|-------------------|-----------------|----------------|
| 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, data |
| 10 meters | 28.300 – 28.500 | CW, SSB |

(www.arrl.org/band-plan) tells you what frequencies may be used by which class of operator and what modes are available to you. The accompanying table shows what HF frequencies are available for Technician class operators. Remember that

phone, voice, and SSB are equivalent terms, so look for SSB in the accompanying table. Keep in mind there are more Technician privileges than just this table ... refer to the aforementioned Band Plan. [\[T1B01 – CO\]](#) [\[T1B01 – AA\]](#)

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

Many US astronauts hold Amateur Radio licenses. And, a ham radio station is on board the International Space Station (ISS). Astronauts will periodically take breaks from their normal duties and use the station on the VHF 2-meter and 70-cm bands. Any amateur licensed for these bands (which includes Technician class operators) may make contact with the ISS. Their call sign is NA1SS. Set your radio to receive at 145.800 MHz and transmit at 145.990 MHz. [\[T1B02 – CO\]](#) [\[T1B02 – AA\]](#)

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

Authorized frequency bands for amateurs are detailed in §97.301. The most popular bands & frequencies used by US (ITU Region 2) Technician class operators are listed in the accompanying table (look for 6 meters).

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

[\[T1B03 – CO\]](#) [\[T1B03 – AA\]](#)

T1B04: Which amateur band includes 146.52 MHz?

You can find a list of all amateur radio frequency allocations at:

https://en.wikipedia.org/wiki/Amateur_radio_frequency_allocations

A screenshot of the very-high frequency bands (above 30 MHz) is below.

You'll find 146.52 in the 2 meter band.

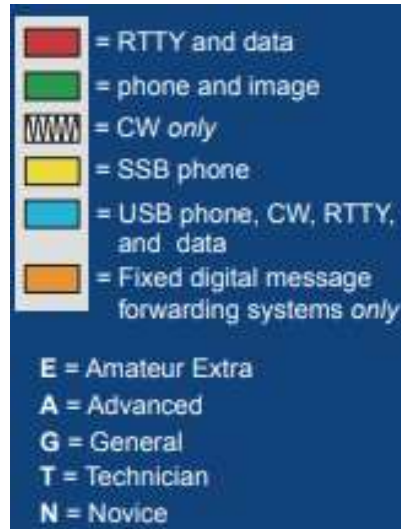
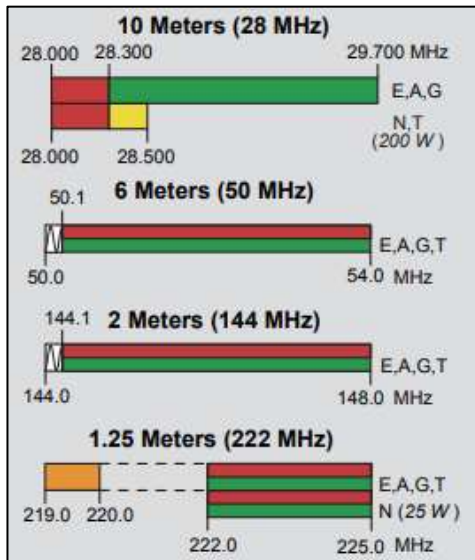
| | | |
|-------------|-------------|-------------|
| 6 metres | 50–54 MHz | |
| 4 metres | 70–70.5 MHz | |
| 2 metres | 144–148 MHz | |
| 1.25 metres | 219–220 MHz | Canada only |
| | 222–225 MHz | US & Canada |

[\[T1B04 – CO\]](#) [\[T1B04 – AA\]](#)

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

We've already mentioned communications or emissions modes. If you refer to the band plan (www.arrl.org/band-plan), you'll note that Technician privileges are somewhat limited. For clarity, we're going to introduce you to the graphic version of the band plan: www.arrl.org/files/file/Regulatory/Band%20Chart/Band%20Chart%208%205%20X%202011%20Color.pdf

While you have this chart open, you should save it to your computer ... you'll refer to it often. Following are some partial screen shots of this graphic band plan. Below (next page) are instructions for interpreting it.



Let's look at the 2 meter (144 MHz) band in the above figure. The red bar from 144.1 to 148.0 means that you can transmit RTTY and data in this frequency range (find the red block in the blue legend). You'll also see the letters E, A, G, and T in the 2 meter band, meaning this is available to Extra, Advanced, General, and Technician class operators. Now, let's answer question T1B05 by reading the 1.25 meter band. Frequency range 219 to 220 is colored orange, meaning that you can use it for fixed digital message forwarding systems only. And, we see the letters E, A, G, and T to the right of this, meaning these four classes of operators may use it. As a follow up (not a test question), how could a Novice use 1.25 meters? The answer is phone/image (green bar) from 222 to 225 MHz, limited to 25 watts (25 W in parentheses). [\[T1B05 – CO\]](#) [\[T1B05 – AA\]](#)

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

To answer this question, we'll refer to the graphic band plan. If you look at the screen shot from the previous question (T1B05), you'll see a yellow block for Technician class operators from 28.3 to 28.5 MHz in the 10 meter band. The legend table tells you this is for SSB phone. [\[T1B06 – CO\]](#) [\[T1B06 – AA\]](#)

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

Let's refer again to the graphic band plan screen shot in T1B05 above. Look for the CW symbol. You'll find it in the 6 and 2 meter bands. The segments of the band are:

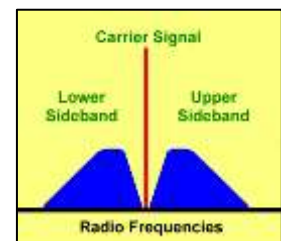
6 meters – 50.0 to 50.1 MHz / 2 meters – 144.0 to 144.1 MHz [\[T1B07 – CO\]](#) [\[T1B07 – AA\]](#)

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

Frequencies in the Amateur Radio Band Plan are *allocated* to amateur radio operators. Many of these are exclusively allocated, while some of these are allocated to different services of the same category. When there is more than one service allocated to use the same frequency range, one is given *primary* allocation and one is given *secondary* allocation. Primary allocations are protected from harmful interference by secondary service users. In other words, secondary service users must avoid interfering with primary service users in those band segments. [\[T1B08 – CO\]](#) [\[T1B08 – AA\]](#)

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

There are several reasons for this. As with all measuring equipment, we must contend with calibration and measurement error. Similarly, transmitter frequencies can drift. You might set your transmitter at one frequency, and over time it might drift a little. AM signals consist of three signals working in concert ... the unmodulated carrier signal and two sidebands (see accompanying figure). The lower sideband is lower in frequency than the carrier, and the upper sideband is higher in frequency. In this example, if you set your transmit frequency at 800 kHz and you were transmitting on the lower sideband, you would actually be transmitting BELOW



800 kHz. If your frequency privilege limit was no less than 800 kHz, you would be operating outside your limit. [\[T1B09 – CO\]](#)
[\[T1B09 – AA\]](#)

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

This is a 4-step question. First, find the band for 50 MHz. You can find this in the graphic band plan screen shot in question T1B05. That's the 6 meter band. Second, find in the legend table in T1B05 the color for PHONE ... it's the dark green AND the light blue (blue is ALL modes). Now, open the entire graphic band chart by clicking the link ...

www.arrl.org/files/file/Regulatory/Band%20Chart/Band%20Chart%208_5%20X%2011%20Color.pdf

Look for the green and light blue bars in each band above 6 m (10, 12, 15, 17, etc.). It's in EVERY band!

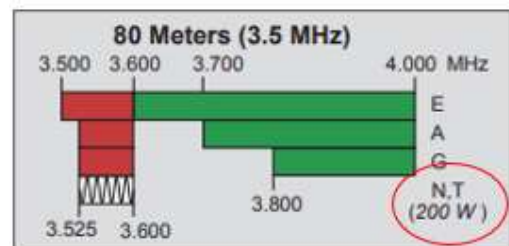
[\[T1B10 – CO\]](#) [\[T1B10 – AA\]](#)

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

The answer to this question is found on the band plan chart, but you need to look carefully. At the top-left corner of the chart is the document title.



Underneath the title is a statement about power limits (*No station may transmit with a transmitter power exceeding 1.5 kW PEP [or 1500 W peak envelope power]*). To determine power limits for Technicians, you'll need to look at each band. At the bottom-right corner of the 80 m band, you'll see a small note (circled in red) regarding Technicians. There is a limit of 200 W in 80 meters for Novice and Technician License Class holders.



You'll also find this in 40, 15, and 10 meters for Novices and Technicians.

[\[T1B11 – CO\]](#) [\[T1B11 – AA\]](#)

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

This is an easy question, once you understand T1B11. The note underneath the title on the band plan chart is very clear ... *No station may transmit with a transmitter power exceeding 1.5 kW PEP*. Converting 1.5 kW to Watts is 1500. With a few specific restrictions amateurs are allowed the full legal limit of 1500 watts PEP output above 28 MHz (10 meters) ... you can see this by reviewing the various bands. [\[T1B12 – CO\]](#) [\[T1B12 – AA\]](#)

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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 **TOC**

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

FCC CFR §97.9(a) specifies the various license classes ... “The classes of amateur operator license grants are: Novice, Technician, General, Advanced, and Amateur Extra. The person named in the operator license grant is authorized to be the control operator of an amateur station with the privileges authorized to the operator class specified on the license grant.” All five of these license classes on the Band Plan. However, NEW licenses are no longer granted for Novice and Advanced. New licenses are only granted for Technician, General, and Extra. [\[T1C01 – CO\]](#) [\[T1C01 – AA\]](#)

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

Per §97.19(a) ... “The person named in an operator/primary station license grant or in a club station license grant is eligible to make application for modification of the license grant, or the renewal thereof, to show a call sign selected by the vanity call sign system.” In other words, every license class operator may select their own vanity call sign. However, the FCC specifies limitations of call sign assignments by license class and region. These limitations can be found at:

www.fcc.gov/wireless/bureau-divisions/mobility-division/amateur-radio-service/amateur-call-sign-systems

One clarification (not on the exam) of this FCC rule regards the assignment of the number portion of the call sign. You will note that specific numbers are assigned to specific geographic areas. However, you may request (and obtain) a vanity call sign with a number outside of where you live. An example is KØILP ... I live in Region 4 (and was originally assigned KK4DEQ), but requested and received the Ø. [\[T1C02 – CO\]](#) [\[T1C02 – AA\]](#)

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

Per §97.117 ... “Transmissions to a different country, where permitted, shall be limited to communications incidental to the purposes of the amateur service and to remarks of a personal character.” There are a small number of countries that do not recognize Amateur Radio. Rules regarding international communications are administered by the International Amateur Radio Union (ITU). [\[T1C03 – CO\]](#) [\[T1C03 – AA\]](#) The entire set of ITU rules can be found at (be aware this is a 50+MB file, if you intend to download it): www.itu.int/pub/R-REG-RR-2020

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

The FCC takes communications seriously. Per §97.23 ... “Each license grant must show the grantee's correct name, mailing address, and email address. The email address must be an address where the grantee can receive electronic correspondence. Revocation of the station license or suspension of the operator license may result when correspondence from the FCC is returned as undeliverable because the grantee failed to provide the correct email address.” If you move or even change P.O. boxes, be sure to update your information using the FCC ULS online system. [\[T1C04 – CO\]](#) [\[T1C04 – AA\]](#)

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

This information can be found at the following reference:

www.fcc.gov/wireless/bureau-divisions/mobility-division/amateur-radio-service/amateur-call-sign-systems

The first thing you need to know is this excerpt from the above reference: “Each call sign has a one letter prefix (K, N, W) or a two letter prefix (AA-AL, KA-KZ, NA-NZ, WA-WZ) and a one, two, or three letter suffix separated by a numeral (0-9) indicating the geographic region ...” Since Region 10 uses the numeral 0 (zero or Ø), the only numerals available to Technicians (or any other class operator in the states) are 0-9. The groups listed in this reference are A, B, C, and D. Group A is reserved for Extra Class operators. Group B is for Advanced class. This leaves our choices as Groups C and D. Reading the text above, we know that the prefix in our region can be one or two letters. Group C says it must begin with a K, N, or W. We already know the numeral must be 0-9. And, Group C says it must have a 3-letter suffix. So, acceptable call sign formats for a technician might be KØILP (referred to as a 1X3 format), NC4ARX (2X3 format), or WR8URW (2X3 format). When you look at the responses, you can immediately rule out answers **B** (KA1X) and **C** (W1XX) because neither have a 3-letter suffix. This also rules out **D** (All these choices are correct). So, by elimination, A (KF1XXX) must be the correct response.

[\[T1C05 – CO\]](#) [\[T1C05 – AA\]](#)

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

The answer to this question is a little difficult to find in the federal regulations. It's covered in the section: **§97.5 Station license required**. §97.5(a)(2) states ... "The station apparatus must be under the physical control of a person named in an amateur station license grant on the ULS consolidated license database or a person authorized for alien reciprocal operation by §97.107 of this part, before the station may transmit on any amateur service frequency from any place that is: Within 50 km of the Earth's surface and aboard any vessel or craft that is documented or registered in the United States."

[\[T1C06 – CO\]](#) [\[T1C06 – AA\]](#)

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

This is essentially T1C04 reworded ... The FCC takes communications seriously. Per §97.23 ... "Each license grant must show the grantee's correct name, mailing address, and email address. The email address must be an address where the grantee can receive electronic correspondence. Revocation of the station license or suspension of the operator license may result when correspondence from the FCC is returned as undeliverable because the grantee failed to provide the correct email address."

If you move or even change P.O. boxes, be sure to update your information using the FCC ULS online system. [\[T1C07 – CO\]](#)
[\[T1C07 – AA\]](#)

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

This is found in §97.25 ... "An amateur service license is normally granted for a 10-year term." [\[T1C08 – CO\]](#) [\[T1C08 – AA\]](#)

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

This is found in §97.25(b) ... "A person whose amateur station license grant has expired may apply to the FCC for renewal of the license grant for another term during a 2 year filing grace period. The application must be received at the address specified above prior to the end of the grace period. Unless and until the license grant is renewed, no privileges in this part are conferred." You are supposed to stop transmitting during this grace period. [\[T1C09 – CO\]](#) [\[T1C09 – AA\]](#)

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

Each VEC (that is, amateur radio testing organization) has their own internal requirements for submission of results after a test session. Once a test session summary is received by the VEC, results are submitted to the FCC. The FCC will then notify the test candidate of any fees associated with call sign assignment. As soon as this fee is received by the FCC, the FCC will post your status in their ULS (Universal Licensing System) consolidated database ... that's the proof you're authorized to transmit. There is no specific time limit. With VEC's that submit everything electronically, this can all happen within 24-48 hours. With VEC's that still use the postal system, it can take up to three weeks. [\[T1C10 – CO\]](#) [\[T1C10 – AA\]](#)

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

This is a repeat of question T1C09, from §97.25(b) ... "A person whose amateur station license grant has expired may apply to the FCC for renewal of the license grant for another term during a 2 year filing grace period. The application must be received at the address specified above prior to the end of the grace period. Unless and until the license grant is renewed, no privileges in this part are conferred." You are supposed to stop transmitting during this grace period. [\[T1C11 – CO\]](#)

[\[T1C11 – AA\]](#)

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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* [TOC](#)

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

According to §97.111(a)(1) ... “Transmissions necessary to exchange messages with other stations in the amateur service, except those in any country whose administration has notified the ITU that it objects to such communications. The FCC will issue public notices of current arrangements for international communications.” [\[T1D01 – CO\]](#) [\[T1D01 – AA\]](#)

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

To really answer this question, you should read all of §97.111 and §97.113. However, §97.113 states:

“An amateur station shall not engage in any form of broadcasting, nor may an amateur station transmit one-way communications except as specifically provided in these rules; nor shall an amateur station engage in any activity related to program production or news gathering for broadcasting purposes, except that communications directly related to the immediate safety of human life or the protection of property may be provided by amateur stations to broadcasters for dissemination to the public where no other means of communication is reasonably available before or at the time of the event.” [\[T1D02 – CO\]](#) [\[T1D02 – AA\]](#)

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

§97.211(b) states, “A telecommand station may transmit special codes intended to obscure the meaning of telecommand messages to the station in space operation.” §97.215(a) states, “The station identification procedure is not required for transmissions directed only to the model craft, provided that a label indicating the station call sign and the station licensee's name and address is affixed to the station transmitter.” [\[T1D03 – CO\]](#) [\[T1D03 – AA\]](#)

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

§97.113(a)(4) states, “No amateur station shall transmit ... Music using a phone emission except as specifically provided elsewhere in this section; communications intended to facilitate a criminal act; messages encoded for the purpose of obscuring their meaning, except as otherwise provided herein; obscene or indecent words or language; or false or deceptive messages, signals or identification.” [\[T1D04 – CO\]](#) [\[T1D04 – AA\]](#)

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

§97.113(a)(3)(ii) states, “No amateur station shall transmit ... Communications in which the station licensee or control operator has a pecuniary interest, including communications on behalf of an employer, with the following exceptions ... An amateur operator may notify other amateur operators of the availability for sale or trade of apparatus normally used in an amateur station, provided that such activity is not conducted on a regular basis.” [\[T1D05 – CO\]](#) [\[T1D05 – AA\]](#)

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

§97.113(a)(4) states, “No amateur station shall transmit ... Music using a phone emission except as specifically provided elsewhere in this section; communications intended to facilitate a criminal act; messages encoded for the purpose of obscuring their meaning, except as otherwise provided herein; obscene or indecent words or language; or false or deceptive messages, signals or identification.” [\[T1D06 – CC\]](#) [\[T1D06 – AA\]](#)

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

§97.113(d) states, “No amateur station, except an auxiliary, repeater, or space station, may automatically retransmit the radio signals of other amateur station.” [\[T1D07 – CO\]](#) [\[T1D07 – AA\]](#)

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

§97.113(a)(3)(iii) states, “No amateur station shall transmit ... Communications in which the station licensee or control operator has a pecuniary interest, including communications on behalf of an employer, with the following exceptions: A control operator may accept compensation as an incident of a teaching position during periods of time when an amateur station is used by that teacher as a part of classroom instruction at an educational institution.” [\[T1D08 – CO\]](#) [\[T1D08 – AA\]](#)

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

§97.113(b) states, “An amateur station shall not engage in any form of broadcasting, nor may an amateur station transmit one-way communications except as specifically provided in these rules; nor shall an amateur station engage in any activity related to program production or news gathering for broadcasting purposes, except that communications directly related to the immediate safety of human life or the protection of property may be provided by amateur stations to broadcasters for dissemination to the public where no other means of communication is reasonably available before or at the time of the event.” [\[T1D09 – CO\]](#) [\[T1D09 – AA\]](#)

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

§97.3(a)(10) states, “The definitions of terms used in part 97 are ... Broadcasting. Transmissions intended for reception by the general public, either direct or relayed.” [\[T1D10 – CO\]](#) [\[T1D10 – AA\]](#)

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

§97.119(a) states, “Each amateur station, except a space station or telecommand station, must transmit its assigned call sign on its transmitting channel at the end of each communication, and at least every 10 minutes during a communication, for the purpose of clearly making the source of the transmissions from the station known to those receiving the transmissions. No station may transmit unidentified communications or signals, or transmit as the station call sign, any call sign not authorized to the station.” However, §97.215(a) states, “The station identification procedure is not required for transmissions directed only to the model craft, provided that a label indicating the station call sign and the station licensee's name and address is affixed to the station transmitter.” [\[T1D11 – CO\]](#) [\[T1D11 – AA\]](#)

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

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

§97.7 states, “Control operator required. When transmitting, each amateur station must have a control operator. The control operator must be a person: (a) For whom an amateur operator/primary station license grant appears on the ULS consolidated licensee database, or (b) Who is authorized for alien reciprocal operation by § 97.107 of this part.”

[\[T1E01 – CO\]](#) [\[T1E01 – AA\]](#)

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

Amateur satellites and space stations have uplink (transmit) and downlink (receive) frequencies. Anyone, including unlicensed individuals may LISTEN to traffic from satellites or space stations. To be a control operator, you also need to be able to transmit. As long as your license privileges give you permission to use those uplink frequencies, you may be the control operator of an amateur satellite or space station. [\[T1E02 – CO\]](#) [\[T1E02 – AA\]](#)

T1E03: Who must designate the station control operator?

§97.103 (Station licensee responsibilities) item (b) states, “The station licensee must designate the station control operator. The FCC will presume that the station licensee is also the control operator, unless documentation to the contrary is in the station records.” [\[T1E03 – CO\]](#) [\[T1E03 – AA\]](#)

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

The control operator may operate the station per their license privileges, regardless of the license of the station owner. The station owner DESIGNATES who the control operator is. Let’s review an example. If the station owner holds a Technician class license, and the station owner is also the control operator, the station must operate under Technician transmitting privileges. However, if the owner designates someone who holds an Extra class license as the control operator, the station may operate under Extra transmitting privileges. [\[T1E04 – CO\]](#) [\[T1E04 – AA\]](#)

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

§97.3(a)(14) states, “Control point. The location at which the control operator function is performed.” [\[T1E05 – CO\]](#) [\[T1E05 – AA\]](#)

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?

§97.301 details the authorized amateur radio frequency bands by license class. Operators may not transmit outside of their license class. It’s important to clarify that Extra class license holders may transmit in ALL frequencies available to amateur radio operators. [\[T1E06 – CO\]](#) [\[T1E06 – AA\]](#)

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

§97.103 (Station licensee responsibilities) item (a) states, “The station licensee is responsible for the proper operation of the station in accordance with the FCC Rules. When the control operator is a different amateur operator than the station licensee, both persons are equally responsible for proper operation of the station.” [\[T1E07 – CO\]](#) [\[T1E07 – AA\]](#)

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

§97.205(d) states, “A repeater may be automatically controlled.” §97.3(a)(6) states, “Automatic control. The use of devices and procedures for control of a station when it is transmitting so that compliance with the FCC Rules is achieved without the control operator being present at a control point.” [\[T1E08 – CO\]](#) [\[T1E08 – AA\]](#)

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

§97.109 (Station control) states ... “(a) Each amateur station must have at least one control point. (b) When a station is being locally controlled, the control operator must be at the control point. Any station may be locally controlled. (c) When a station is being remotely controlled, the control operator must be at the control point. Any station may be remotely controlled.

(d) When a station is being automatically controlled, the control operator need not be at the control point. Only stations specifically designated elsewhere in this part may be automatically controlled. Automatic control must cease upon notification by a Regional Director that the station is transmitting improperly or causing harmful interference to other stations. Automatic control must not be resumed without prior approval of the Regional Director.”

[\[T1E09 – CO\]](#) [\[T1E09 – AA\]](#)

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

§97.3(a)(39) states, “Remote control. The use of a control operator who indirectly manipulates the operating adjustments in the station through a control link to achieve compliance with the FCC Rules.” For many stations the control link may operate under remote control over an internet link. [\[T1E10 – CO\]](#) [\[T1E10 – AA\]](#)

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

§97.103 (Station licensee responsibilities) item (b) states, “The station licensee must designate the station control operator. The FCC will presume that the station licensee is also the control operator, unless documentation to the contrary is in the station records.” [\[T1E11 – CO\]](#) [\[T1E11 – AA\]](#)

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

§97.103 (Station licensee responsibilities) item (c) states, “The station licensee must make the station and the station records available for inspection upon request by an FCC representative.” [\[T1F01 – CO\]](#) [\[T1F01 – AA\]](#)

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

§97.119 (Station identification) item (a) states, “Each amateur station, except a space station or telecommand station, must transmit its assigned call sign on its transmitting channel at the end of each communication, and at least every 10 minutes during a communication, for the purpose of clearly making the source of the transmissions from the station known to those receiving the transmissions. No station may transmit unidentified communications or signals, or transmit as the station call sign, any call sign not authorized to the station.” [\[T1F02 – CO\]](#) [\[T1F02 – AA\]](#)

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

This is essentially a repeat of T1F02. §97.119 (Station identification) item (a) states, “Each amateur station, except a space station or telecommand station, must transmit its assigned call sign on its transmitting channel at the end of each communication, and at least every 10 minutes during a communication, for the purpose of clearly making the source of the transmissions from the station known to those receiving the transmissions. No station may transmit unidentified communications or signals, or transmit as the station call sign, any call sign not authorized to the station.”

[\[T1F03 – CO\]](#) [\[T1F03 – AA\]](#)

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

§97.119 (Station identification) item (b) states, “The call sign must be transmitted with an emission authorized for the transmitting channel in one of the following ways: (2) By a phone emission in the English language. Use of a phonetic alphabet as an aid for correct station identification is encouraged” [\[T1F04 – CO\]](#) [\[T1F04 – AA\]](#)

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

This question is almost identical to T1F04. §97.119 (Station identification) item (b)(2) states, “(b) The call sign must be transmitted with an emission authorized for the transmitting channel in one of the following ways:” “(2) By a phone emission in the English language. Use of a phonetic alphabet as an aid for correct station identification is encouraged.”

[\[T1F05 – CO\]](#) [\[T1F05 – AA\]](#)

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

§97.119 (Station identification) item (c) states, “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. No self-assigned indicator may conflict with any other indicator specified by the FCC Rules or with any prefix assigned to another country.”

[\[T1F06 – CO\]](#) [\[T1F06 – AA\]](#)

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?

§97.115 (Third party communications) item (a)(2) states, “(a) An amateur station may transmit messages for a third party to: (2) Any station within the jurisdiction of any foreign government when transmitting emergency or disaster relief communications and any station within the jurisdiction of any foreign government whose administration has made arrangements with the United States to allow amateur stations to be used for transmitting international communications on behalf of third parties. No station shall transmit messages for a third party to any station within the jurisdiction of any foreign government whose administration has not made such an arrangement. This prohibition does not apply to a message for any third party who is eligible to be a control operator of the station.” [\[T1F07 – CO\]](#) [\[T1F07 – AA\]](#)

T1F08: What is the definition of third party communications?

§97.3 (Definitions), item (a)(47) states, “Third party communications. A message from the control operator (first party) of an amateur station to another amateur station control operator (second party) on behalf of another person (third party).”

[\[T1F08 – CO\]](#) [\[T1F08 – AA\]](#)

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

§97.3 (Definitions), item (a)(40) states, “Repeater. An amateur station that simultaneously retransmits the transmission of another amateur station on a different channel or channels.” [\[T1F09 – CO\]](#) [\[T1F09 – CO\]](#)

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

§97.205 (Repeater station) item (g) states, “The control operator of a repeater that retransmits inadvertently communications that violate the rules in this part is not accountable for the violative communications.” However, a control operator must be present when the repeater is operating. [\[T1F10 – CO\]](#) [\[T1F10 – AA\]](#)

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

§97.5 (Station license required), item (b)(2) states, “(b) The types of station license grants are:” “(2) A club station license grant. A club station license grant may be held only by the person who is the license trustee designated by an officer of the club. The trustee must be a person who holds an operator/primary station license grant. The club must be composed of at least four persons and must have a name, a document of organization, management, and a primary purpose devoted to amateur service activities consistent with this part.” [\[T1F11 – CO\]](#) [\[T1F11 – AA\]](#)

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SUBLEMENT T2 — OPERATING PROCEDURES

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?

To answer this question, you first need to know a little about repeaters. From Wikipedia, “An amateur radio repeater is an electronic device that receives a weak or low-level amateur radio signal and retransmits it at a higher level or higher power, so that the signal can cover longer distances without degradation. Many repeaters are located on hilltops or on tall buildings as the higher location increases their coverage area, sometimes referred to as the radio horizon, or *footprint*. Amateur radio repeaters are similar in concept to those used by public safety entities (police, fire department, etc.), businesses, government, military, and more. Amateur radio repeaters may even use commercially packaged repeater systems that have been adjusted to operate within amateur radio frequency bands, but more often amateur repeaters are assembled from receivers, transmitters, controllers, power supplies, antennas, and other components, from various sources.” The retransmission in the aforementioned reference is done at a different frequency from the received signal. The difference between these two frequencies is the *repeater frequency offset*. This offset is generally common within a frequency band, but it’s not a specific requirement. You can find a list of repeaters in Repeater Book (www.repeaterbook.com). A screenshot of 2 meter repeaters in North Carolina from this reference is below:

| Frequency | Offset | Tone Up / Down | Location | County | Call | Use | Modes |
|-----------|----------|----------------|--------------------------------|-------------|--------|------|------------------|
| 144.9200 | +2.5 MHz | CC1 | Albemarle | Stanly | K4DVA | OPEN | DMR DSTAR Fusion |
| 145.0400 | -0.6 MHz | 100.0 | Wilkesboro | Wilkes | W4MIS | OPEN | FM |
| 145.0800 | +1.4 MHz | | Kings Mountain | Cleveland | W4NYR | OPEN | DSTAR |
| 145.1100 | -0.6 MHz | 131.8 / 131.8 | Kill Devil Hills, Colington | Dare | W4PCN | OPEN | FM EchoLink |
| 145.1100 | -0.6 MHz | 151.4 | Robbinsville | Graham | N4GSM | OPEN | FM AiStar |
| 145.1100 | -0.6 MHz | 88.5 | Youngsville | Franklin | KD4MYE | OPEN | FM |
| 145.1300 | -0.6 MHz | 131.8 | Ahoskie | Hertford | WB4YNF | OPEN | FM |
| 145.1300 | -0.6 MHz | 103.5 / 103.5 | Mount Airy, Fisher Peak | Surry | N4VL | OPEN | FM |
| 145.1300 | -0.6 MHz | 82.5 | Research Triangle Park | Durham | W4DW | OPEN | FM |
| 145.1400 | -0.6 MHz | | Charlotte, Charlotte Hood Road | Mecklenburg | KI4WXS | OPEN | DSTAR |
| 145.1500 | -0.6 MHz | 131.8 / 131.8 | Buxton | Dare | K4OBX | OPEN | FM EchoLink |

The most common offset for 2 meters is -0.6 MHz (or -600 kHz). If you keep scrolling down the list, you’ll also see many repeaters with offsets of +0.6MHz. What this means as a radio operator is that when programming your radio to access at repeater, you will need to enter both the listed frequency (far left column – this is the TRANSMIT frequency for the repeater and RECEIVE frequency for you) and the offset (the listed frequency plus or minus the offset). If you simply want to listen to repeater *traffic*, just use the listed frequency. Your radio manual will have a section on programming repeaters.

[\[T2A01 – CO\]](#) [\[T2A01 – AA\]](#)

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

In the US, amateurs use specific simplex calling frequencies (one in most ham bands) as sort of a universal *home* frequency. For example, when traveling by car, it’s common to set your radio to these frequencies, and 146.52 MHz (in the 2 meter band) is one of those. A list of the more common ones is found below in the accompanying table.

[\[T2A02 – CO\]](#) [\[T2A02 – AA\]](#)

| Frequency (MHz) | Band |
|-----------------|-------------------|
| 446.000 | 70 cm |
| 222.1 | 1.25 m (SSB & CW) |
| 146.52 | 2 m |
| 50.125 | 6 m (SSB) |
| 28.400 | 10 m (unofficial) |
| 14.286 | 20 m |
| 7.290 | 40 m |
| 3.885 | 80 m |

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

See question T2A01 above for an explanation of repeaters. You can find a list of repeaters in Repeater Book (www.repeaterbook.com). A screenshot of 70 cm repeaters in North Carolina from this reference is below:

| Frequency | Offset | Tone Up / Down | Location | County | Call | Use | Modes | T |
|-----------|---------|----------------|--|----------|--------|------|-------|---|
| 439.1000 | +10 MHz | 100.0 / 100.0 | Saint Pauls, WUNU-TV Tower | Robeson | N4DBM | OPEN | FM | + |
| 440.1000 | +5 MHz | CC1 | Wilson | Wilson | NE4J | OPEN | DMR | + |
| 440.5125 | +5 MHz | CC1 | Greenville, FC1 - SMAT mobile repeater | Pitt | NC4ES | OPEN | DMR | + |
| 440.5250 | +5 MHz | CC1 | Washington, Vidant Beaufort Hospital | Beaufort | NC4ES | OPEN | DMR | + |
| 440.5375 | +5 MHz | CC1 | Kenansville, Vidant Duplin Hospital | Duplin | NC4ES | OPEN | DMR | + |
| 440.5375 | +5 MHz | CC1 | Wilkesboro, Bucks Knob | Wilkes | W4FAR | OPEN | DMR | + |
| 440.5625 | +5 MHz | CC1 | Albemarle | Stanly | K4DVA | OPEN | DMR | + |
| 440.5750 | +5 MHz | CC1 | Farmville | Greene | NC4ES | OPEN | DMR | + |
| 440.5750 | +5 MHz | NAC 293 | Graham, Downtown Graham | Alamance | KK4ME1 | OPEN | P-25 | + |
| 440.6000 | +5 MHz | | Jacksonville | Onslow | KO4DQ5 | OPEN | DSTAR | + |
| 440.6250 | +5 MHz | CC1 | Roanoke Rapids | Halifax | NC4ES | OPEN | DMR | + |

The most common offset for 70 cm is +5 MHz (or +5000 kHz). If you keep scrolling down the list, you'll also see many repeaters with offsets of -5 MHz. What this means as a radio operator is that when programming your radio to access at repeater, you will need to enter both the listed frequency (far left column – this is the TRANSMIT frequency for the repeater and RECEIVE frequency for you) and the offset (the listed frequency plus or minus the offset). If you simply want to listen to repeater traffic, just use the listed frequency. Your radio manual will have a section on programming repeaters.

[\[T2A03 – CO\]](#) [\[T2A03 – AA\]](#)

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

Whether you're responding to a call or initiating a call, use the same protocol. Give the other call sign first followed by FROM or THIS IS and give your call sign once. Or, you can give their call sign and then yours. For example, if you're calling KX4IU, the call would go like this ...

KX4IU this is KØILP or *KX4IU from KØILP* or simply *KX4IU KØILP* [\[T2A04 – CO\]](#) [\[T2A04 – AA\]](#)

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

When responding to a CQ, give the other call sign first followed by FROM or THIS IS and give your call sign once. Or, you can give their call sign and then yours. When using phone/voice, it's also helpful (but not required) to give your call phonetically. You don't need to give theirs phonetically because they obviously already know it ... the primary reason for using phonetics is clarity. For example, if you're responding to a CQ from KX4IU, the call would go like this ...

KX4IU this is kilo-zero-india-lima-papa or simply *KX4IU kilo-zero-india-lima-papa* [\[T2A05 – CO\]](#) [\[T2A05 – AA\]](#)

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

Remember when testing, as with all other transmissions, you must follow the identification rules ... give your call sign every ten (10) minutes. That's really the only requirement ... identify the transmitting station. Keep the test short, for example, a test might sound like this ...

KØILP testing or in Morse Code (CW) *KØILP VVV (-.- - - - - . . . - . - . / ... - ... - -)* [\[T2A06 – CO\]](#) [\[T2A06 – AA\]](#)

T2A07: What is meant by "repeater offset"?

This is similar to questions T2A01 and T2A03. Repeater receive signals on one frequency and retransmit the signal on another frequency. The difference between these two frequencies (transmit and receive) is the repeater offset.

[\[T2A07 – CO\]](#) [\[T2A07 – AA\]](#)

T2A08: What is the meaning of the procedural signal "CQ"?

The code CQ originated in Europe (the UK). At the time, French was used as the international postal service's official language. The French word *sécurité* (meaning "pay attention") sounds like the letters C - Q when pronounced in French. In

amateur radio lingo it means *Calling Any Station*. It's also commonly used in Morse Code or CW transmissions (-.-. --.-). The station trying to contact another station should send CQ two or three times followed by their call sign, as follows:

CQ CQ CQ, this is KØILP kilo-zero-india-lima-papa calling CQ and monitoring

In Morse Code or digital modes, it would be: *CQ CQ CQ DE KØILP KØILP KØILP K* [\[T2A08 – CO\]](#) [\[T2A08 – AA\]](#)

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

One advantage of communicating through repeaters is their strong signal on a very specific frequency. As a result, you don't need to make a long transmission to make a contact. In other words, it's relatively easy for someone to hear you. A common approach is to simply give your call sign followed by saying the word *monitoring*. For example:

KØILP monitoring or *KØILP is monitoring* or *KØILP standing by* [\[T2A09 – CO\]](#) [\[T2A09 – AA\]](#)

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

Per Wikipedia (https://en.wikipedia.org/wiki/Amateur_radio_frequency_allocations), amateur radio frequency allocations are determined by international agreements and US regulations, and national authorities regulate amateur usage of radio bands. However, within those frequency allocations, groups of volunteers in the US determine how specific bands are used under normal conditions. In short, band plans are voluntary guidelines, and not regulatory requirements. [\[T2A10 – CO\]](#)
[\[T2A10 – AA\]](#)

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

From www.hamradioschool.com, "... simplex operation means the radio stations are communicating with each other directly, on the same frequency. Both stations take turns transmitting and receiving on the same frequency with no repeater or other device in between." [\[T2A11 – CO\]](#) [\[T2A11 – AA\]](#)

T2A12: What should you do before calling CQ?

There are several things you need to do before making a transmission. Most importantly, be sure your license privileges give you access to the frequency. Next, make sure no one else is using the frequency. Do this by listening for a few seconds. Finally, make sure the frequency isn't in use. It's possible that a conversation (QSO) might have paused for a few seconds. You can do this by just asking, "Is this frequency being used?" followed by your call sign. [\[T2A12 – CO\]](#) [\[T2A12 – AA\]](#)

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

This is a useful radio feature when accessing repeaters. As you know from previous questions, repeaters operate in *duplex* mode, utilizing different transmit (output) and receive (input) frequencies. Sometimes someone talking to you via a repeater will be located physically closer to you than they are to the repeater. Their signal going to the repeater may be weak, and the retransmitted signal by the repeater may be garbled. This would be a good time to try the reverse function on your radio (labeled **REV** on most FM transmitters) to listen in on the input frequency of the repeater. If the signal is clearer, consider the option of talking to your friend *simplex* instead of using the repeater. [\[T2B01 – CO\]](#) [\[T2B01 – AA\]](#)

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

From www.electronics-notes.com, most repeaters require some sort of access tone to prevent the repeater from being unnecessarily activated. The most common ones are *Private Line* (or, PL, invented by Motorola), *privacy tones* (used in FRS and GMRS radios), and *Continuous Tone Coded Squelch System* (CTCSS). Most repeaters won't retransmit the signal until they receive this tone. Other tone options include the squelch and digital code squelch (DCS). When programming your radio for repeater access, you'll need to include the tone and tone options. The tones are listed in www.repeaterbook.com. [\[T2B02 – CO\]](#) [\[T2B02 – AA\]](#)

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

Don't over-complicate this question. The answer is just as the question implies. Repeaters, even repeaters at different frequencies, are often linked together using remote receivers to extend their range or overcome obstacles. The received signals are then transmitted by all the repeaters in the network. Repeaters located at the same site can be physically connected with cables. [\[T2B03 – CO\]](#) [\[T2B03 – AA\]](#)

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

You already know this answer from the questions on repeater offset (T2A07) and repeater tones (T2B02). Re-read those to familiarize yourself. If the repeater offset is incorrect, you'll reach the repeater but you won't be able to hear it. If your access tone is incorrect, the repeater won't pass your signal. And, the digital code squelch serves about the same purpose as the CTCSS. [\[T2B04 – CO\]](#) [\[T2B04 – AA\]](#)

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

This distortion is also referred to as overmodulation. Per Wikipedia (<https://en.wikipedia.org/wiki/Overmodulation>), overmodulation is, "the condition that prevails in telecommunication when the instantaneous level of the modulating signal exceeds the value necessary to produce 100% modulation of the carrier. In the sense of this definition, it is almost always considered a fault condition. In layman's terms, the signal is going *off the scale*. Overmodulation results in spurious emissions by the modulated carrier, and distortion of the recovered modulating signal. This means that the envelope of the output waveform is distorted." This definition "signal going off the scale" points to the cause ... you're speaking too loudly! [\[T2B05 – CO\]](#) [\[T2B05 – AA\]](#)

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

Linking repeaters is a technique used for extending the range of a single repeater. Two such linked systems are the Internet Radio Linking Project (IRLP) and EchoLink. From your previous reading about repeaters (question T2B02), you know that repeater control codes are used for requesting a connection. For IRLP connections, the code is a sequence of DTMF Dual-tone Multi-Frequency (DTMF) tones. "Dual-tone" indicates the signal is a pair of tones. [\[T2B06 – CO\]](#) [\[T2B06 – AA\]](#)

T2B07: How can you join a digital repeater's "talkgroup"?

Some common digital repeater systems include EchoLink, IRLP, DMA, and D-STAR. A good and simple explanation of Digital Repeaters can be found at: www.cwtouchkeyer.com/digital-repeater-systems-all-you-need-to-know/

Most digital repeater controllers organize users of the network into *talk groups*. These talk groups require some sort of identification or code to access them. Radios capable of accessing digital repeaters can be programmed with these codes or IDs ... that's all you need to join a group. [\[T2B07 – CO\]](#) [\[T2B07 – AA\]](#)

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

This is referred to as *harmful interference*. If you search the Part 97 standard, you'll find dozens of references to *interference*. The bottom line is that unless it's specified in the standard, no one has an absolute right to any frequency. So be flexible and creative. Try changing frequencies. Try re-positioning your antenna. Reduce power. Negotiate with the other station continued use of the frequency (such as working out a time schedule, etc.). [\[T2B08 – CO\]](#) [\[T2B08 – AA\]](#)

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

Question T2B01 gives insight into the answer for this. Talking to another station via simplex avoids typing up a repeater. [\[T2B09 – CO\]](#) [\[T2B09 – AA\]](#)

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

Q signals (or Q codes) are 3-letter abbreviations for common amateur radio messages. The codes are used in two ways ... as a question and as a statement. For example, QSL is both the question (Is the frequency busy?) and the statement (The frequency is busy.). Q codes are especially useful in Morse Code (CW) communications because they significantly shorten the length of the message. The following website provides a good explanation and list of Q codes/signals:

www.giangrandi.org/electronics/radio/qcode.shtml

Some of the more common Q signals are:

- QRL Is the frequency busy? The frequency is busy.
- QRM Abbreviation for interference from other signals.
- QRN Abbreviation for interference from natural or human-made static.
- QRX Stand by.
- QSL Did you receive and understand? Received and understood.
- QSO Abbreviation for a contact.
- QSY Change to transmission on another frequency (or to ____ kHz).
- QTH What is your location? My location is ____.

[\[T2B10 – CO\]](#) [\[T2B10 – AA\]](#)

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

See question T2B10. This is one of the more common Q signals. QSY as a question is: *Shall I change transmission frequency (to ... kHz (or MHz))?* As an answer is: *Please change transmission frequency (to ... kHz (or MHz)).* [\[T2B11 – CO\]](#) [\[T2B11 – AA\]](#)

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

An excellent DMR reference is www.dmrfordummies.com. Don't let the word *color* confuse you. From previous questions you already know that repeaters require access tones or codes. *Color Code* is simply the term for this in DMR repeaters, sort of like a PL access tone on an analog FM repeater. [\[T2B12 – CO\]](#) [\[T2B12 – AA\]](#)

T2B13: What is the purpose of a squelch function?

A detailed explanation of squelch can be found at: <https://newhams.info/2020/03/22/squelch>. From this website, "... squelch makes radio operation more bearable by turning off the audio when there is no valid signal. Without squelch our radios would be cranking out a lot of unwanted background noise." In short, it filters out receiver noise (by muting the audio) when there is no signal. [\[T2B13 – CO\]](#) [\[T2B13 – AA\]](#)

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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*

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

§97.103 (Station licensee responsibilities) item (a) states, “The station licensee is responsible for the proper operation of the station in accordance with the FCC Rules. When the control operator is a different amateur operator than the station licensee, both persons are equally responsible for proper operation of the station.” No IFs, ANDs, or BUTs ... FCC rules always apply! [\[T2C01 – CO\]](#) [\[T2C01 – AA\]](#)

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

Per Wikipedia, “An amateur radio net, or simply ham net, is an ‘on-the-air’ gathering of amateur radio operators. Most nets convene on a regular schedule and specific frequency, and are organized for a particular purpose, such as relaying messages, discussing a common topic of interest, in severe weather (for example, during a Skywarn activation), emergencies, or simply as a regular gathering of friends for conversation.” Nets are directed by a Net Control Station or Net Controller. Net Control’s job is to direct communications between stations checking into the net. [\[T2C02 – CO\]](#) [\[T2C02 – AA\]](#)

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

From www.hamradioschool.com, “For clear communications under all conditions, we use a phonetic alphabet for spelling out critical information.” [\[T2C03 – CO\]](#) [\[T2C03 – AA\]](#)

T2C04: *What is RACES?*

Since its inception, amateur radio has been involved in emergency communication. The two largest emergency response organizations in the US are RACES and ARES (Amateur Radio Emergency Service). It’s common for licensed amateur radio operators to be members of both organizations. Per §97.3(a)(38) “RACES (radio amateur civil emergency service). A radio service using amateur stations for civil defense communications during periods of local, regional or national civil emergencies.” For more information about ARES, go to www.arrl.org/ares. For more information about RACES, go to www.usraces.org. [\[T2C04 – CO\]](#) [\[T2C04 – AA\]](#)

T2C05: *What does the term “traffic” refer to in net operation?*

For information about nets see https://en.wikipedia.org/wiki/Amateur_radio_net. In amateur radio, *traffic* can have two separate meanings. One is that it’s a type of net whose focus is to relay and exchange messages. The other definition of *traffic* comes from *traffic net* ... messages exchanged during the net. [\[T2C05 – CO\]](#) [\[T2C05 – AA\]](#)

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

See question T2C04. From the ARES website (www.arrl.org/ares), “the Amateur Radio Emergency Service (ARES) consists of licensed amateurs who have voluntarily registered their qualifications and equipment, with their local ARES leadership, for communications duty in the public service when disaster strikes.” [\[T2C06 – CO\]](#) [\[T2C06 – AA\]](#)

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

From question T2C02 you learned that “nets” are directed by a Net Control Station or net controller. It’s important that you operate as directed by net control, and not disrupt the net. Unless there’s an emergency, you should wait for direction from net control to transmit. [\[T2C07 – CO\]](#) [\[T2C07 – AA\]](#)

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

From previous questions, you know that nets are formed to exchange or relay messages or traffic. For emergency nets these messages must be relayed or passed exactly as received. [\[T2C08 – CO\]](#) [\[T2C08 – AA\]](#)

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

§97.403 (Safety of life and protection of property) states, “No provision of these rules prevents the use by an amateur station of any means of radiocommunication at its disposal to provide essential communication needs in connection with the

immediate safety of human life and immediate protection of property when normal communication systems are not available.” In other words, when there is immediate risk to life or property, and normal methods or communications aren’t available, you may use radiocommunication, even if you’re operating outside of your normal frequency privileges. Even unlicensed individuals may use amateur radio frequencies in times of emergency. [\[T2C09 – CO\]](#) [\[T2C09 – AA\]](#)

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

From Wikipedia (https://en.wikipedia.org/wiki/ARRL_Radiogram), “All messages must have a preamble. The preamble of the message contains information about the message necessary to keep track of it as it passes through the amateur system. The parts of the preamble, except for the check as noted later, are not changed by any station relaying or delivering the message. They are permanent parts of the message created by the station of origin and must remain with the message all the way to the delivery point. Preamble information is used to service undeliverable messages and to generate replies to specific handling instructions.” [\[T2C10 – CO\]](#) [\[T2C10 – AA\]](#)

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

Again, refer to Wikipedia (https://en.wikipedia.org/wiki/ARRL_Radiogram). “The check is the number of word ‘groups’ in the text of the message and must be used on all messages. This number is used by operators to verify that the text has been copied with the correct number of groups.” [\[T2C11 – CO\]](#) [\[T2C11 – AA\]](#)

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SUBLEMENT T3 — RADIO WAVE PROPAGATION

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

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

To answer this, you'll need to understand radio propagation. Here's a good reference. www.electronics-notes.com/articles/antennas-propagation/propagation-overview/basics.php. At this site, click the link to Multipath Propagation. Radio waves can be diffracted by mountains, building, and other objects. This diffraction causes the waves to take slightly different paths from the transmitting station to the receiving station. This is called *multipath propagation*. This can result in distorted or weak signals, or even dead spots, even when reception is generally good. These dead spots are often only ½ wavelength apart. Because the spacing is relatively close, sometimes you can resolve the weak signal by moving your antenna only a few feet. [\[T3A01 – CO\]](#) [\[T3A01 – AA\]](#)

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

See article titled “Effect of Temperature and Ground Water on VHF Radio Wave Propagation in Tropical Climate” by Suleman K.O., Bello I.T., Tijani L.O., Ogunbode A.O., Olayiwola W.A. (www.ijser.org/researchpaper/Effect-of-Temperature-and-Ground-Water-on-VHF-Radio-Wave-Propagation-in-Tropical-Climate.pdf). The article states “... Ultra-High Frequency (UHF) and Very High Frequency (VHF) signals are easily reflected by substances and can also be absorbed by some environmental factors such as relative humidity, wind, air and ground temperature, and vegetation.” [\[T3A02 – CO\]](#) [\[T3A03 – AA\]](#)

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

A good, basic antenna reference is *Antennas 101* by Eric Webner K4FAN and Dave Tyndell KK4LY (https://w4bfb.org/wordpress/wp-content/uploads/presentations/antennas_101.pdf). Yagi or beam antennas are excellent for long distance communications. Horizontal polarization is preferred because it usually results in less ground losses. [\[T3A03 – CO\]](#) [\[T3A03 – AA\]](#)

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

Polarization describes the way the electric field of the radio wave is oriented. A vertically polarized antenna will generate a radio wave whose electric field is vertically polarized. For best results, you should align the antenna of your receiver with the antenna of the transmitting station. Otherwise, your received signal will be noticeably reduced. [\[T3A04 – CO\]](#) [\[T3A04 – AA\]](#)

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?

Recall the discussion of multipath in question T3A01. Buildings and solid objects don't really BLOCK radio signals. Instead, they REFLECT them. Knowing this, with a directional antenna, you may be able to find a path that will reflect the repeater's signal to your receiver, and your transmissions to the repeater. Amateur radio enthusiasts use the same concept to bounce signals off the moon. [\[T3A05 – CO\]](#) [\[T3A05 – AA\]](#)

T3A06: What is the meaning of the term “picket fencing”?

See question T3A01. These dead spots mentioned in that question are close together – often only ½ wavelength apart. Because the spacing is relatively close, the signal might even sound like a flutter. This is also called *picket fencing*. [\[T3A06 – CO\]](#) [\[T3A06 – AA\]](#)

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

See article referenced in question T3A02. The same applies to microwave frequencies. The article further states, “With high relative humidity, the water vapor content in the air can affect the refraction, diffraction and scattering of the radio wave. He also studied several other factors that can affect its propagation such as terrain, building, vegetation, weather parameters (such as rain, snow, haze and dust).” [\[T3A07 – CO\]](#) [\[T3A07 – AA\]](#)

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

See question T3A01 ... Radio waves can be diffracted by mountains, building, and other objects. This diffraction causes the waves to take slightly different paths from the transmitting station to the receiving station. This is called *multipath propagation*. This can result in distorted or weak signals, or even dead spots, even when reception is generally good.

[\[T3A08 – CO\]](#) [\[T3A08 – AA\]](#)

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

Don't confuse this with question T3A04. That question refers generally to VHF and UHF frequencies (very high and ultra-high). You know from that question that radio waves start out as either vertically or horizontally polarized. When a radio wave travels through the ionosphere, the polarization changes to a combination of horizontal and vertical ... in other words, to *elliptical polarization*. Because of this phenomenon, either a vertically or horizontally polarized antennas can transmit and receive these signals, especially on HF frequencies that are more likely to penetrate the ionosphere than VHF or UHF.

[\[T3A09 – CO\]](#) [\[T3A09 – AA\]](#)

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

See questions T3A01 and T3A08. As you would expect, the dead spots (multi-path) caused by radio wave diffraction can result in data signals with high error rates, even with relatively strong signal strength. [\[T3A10 – CO\]](#) [\[T3A10 – AA\]](#)

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

The region of the atmosphere above the lower atmosphere is called the *ionosphere* (also called thermosphere). This region extends from 30 to 260 miles above the Earth and contains relatively few molecules (primarily oxygen and nitrogen). Those molecules that are there are being constantly bombarded by ultraviolet rays from the Sun. This tends to strip some of the electrons from the oxygen and nitrogen atoms, making them positively charged or *ionized*, rendering the ionosphere slightly conductive. This conductivity can reflect radio waves that hit the ionosphere back to the earth's surface. And, because the earth's surface is also conductivity, this can cause the radio waves to reflect back and forth and continue for hundreds or thousands of miles. This is what enables radio operators to communicate around the world. [\[T3A11 – CO\]](#) [\[T3A11 – AA\]](#)

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

This is a continuation of questions T3A02 and T3A07. Precipitation and fog can impact VHF frequencies, but has little effect on HF bands (below about 30 MHz), such a 10 meter and 6 meter. [\[T3A12 – CO\]](#) [\[T3A12 – AA\]](#)

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

The following link contains a good overview of radio waves. https://en.wikipedia.org/wiki/Radio_wave. The article states, "Like other electromagnetic waves, a radio wave has a property called polarization, which is defined as the direction of the wave's oscillating electric field perpendicular to the direction of motion. A plane polarized radio wave has an electric field which oscillates in a plane along the direction of motion. In a horizontally polarized radio wave, the electric field oscillates in a horizontal direction. In a vertically polarized wave, the electric field oscillates in a vertical direction. In a circularly polarized wave, the electric field at any point rotates about the direction of travel, once per cycle. A right circularly polarized wave rotates in a right hand sense about the direction of travel, while a left circularly polarized wave rotates in the opposite sense. The wave's magnetic field is perpendicular to the electric field, and the electric and magnetic field are oriented in a right hand sense with respect to the direction of radiation." [\[T3B01 – CO\]](#) [\[T3B01 – AA\]](#)

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

See link for question T3B01. The article states, "Like other electromagnetic waves, a radio wave has a property called polarization, which is defined as the direction of the wave's oscillating electric field perpendicular to the direction of motion. A plane polarized radio wave has an electric field which oscillates in a plane along the direction of motion. In a horizontally polarized radio wave, the electric field oscillates in a horizontal direction. In a vertically polarized wave, the electric field oscillates in a vertical direction. In a circularly polarized wave, the electric field at any point rotates about the direction of travel, once per cycle." [\[T3B02 – CO\]](#) [\[T3B02 – AA\]](#)

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

See link for question T3B01. In this article, the first sentence answers the question, "Radio waves are a type of electromagnetic radiation ...". Electromagnetic tells us the two components are electric fields and magnetic fields. [\[T3B03 – CO\]](#) [\[T3B03 – AA\]](#)

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

See link for question T3B01. The PROPERTIES section of the article states, "Radio waves in a vacuum travel at the speed of light. When passing through a material medium, they are slowed depending on the medium ... Air is thin enough that in the Earth's atmosphere radio waves travel very close to the speed of light." [\[T3B04 – CO\]](#) [\[T3B04 – AA\]](#)

T3B05: What is the relationship between wavelength and frequency?

See link for question T3B01. The PROPERTIES section of this article states, "The wavelength (λ) is the distance from one peak (crest) of the wave's electric field to the next, and is inversely proportional to the frequency (f) of the wave. The relation of frequency and wavelength in a radio wave traveling in vacuum or air is:

$$\lambda = \frac{c}{f} \quad \text{where } \lambda \text{ is wavelength (meters), } c \text{ is speed of light } (3 \times 10^8 \text{ m/s}), \text{ and } f = \text{frequency (Hertz)}$$

Inversely proportional in the above reference means that as wavelength gets shorter, frequency increases, and vice versa."

[\[T3B05 – CO\]](#) [\[T3B05 – AA\]](#)

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

You can derive this formula from the information given in question T3B05. Let's first convert 3×10^8 m/s from scientific notation to standard notation = 300000000 meters/second.

$$\lambda \text{ (in meters)} = \frac{c}{f} = \frac{300000000 \text{ m/s}}{f \text{ (in Hertz)}}$$

The above formula shows the relationship in Hertz. To convert to megahertz (MHz), we need to divide by one million

(1000000).
$$\lambda \text{ (in meters)} = \frac{c}{f} = \frac{300000000 \text{ m/s}}{1000000 f} = \frac{300}{f \text{ (in MHz)}}$$

This reads: wavelength in meters equals 300 divided by frequency in megahertz. [\[T3B06 – CO\]](#) [\[T3B06 – AA\]](#)

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

The formula in question T3B06 provides this answer. You can see in the formula the relationship between wavelength and frequency. For example, if the frequency is 146 MHz, it's easy to calculate the wavelength.

$$\lambda = \frac{300}{f} = \frac{300}{146} = 2.05 = 2 \text{ meters}$$

In summary, amateur radio operators identify bands using both frequency and wavelength. [\[T3B07 – CO\]](#) [\[T3B07 – AA\]](#)

T3B08: What frequency range is referred to as VHF?

A useful reference table for amateur radio operators is the following. There will be several test questions on this, including the General Exam. You should commit this to memory. [\[T3B08 – CO\]](#) [\[T3B08 – AA\]](#)

| RADIO FREQUENCY SPECTRUM RANGES | | | |
|---------------------------------|--------------|---------|---------|
| RANGE NAME | ABBREVIATION | LOW | HIGH |
| 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 |

T3B09: What frequency range is referred to as UHF?

Refer to the table of **RADIO FREQUENCY SPECTRUM RANGES** in question T3B08. [\[T3B09 – CO\]](#) [\[T3B09 – AA\]](#)

T3B10: What frequency range is referred to as HF?

Refer to the table of **RADIO FREQUENCY SPECTRUM RANGES** in question T3B08. [\[T3B10 – CO\]](#) [\[T3B10 – AA\]](#)

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

This can also be found in questions T3B04 and T3B05. Radio waves travel at the speed of light, which is approximately 300 million meters per second (300,000,000 or 3×10^8 meters per second). [\[T3B11 – CO\]](#) [\[T3B11 – AA\]](#)

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

Refer to question T3A11. Because of the reflection of radio waves between the ionosphere and earth's surface, it's common on High Frequency (HF) bands to communicate very long distances – hundreds or thousands of miles. However, Very High Frequency (VHF) and Ultra High Frequency (UHF) signals usually pass through the ionosphere with little bending or reflection. In other words, VHF and higher signals aren't propagated by the ionosphere. [T3C01 – CO] [T3C01 – AA]

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

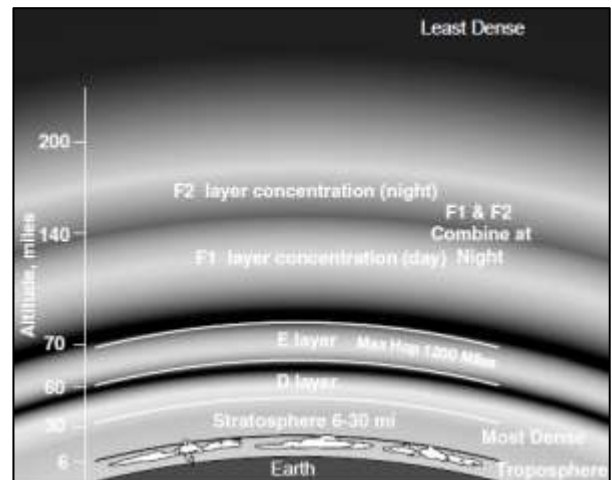
This is essentially the same as question T3C01. HF signals are propagated by the ionosphere, while VHF and UHF are usually not. This makes long-distance communication much more common with HF. [T3C02 – CO] [T3C02 – AA]

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

The word *auroral* in this question refers to the aurora borealis or *northern lights*. If you've been fortunate enough to experience this phenomenon, you know that it's constantly changing. Consequently, any signals reflected by it will also be inconsistent in strength, resulting in significant distortion. [T3C03 – CO] [T3C03 – AA]

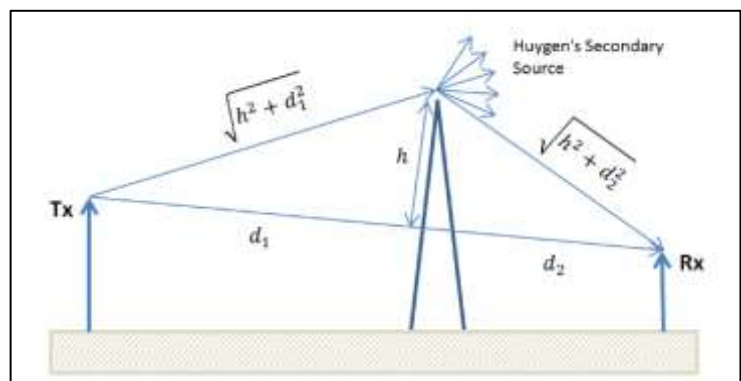
T3C04: Which of the following types of propagation is most commonly associated with occasional strong signals on the 10, 6, and 2 meter bands from beyond the radio horizon?

From question T3A11, we know that the ionosphere is ionized. The ionosphere consists of layers D (most dense), E, F1, and F2 (least dense). See accompanying diagram. Under certain conditions (specifically, certain times of the year ... early summer and mid-winter), the E layer can periodically become ionized enough to reflect VHF and UHF signals back to the earth. This is referred to as sporadic E propagation (sometimes called E-skip) and can be heard on 10, 6 and 2 meters (although not very common on 2 meters). [T3C04 – CO] [T3C04 – AA]



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

Radio waves can be refracted or disrupted by changes in the path ... atmospheric conditions, mountains, buildings, trees, etc. The accompanying diagram from www.raymaps.com depicts what happens when a radio wave is diffracted by a sharp object. The transmitted signal originates at Tx. With the receiver at Rx, it's easy to see that the direct line-of-sight is obstructed. However, the highest point of the obstruction, and the wave is diffracted into a set of alternate signals, one or more of which may reach the receiver. This is called knife-edge diffraction. [T3C05 – CO] [T3C05 – AA]



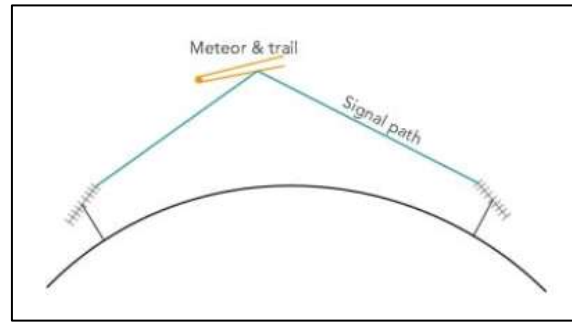
T3C06: What type of propagation is responsible for allowing over-the-horizon VHF and UHF communications to ranges of approximately 300 miles on a regular basis?

Refer to <https://encyclopedia2.thefreedictionary.com/tropospheric+propagation>. Weather fronts, temperature inversions, and other atmospheric conditions in the troposphere (lower atmosphere) can create layers of air with varying characteristics.

These different layers can create pathways or *ducts* that allow microwave, VHF, and UHF signals to pass through, sometimes for hundreds of miles. This phenomenon is called *tropospheric propagation or ducting*. [\[T3C06 – CO\]](#) [\[T3C06 – AA\]](#)

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

From www.electronics-notes.com. "Meteor scatter or meteor burst communications uses a form of radio propagation that utilizes the dense trails of ionisation left by meteors as they enter the upper layers of the Earth's atmosphere. The trails are dense and can reflect signals into the VHF and sometimes the UHF region of the radio spectrum, but they are only present for a very short time, and therefore the radio system must be able to accommodate this." A diagram of this phenomenon is shown in the accompanying figure.



Signals distances commonly exceed 1000 miles. The best band for meteor scatter is 6 meters (50 MHz to 54 MHz). [\[T3C07 – CO\]](#) [\[T3C07 – AA\]](#)

T3C08: What causes tropospheric ducting?

Refer to question T3C06. Weather fronts, temperature inversions, and other atmospheric conditions in the troposphere (lower atmosphere) can create layers of air with varying characteristics. [\[T3C08 – CO\]](#) [\[T3C08 – AA\]](#)

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

You can use logic to answer this question. The best time for signals to be reflected by the ionosphere (see figure in question T3C04) is when the ionosphere is the most active (the most ionized). This occurs when the solar activity is at its highest, in other words, daylight hours ... from dawn until shortly after sunset. The ionosphere is especially active during times of high sunspot activity. [\[T3C09 – CO\]](#) [\[T3C09 – AA\]](#)

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

This question is answered by question T3C09. T3C09 specifically states the 10 meter band. But, you can also use this type of propagation for 6 meters. [\[T3C10 – CO\]](#) [\[T3C10 – AA\]](#)

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

VHF and UHF radio waves are slightly refracted by the atmosphere. In other words, the radio waves curve slightly towards the earth's surface. This phenomenon allows for signals to be received at distances somewhat further than the visual horizon.

[\[T3C11 – CO\]](#) [\[T3C11 – AA\]](#)

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SUBLELEMENT T4 — AMATEUR RADIO PRACTICES

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

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T4A01: Which of the following is an appropriate power supply rating for a typical 50 watt output mobile FM transceiver?
Amateur radio equipment is designed to operate using a typical vehicle power supply. We typically refer to a *car battery* as a *12 volt battery*. However, they consist of 6 individual cells of 2.3V each. So, the voltage rating is $2.3V \times 6 = 13.8$ Volts. Given this, let's calculate the amps required.

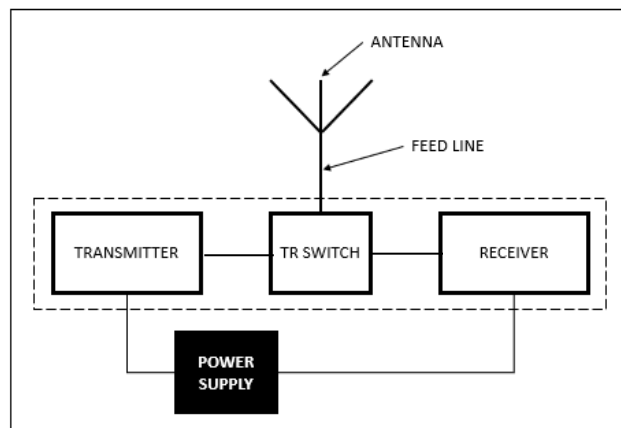
$$\text{Power (in Watts)} = \text{Current (in Amps)} \times \text{Voltage (in Volts)} \quad \text{or} \quad P = I \times E \quad \text{or} \quad 50 \text{ Watts} = I \times 13.8 \text{ Volts}$$

$$\text{Solving for current, we have ...} \quad I = 50 \div 13.8 = 3.62 \text{ Amps}$$

Because equipment draws significantly more current at start-up than while operating, you should double this value to have a safety margin. Doubling it yields $3.62 \times 2 = 7.2A$. Rounding up to the nearest whole number = 8 Amps. So, you need a power supply rated at 13.8 Volts and at least 8 Amps. You'll note the answer on the test is greater than 8 Amps. But, you know for certain you need 13.8 Volts. You'll also note in the above formula the use of the variable *E* for voltage. *E* stands for *electromotive force*. [\[T4A01 – CO\]](#) [\[T4A01 – AA\]](#)

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

A diagram of a basic radio station is shown below in the accompanying figure. The dotted line in the diagram is called the *transceiver*. You'll see a TR SWITCH between the Transmitter and Receiver. This switches between transmit and receive. When transmitting, power goes from the transmitter through the feed line and into the antenna (also called *load*). This is called *forward power*. Resistance to flow of power or energy in the feedline and antenna is called *impedance*. If the antenna and feedline impedances are equal or matched, the power is completely transferred to the antenna. However, if the impedances are NOT matched, some of the power is reflected by the antenna back to the transmitter. This is called *reflected power*. The greater this difference, the more power is reflected. Forward and reflected power move in opposite directions, and can cause an interference pattern called a *standing wave*. The ratio of the maximum value to the minimum value of this interference pattern is the *standing wave ratio* or *SWR*. High enough SWR can damage the transmitter. For an SWR meter to be effective, it must be able to measure in the frequency range of the transmitter and should accommodate the amount of power. [\[T4A02 – CO\]](#) [\[T4A02 – AA\]](#)

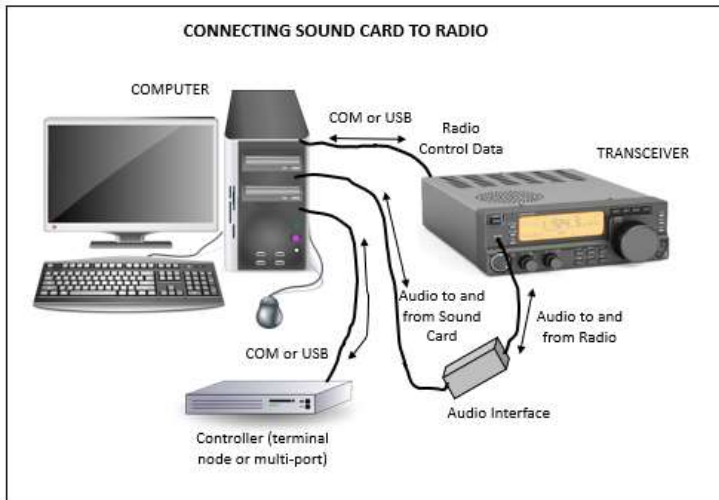


T4A03: Why are short, heavy-gauge wires used for a transceiver's DC power connection?

The smaller the diameter of a wire, the greater the resistance. Similarly, the longer the wire, the greater the resistance. Radio equipment draws a significant amount of current when transmitting. The high resistance of long, thin wires can create voltage drops, per the formula ... $E = I \times R$ (remember that *E* = Voltage) [\[T4A03 – CO\]](#) [\[T4A03 – AA\]](#)

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

FT8 communications is a digital mode, using a sound card to capture audio data from your radio. The audio data is processed by software in the computer that decodes the information imbedded in the radio signal. See the accompanying diagram, "Connecting Sound Card to Radio." You'll note that the radio is connected to the audio input and output of a computer. Many modern radios (e.g., ICOM-7300) have built-in sound cards, so there's no need to purchase a sound card or audio interface. The decoding software should be designed for weak-signal digital communication, such as WSJT-X (see <https://physics.princeton.edu/pulsar/k1jt/>). [\[T4A04 – CO\]](#) [\[T4A04 – AA\]](#)



T4A05: Where should an RF power meter be installed?

Re-read the discussion of SWR in question T4A02. The SWR meter should be connected to the feedline, between the transmitter and the antenna. Many modern radios have built-in SWR meters. [\[T4A05 – CO\]](#) [\[T4A05 – AA\]](#)

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

You can answer this question from the diagram associated with question T4A04. You need audio signals to and from the radio (receive and transmit, respectively). And, you'll need to key the transmitter so it will send. [\[T4A06 – CO\]](#) [\[T4A06 – AA\]](#)

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

See question T4A04. In digital modes, your computer software decodes the received audio signal. So, it must be connected to the speaker ... this eliminates the two responses containing "connection to push-to-talk." And, since it's decoding the incoming message, the response must contain "line in" and not "line out." [\[T4A07 – CO\]](#) [\[T4A07 – AA\]](#)

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

Refer to question T4A03. The word *bond* means to ground all equipment together. You want as good a conductor as you can get ... minimal resistance (a short conductor with a large cross section). The most conductive metal is silver, but copper isn't far behind, and it's much cheaper. Solid rectangular bar would be ideal, but it's difficult to work with (hard to bend a sharp radius). Solid copper strap is the better compromise ... easy to work with and low impedance. [\[T4A08 – CO\]](#) [\[T4A08 – AA\]](#)

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

This is another question you can answer logically. Energy rating of equipment is measured in amp-hours (amps × hours). Here's a simple mathematical tip that will serve you well. You can simplify rather complex equations, if you have "like terms" in both the numerator and denominator. For example, $\frac{a \times b}{a}$ can be simplified because the *a* in the numerator and denominator cancel, resulting in the answer *b*. You can do the same with units of measurement. The term $\frac{\text{amp-hours}}{\text{amps}}$ simplifies to *hours* because the amp term in the numerator and denominator cancel. This gives you the answer. To determine the length of time (in hours) that equipment can be powered from a battery, divide the amp-hour rating of the battery (in amp-hours) by the equipment current draw (amps). [\[T4A09 – CO\]](#) [\[T4A09 – AA\]](#)

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

Just as a smartphone can provide a hot spot to connect a Wi-Fi enabled computer to the internet, a digital mode hot spot allows you link your digital mode transceiver to the internet. The software included with the hot spot allows you to use several different digital modes with one transceiver, eliminating the need to purchase a separate radio for each mode. [\[T4A10 – CO\]](#) [\[T4A10 – AA\]](#)

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

Ideally, you should connect it to the negative battery terminal. But, if it's not practical to do this, connect it to a well-grounded part of the vehicle's chassis. [\[T4A11 – CO\]](#) [\[T4A11 – AA\]](#)

T4A12: What is an electronic keyer?

A key or keyer is a device used for sending Morse Code signals. Specifically, the key turns the transmitter signal on and off. A *straight key* does this manually, referred to as hand keying. An electronic keyer does basically the same thing, but it can be programmed to send short messages. For more information, www.telegraphkeys.com/pages/keyerpaddles.html.

[\[T4A12 – CO\]](#) [\[T4A12 – AA\]](#)

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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 **TOC**

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

This is referred to as *overmodulation*. Overmodulation (which can also be caused by speaking too loudly or holding the microphone too close to your mouth) can result in noise or distorted signals. [\[T4B01 – CO\]](#) [\[T4B01 – AA\]](#)

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

Older radios use a variable frequency oscillator or VFO (sometimes called a *tuner*) to tune to the operating frequency. The VFO is operated by a knob. Some newer radios also have a numeric keypad that allows you to literally enter the operating frequency. Most of today's better radios include both a VFO knob and keypad. To save space, most of today's handheld transceivers (HT's) only use a keypad. [\[T4B02 – CO\]](#) [\[T4B02 – AA\]](#)

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

When there is no signal coming through your receiver, there is often a continuous background noise. Squelch circuits are designed to mute the audio output when no signal is present. However, this will often mute weak FM signals. Fortunately, radio controls allow you to adjust the squelch to hear this noise and any weak FM signals. Look on your front radio panel for one of the following controls: SQUELCH, SQUELCH THRESHOLD, MONITOR, or MON. [\[T4B03 – CO\]](#) [\[T4B03 – AA\]](#)

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

Most modern radios, even inexpensive handhelds (or HTs) have memories or memory channels for storing your favorite frequencies or modes. So, store your favorites in memory. If you have an older radio (like my old Kenwood TS-120S ... dating back to 1979 ... shown here), you'll need to keep a written list of your favorite frequencies. [\[T4B04 – CO\]](#) [\[T4B04 – AA\]](#)



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

The SCAN function or button on your radio scans through the frequencies you have programmed into memory (refer to question T4B04 about programming frequencies). Most radios will pause for a few seconds on frequencies where an audio signal is detected (giving you the opportunity of manually stopping at this frequency ... for most radios, you simply hit the scan button again during this pause). If you have not yet programmed any frequencies into memory, the scan function might not work at all, or it might scan every available frequency ... depending upon the brand and model of radio you have. [\[T4B05 – CO\]](#) [\[T4B05 – AA\]](#)

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?

Transceivers with SSB (single sideband) or CW (continuous wave or Morse Code) capability often come with a fine-tuning control called receiver incremental tuning (RIT). On some radios, this is called the clarifier (labeled CLAR). This allows you to adjust the receiver frequency without changing the transmitter frequency. Its purpose is to allow 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. [\[T4B06 – CO\]](#) [\[T4B06 – AA\]](#)

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

DMRs or Digital Mobile Radios must be programmed with digital codes (color codes) to access a specific repeater. These codes are similar to the PL access tones on an analog FM repeater. DMRs also require specific codes to access specific talk groups. And, each DMR user is assigned an individual identification code (different from your call sign). All these codes are combined into a computer file called a *code plug*. [\[T4B07 – CO\]](#) [\[T4B07 – AA\]](#)

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

This question refers to the use of receiver input filters. To understand the question, you'll need to know a little about filters. A receiver uses filters to reject unwanted signals. Ideally, the filter only allows desired signals to pass. You can have *narrow* (smaller bandwidth, about 500 Hz wide) or *wide* (wider bandwidth, about 2400 Hz wide) filters. The reference to *bandwidth*

choices refers to the option of choosing from multiple filters. These choices allow you to reduce noise by selecting a filter with just enough bandwidth to pass the desired signal. [\[T4B08 – CO\]](#) [\[T4B08 – AA\]](#)

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

Refer to question T4B07 and www.dmrfordummies.com. Digital repeater systems (such as DMR, D-STAR, etc.) use talk groups for organizing radio traffic ... that is to group stations together (usually for a common purpose ... by country, by topic, etc.). Each talk group requires a code for accessing it. All you need to do to select a specific talk group is to enter its identification code into your radio. [\[T4B09 – CO\]](#) [\[T4B09 – AA\]](#)

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

This is simply one of those questions you'll need to memorize. You need to select a bandwidth that matches the bandwidth of the mode and that optimizes the ratio of desired signal to undesired noise or interference. For SSB, this is approximately 2400 Hz (2.4 kHz). [\[T4B10 – CO\]](#) [\[T4B10 – AA\]](#)

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

Similar to DMR, D-STAR uses talk groups. However, unlike DMR, instead of your DMR identification code, you must program your call sign into the radio prior to transmitting. [\[T4B11 – CO\]](#) [\[T4B11 – AA\]](#)

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

For clarification, this means tuning the receiver above or below the INCOMING signal's frequency. If you tune the receiver **too far** above or below the signal, you'll lose the signal entirely. However, if you only tune your receiver a little above or below the signal, you will still be able to hear it, but the audio will be distorted. [\[T4B12 – CO\]](#) [\[T4B12 – AA\]](#)

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SUBELEMENT T5 — ELECTRICAL PRINCIPLES

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

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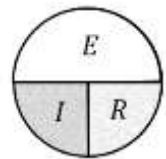
Read the following article before answering the questions in this section.

BASIC ELECTRICAL PRINCIPLES. Before you begin this section, we need to introduce you to a few new terms. We'll refer to this in the questions in this section (T5A). For additional details, check out this website: www.ia470.com/primer/electric.htm

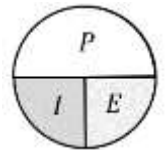
Electrical current is the flow of electrons. The mathematical symbol for current is I and is measured in *amperes* (also *amps* or *A*). Voltage is the force that moves electrons ... causes current/electrons to flow. Voltage is measured in *Volts*. The symbol for Voltage is E (stands for electric potential or electromotive force ... you may see older references use V for voltage). Current flows through conductors (wires, etc.). Since no conductor is perfect, there is always *resistance* to flow. Resistance is measured in *Ohms* (symbol Ω). There is a mathematical relationship between current, voltage, and resistance, (called Ohm's Law) as follows:

$$I = E / R \quad E = I \times R \quad R = E / I$$

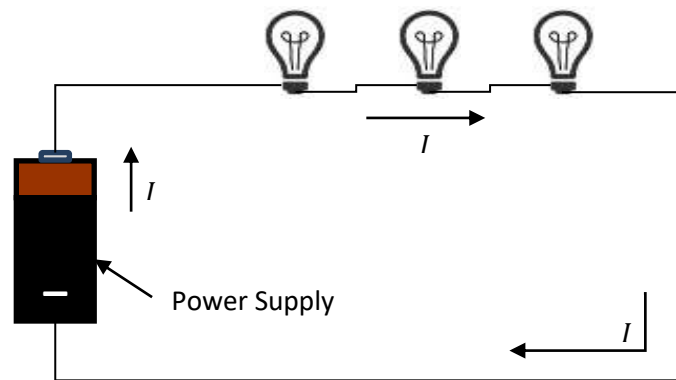
An easy way to remember these basic formulas is to use the accompanying diagram. Here's how you use the diagram. If you know any two of the quantities, the equation to find the third is shown by covering up the unknown quantity. The positions of the remaining two symbols show if you have to multiply (side-by-side) or divide (one above the other). Voltage (electric potential) is measured with a voltmeter. Current is measured with an ammeter. Resistance is measured with an ohmmeter.



Electric *power* is the rate at which electrical energy is used. Power is measured in *Watts* (symbol W). As with Ohm's Law, there is a similar relationship between power, current, and voltage. And, there's a corresponding diagram to help you remember these formulas. $E = P / I$ $P = I \times E$ $I = P / E$



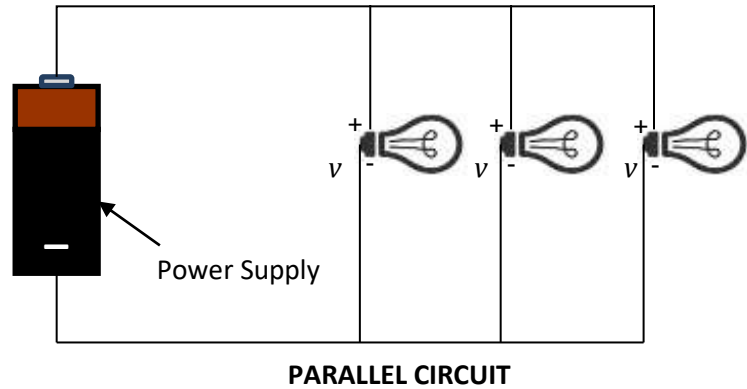
You've certainly heard the terms AC and DC when it comes to electricity. Here's an explanation from Northwestern University's Physics Department. *Electron flow is what we think of as electrical current. We are familiar with two types of electron flow, Direct Current, or DC, and Alternating Current, or AC. Direct Current is the kind of electrical flow we get from batteries and solar cells, when electrons travel in only one direction. On the other hand, AC is the kind of electrical flow we get from a typical electrical outlet in a home. AC is when the electrons flow in two directions, from the positive to the negative terminal and from the negative to the positive terminal, 'alternating' between the two directions. (Your lights will light up regardless of the direction of the electron flow.) A lot of people think of electron flow as electrons moving along a wire freely like cars go down a highway. Actually, it works a little differently. Any conductor (thing that electricity can go through) is made of atoms. Each atom has electrons in it. If you put new electrons in a conductor, they will join atoms, and each atom will spit out an electron to the next atom. This next atom takes in the electron and spits out another one on the other side. All of this happens faster than we can keep track of, which is why the light will go on as soon as you turn it on. Be aware that resistance applies to both AC and DC circuits.*



SERIES CIRCUIT

Finally, let's talk briefly about series and parallel circuits. If you're as old as I am, you probably recall the struggle of finding a burnt-out bulb on a string of Christmas lights – when one bulb went out, they ALL went out. That's because they were wired in **SERIES**. Most of today's Christmas lights are wired in **PARALLEL**. Let's look at some diagrams.

The first diagram shows a series circuit. If you break the circuit at any point (such as a single bulb filament), all the bulbs go out. The second diagram shows a parallel circuit. If one bulb's filament breaks, the circuit is completed by the other bulbs. In fact, you can lose all but ONE bulb and still complete the circuit. In a series circuit, the same current flows through all components. In a parallel circuit, the same voltage flows through all components.



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

Refer to **BASIC ELECTRICAL PRINCIPLES** at the beginning of this section. Electric current (symbol I) is measured in units of amperes (abbreviated as A or *amps*). [\[T5A01 – CO\]](#) [\[T5A01 – AA\]](#)

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

Refer to **BASIC ELECTRICAL PRINCIPLES** at the beginning of this section. Electric power (symbol P) is measured in units of Watts (abbreviated as W). [\[T5A02 – CO\]](#) [\[T5A02 – AA\]](#)

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

Refer to **BASIC ELECTRICAL PRINCIPLES** at the beginning of this section. Electric current (symbol I , measured in *amperes* or *amps*) is the flow of electrons. [\[T5A03 – CO\]](#) [\[T5A03 – AA\]](#)

T5A04: What are the units of electrical resistance?

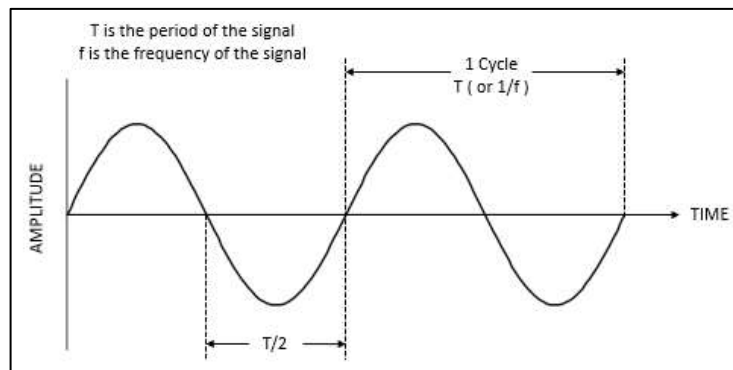
Refer to **BASIC ELECTRICAL PRINCIPLES** at the beginning of this section. Electrical resistance (symbol R) measured in *Ohms* (abbreviated as Ω – Omega). [\[T5A04 – CO\]](#) [\[T5A04 – AA\]](#)

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

Refer to **BASIC ELECTRICAL PRINCIPLES** at the beginning of this section. Voltage (symbol E or V in older texts) is the force that makes electrons move. The symbol E comes from the term *electromotive force*. [\[T5A05 – CO\]](#) [\[T5A05 – AA\]](#)

T5A06: What is the unit of frequency?

See accompanying figure. The number of cycles per second is the signal's *frequency* (symbol f). Frequency is measured in Hertz (symbol Hz). The period of the cycle (symbol T) is its duration, usually measured in seconds. Frequency is the reciprocal of the period ($f = 1 / T$ or $T = 1 / f$). [\[T5A06 – CO\]](#) [\[T5A06 – AA\]](#)



T5A07: Why are metals generally good conductors of electricity?

Metals are good conductors of heat AND electricity because they have at one free electron per atom. This atom isn't tied to any specific atom, and is free to move around. One free electron per atom may not sound like much, but there are over 10^{21} (that's 21 zeroes) atoms in just one gram of copper. So, metals have a LOT of free electrons. [\[T5A07 – CO\]](#) [\[T5A07 – AA\]](#)

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

If you look carefully, this is answered by the wording of question T5A07. The opposite of *insulator* is *conductor*. If metals are good conductors (from T5A07), the look for the choices in T5A08 that isn't a metal (glass is the only non-metal listed).

Insulators RESIST the flow of electricity ... their electrons are bound tightly to the atoms. Other examples are wood/paper, plastics/rubber, ceramics, etc. [\[T5A08 – CO\]](#) [\[T5A08 – AA\]](#)

T5A09: Which of the following describes alternating current?

Look at the graph in question T5A06. Alternating current (AC or *ac*) follows the same pattern in that it changes polarity and magnitude continuously. In other words, polarity alternates between positive and negative continuously. Typical household current in the United States has a frequency of 60 Hertz (Hz) or 60 cycles per second. So, AC alternates between positive and negative 60 times in one second. [\[T5A09 – CO\]](#) [\[T5A09 – AA\]](#)

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

Refer to **BASIC ELECTRICAL PRINCIPLES** at the beginning of this section. The term power describes the rate at which electric energy is used. Measured in *Watts* (symbol *W*). [\[T5A10 – CO\]](#) [\[T5A10 – AA\]](#)

T5A11: What type of current flow is opposed by resistance?

Refer to **BASIC ELECTRICAL PRINCIPLES** at the beginning of this section. The answer choices for this question are *Direct current*, *Alternating current*, *RF current*, or *All these choices are correct*. We know from the Basic Electrical Principles discussion that resistance applies to AC and DC. But, we don't yet know about *RF current*. However, the only correct answer must be All these choices are correct. [\[T5A11 – CO\]](#) [\[T5A11 – AA\]](#)

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

Refer to question T5A06. Each complete up-and-down sequence is called a *cycle* (marked on the graph as **1 Cycle**). The number of cycles per second is the signal's frequency (measured in *Hertz* or *Hz*, symbol *f*). [\[T5A12 – CO\]](#) [\[T5A12 – AA\]](#)

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Refer to the accompanying table and discussion for questions in this section (T5B). These prefixes may be used with any measurement:

ohms, volts, amperes, hertz, watts, meters, etc. Note that some of the symbols are capitalized while some are lower case (it's important to keep this straight). A megagram, for example, is 1,000,000 or 10^6 grams. The symbol is Mg (capital M). The most common prefixes you'll encounter in amateur radio are pico (p), nano (n), micro (μ), milli (m), centi (c), kilo (k), mega (M), and giga (G).

| International System of Units (Metric) | | |
|--|-----------|-------------------------------|
| Prefix | Sym | Multiplication Factor |
| Tera | <i>T</i> | $10^{12} = 1,000,000,000,000$ |
| Giga | <i>G</i> | $10^9 = 1,000,000,000$ |
| Mega | <i>M</i> | $10^6 = 1,000,000$ |
| Kilo | <i>k</i> | $10^3 = 1,000$ |
| Hecto | <i>h</i> | $10^2 = 100$ |
| Deca | <i>da</i> | $10^1 = 10$ |
| Deci | <i>d</i> | $10^{-1} = 0.1$ |
| None | --- | $10^0 = 1$ |
| Centi | <i>c</i> | $10^{-2} = 0.01$ |
| Milli | <i>m</i> | $10^{-3} = 0.001$ |
| Micro | μ | $10^{-6} = 0.000001$ |
| Nano | <i>n</i> | $10^{-9} = 0.000000001$ |
| Pico | <i>p</i> | $10^{-12} = 0.000000000001$ |

T5B01: How many milliamperes is 1.5 amperes?

From the table at T5B we know that *milli* means 10^{-3} or 0.001. To move from no prefix (amperes) to the milli prefix, we will need to add three zeroes (add zeroes when you move DOWN the table; remove zeroes when you move UP the table). So, the correct answer is 1,500 or 1500 mA or milliamperes. [\[T5B01 – CO\]](#) [\[T5B01 – AA\]](#)

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

For this question, we need to look at each answer and test it. The first answer (**A**) is 1500 kHz (or kilohertz). To move from no prefix (hertz) to kilo we're moving up the table so we will need to remove three zeroes. Removing three zeroes from 1,500,000 hertz gives us 1500 kHz. That looks correct. But, to be on the safe side, let's test the other choices. **B** is 1500 MHz. Going from no prefix to mega would remove six zeroes. Removing six zeroes from 1,500,000 would be 1.5 MHz, not 1500 MHz. So, **B** is incorrect. **C** is 15 GHz. Going from no prefix to giga would remove nine zeroes. Removing nine zeroes from 1,500,000 would be 0.015 GHz, not 15 GHz, so **C** is also incorrect. **D** is 150 kHz. But, we know from **A** the correct answer for the *kilo* prefix is 1500. So, **D** is also incorrect. [\[T5B02 – CO\]](#) [\[T5B02 – AA\]](#)

T5B03: Which is equal to one kilovolt?

For this question, we need to look at each answer and test it. The first answer (**A**) is one one-thousandth of a volt or 0.001 volt. To move from kilo to no prefix we go down the table so we need to add three zeroes. Adding 3 zeroes to one kilovolt would be 1000 volts. So, **A** is incorrect. **B** is 100 volts. We already know this is incorrect (the correct answer in volts is 1000). Let's look at **C**. **C** is 1000 volts. Bingo! Just in case, let's look at **D** ... one million volts ... incorrect. [\[T5B03 – CO\]](#) [\[T5B03 – AA\]](#)

T5B04: Which is equal to one microvolt?

Let's look at answer **A** ... one one-millionth of a volt. To move from micro to no prefix (volt) we go up the table so we need to remove six zeroes. Removing 6 zeroes from one microvolt would be 0.000001 or one one-millionth of a volt. So, **A** is correct. [\[T5B04 – CO\]](#) [\[T5B04 – AA\]](#)

T5B05: Which is equal to 500 milliwatts?

Let's look at answer **A** ... 0.02 watts. We can immediately rule it out because we're only moving zeroes ... the **2** in the answer rules it out. Let's look at answer **B** ... 0.5 watts. To move from milli to no prefix (watts) we go up the table, so we need to remove three zeroes. Removing 3 zeroes from 500 would be 0.5 watts ... **B** is correct. [\[T5B05 – CO\]](#) [\[T5B05 – AA\]](#)

T5B06: Which is equal to 3000 milliamperes?

Let's look at answer **A** ... 0.003 amperes. To move from milli to no prefix we go up the table, so we need to remove three zeroes. Removing 3 zeroes from 3000 would be 3 amperes. So, **A** is incorrect. **B** is 0.3 amperes ... same prefix, so the answer is 3 amperes ... **B** is incorrect. **C** is 3,000,000 amperes ... same prefix, so the answer is 3 amperes ... **C** is incorrect. That only leaves **D**. **D** is 3 amperes ... the correct answer. [\[T5B06 – CO\]](#) [\[T5B06 – AA\]](#)

T5B07: Which is equal to 3.525 MHz?

Let's look at answer **A** ... 0.003525 kHz. To move from mega (M) to kilo (k) we go down the table, so we need add three zeroes. Adding 3 zeroes to 3.525 MHz would be 3525 kHz. So, **A** is incorrect. **B** is 35.25 kHz ... also incorrect. **C** is 3535 kHz ... that's it. [\[T5B07 – CO\]](#) [\[T5B07 – AA\]](#)

T5B08: Which is equal to 1,000,000 picofarads?

Let's look at answer **A** ... 0.001 microfarads. To move from pico to micro we go up the table, so we need to remove six zeroes. Removing 6 zeroes from 1,000,000 picofarads would be 1 microfarad. So, **A** is incorrect. **B** is 1 microfarad ... that's it.

[\[T5B08 – CO\]](#) [\[T5B08 – AA\]](#)

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

There are 2 formulas for calculating the decibels (dB) of an amplified or reduced radio signal ... one from the power (measured in Watts) and one from voltage (measured in Volts).

$$\text{Voltage: } dB = 20 \times \log\left(\frac{E_1}{E_2}\right) \qquad \text{Power: } dB = 10 \times \log\left(\frac{P_1}{P_2}\right)$$

If the signal is amplified, the larger voltage (E) or power (P) value is in the numerator in the above fraction. If the signal is reduced, the larger value is in the denominator. For this question, we would use the Power equation. Since the power INCREASES, the larger value is the numerator, as follows:

$$dB = 10 \times \log\left(\frac{P_1}{P_2}\right) = 10 \times \log\left(\frac{10}{5}\right) = 10 \times \log(2) = 10 \times 0.301 = 3.01 \text{ or } 3 \text{ dB}$$

So, the answer is 3 dB. [\[T5B09 – CO\]](#) [\[T5B09 – AA\]](#)

T5B10: Which decibel value most closely represents a power decrease from 12 watts to 3 watts?

Refer to question T5B09. We'll use the power formula. Since there's a power DECREASE, the large value is the denominator.

$$dB = 10 \times \log\left(\frac{P_1}{P_2}\right) = 10 \times \log\left(\frac{3}{12}\right) = 10 \times \log(0.25) = 10 \times (-.602) = -6.02 = -6 \text{ dB}$$

The correct answer is -6 db. [\[T5B10 – CO\]](#) [\[T5B10 – AA\]](#)

T5B11: Which decibel value represents a power increase from 20 watts to 200 watts?

Refer to question T5B09. We'll use the power formula. Since there's a power INCREASE, the large value is the numerator.

$$dB = 10 \times \log\left(\frac{P_1}{P_2}\right) = 10 \times \log\left(\frac{200}{20}\right) = 10 \times \log(10) = 10 \times 1 = 10 \text{ dB}$$

The correct answer is 10 dB. [\[T5B11 – CO\]](#) [\[T5B11 – AA\]](#)

T5B12: Which is equal to 28400 kHz?

Refer to the table at T5B (beginning of this section). Let's first look at answer **A** ... 28.400 kHz. Clearly 28400 kHz isn't equal to 28.400 kHz. Let's look at **B** ... 2.800 MHz. To move from kilo to Mega we need to go up the table, so we need to remove 3 zeroes. Remove 3 zeroes from 28400 kHz gives us 28.4 MHz. So, **B** is incorrect. **C** is 284.00 MHz ... also incorrect. By elimination, **D** is the only answer left, but let's check anyway ... 28.400 MHz is correct. [\[T5B12 – CO\]](#) [\[T5B12 – AA\]](#)

T5B13: Which is equal to 2425 MHz?

Refer to the table at T5B. Let's first look at answer **A** ... 0.002425 GHz. To move from Mega to Giga we need to go up the table, so we need to remove 3 zeroes. Removing 3 zeroes from 2425 MHz gives us 2.425 GHz, so **A** is incorrect. Let's look at **B** ... 24.25 GHz. Also, incorrect. Let's look at **C** ... 2.425 GHz ... that's the correct answer. [\[T5B13 – CO\]](#) [\[T5B13 – AA\]](#)

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T5C01: What describes the ability to store energy in an electric field?

Per www.analog.com, "A capacitor ... consists of two conductive plates separated by an insulating dielectric. A voltage applied to the plates develops an electric field across the dielectric and causes the plates to accumulate a charge. When the voltage source is removed, the field and the charge remain until discharged, storing energy. Capacitance (measured in farads), dictates the amount of charge that can be stored at a given voltage." [\[T5C01 – CO\]](#) [\[T5C01 – AA\]](#)

T5C02: What is the unit of capacitance?

See question T5C01. Capacitance is measured in farads. [\[T5C02 – CO\]](#) [\[T5C02 – AA\]](#)

T5C03: What describes the ability to store energy in a magnetic field?

From www.techtargget.com, "An inductor is a passive electronic component that temporarily stores energy in a magnetic field when electric current flows through the inductor's coil. In its simplest form, an inductor consists of two terminals and an insulated wire coil that either loops around air or surrounds a core material that enhances the magnetic field. Inductors help to handle fluctuations in an electric current running through a circuit ... The inductor's ability to resist changes to the current is referred to as its inductance, which is the ratio of voltage to the current's rate of change within the coil. The standard unit of inductance is the henry (*H*)." [\[T5C03 – CO\]](#) [\[T5C03 – AA\]](#)

T5C04: What is the unit of inductance?

See question T5C03. Inductance is measured in henries (*H*). [\[T5C04 – CO\]](#) [\[T5C04 – AA\]](#)

T5C05: What is the unit of impedance?

In **BASIC ELECTRICAL PRINCIPLES** at the beginning of T5A we talked about opposition to current flow in DC circuits. It's called *resistance*. In an AC circuit, current and voltage are out of phase (current leads voltage in capacitors and current lags voltage in inductors). This out of phase condition also creates opposition to current flow that we call *reactance*. In AC circuits, the combination of resistance and reactance is impedance, and is measured in Ohms (Ω). [\[T5C05 – CO\]](#) [\[T5C05 – AA\]](#)

T5C06: What does the abbreviation "RF" mean?

RF stands for radio frequency. RF signals start at about 20 kHz, just above the range of human hearing (called *audio frequency*). [\[T5C06 – CO\]](#) [\[T5C06 – AA\]](#)

T5C07: What is the abbreviation for megahertz?

Refer to table at T5B. Megahertz is abbreviated MHz (upper case *M*, upper case *H*, lower case *z*). [\[T5C07 – CO\]](#) [\[T5C07 – AA\]](#)

T5C08: What is the formula used to calculate electrical power (P) in a DC circuit?

Refer to the discussion diagrams of **BASIC ELECTRICAL PRINCIPLE** at T5A. The formula for power is: $P = I \times E$
[\[T5C08 – CO\]](#) [\[T5C08 – AA\]](#)

T5C09: How much power is delivered by a voltage of 13.8 volts DC and a current of 10 amperes?

Refer to **BASIC ELECTRICAL PRINCIPLES** at the beginning of section T5A. We need to use the formula for Power.

$$P = I \times E = 10 A \times 13.8 V = 138 \text{ Watts} \quad \text{Correct answer is 138 W.} \quad \text{\a href="#">[T5C09 – CO] \a href="#">[T5C09 – AA]$$

T5C10: How much power is delivered by a voltage of 12 volts DC and a current of 2.5 amperes?

Refer to **BASIC ELECTRICAL PRINCIPLES** at the beginning of section T5A. We need to use the formula for Power.

$$P = I \times E = 2.5 A \times 12 V = 30 \text{ Watts} \quad \text{Correct answer is 30 W.} \quad \text{\a href="#">[T5C10 – CO] \a href="#">[T5C10 – AA]$$

T5C11: How much current is required to deliver 120 watts at a voltage of 12 volts DC?

Refer to **BASIC ELECTRICAL PRINCIPLES** at the beginning of section T5A. We need to use the formula for Current.

$$I = \frac{P}{E} = \frac{120 W}{12 V} = 10 A \quad \text{Correct answer is 10 Amps.} \quad \text{\a href="#">[T5C11 – CO] \a href="#">[T5C11 – AA]$$

T5C12: What is impedance?

Also see question T5C05. In AC circuits, impedance is the opposition to current flow, a combination of resistance and reactance. Symbol Z , measured in ohms (Ω). [\[T5C12 – CO\]](#) [\[T5C12 – AA\]](#)

T5C13: What is the abbreviation for kilohertz?

See table at T5B. The abbreviation for kilohertz is kHz (lower case k , uppercase H). [\[T5C13 – CO\]](#) [\[T5C13 – AA\]](#)

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T5D01: What formula is used to calculate current in a circuit?

See **BASIC ELECTRICAL PRINCIPLES** at T5A. Current (in amps) is Voltage (volts) divided by Resistance (ohms), $I = E/R$.

[\[T5D01 – CO\]](#) [\[T5D01 – AA\]](#)

T5D02: What formula is used to calculate voltage in a circuit?

See **BASIC ELECTRICAL PRINCIPLES** at T5A. Voltage (E) is Current (I) times resistance (R), $E = I \times R$. [\[T5D02 – CO\]](#)

[\[T5D02 – AA\]](#)

T5D03: What formula is used to calculate resistance in a circuit?

See **BASIC ELECTRICAL PRINCIPLES** at T5A. Resistance (R) is Voltage (E) divided by Current (I). $R = E/I$. [\[T5D03 – CO\]](#)

[\[T5D03 – AA\]](#)

T5D04: What is the resistance of a circuit in which a current of 3 amperes flows when connected to 90 volts?

See **BASIC ELECTRICAL PRINCIPLES** at T5A. The formula for Resistance is:

$$R = \frac{E}{I} = \frac{90\text{ V}}{3\text{ A}} = 30\ \Omega \quad \text{Correct answer is } \underline{30\text{ ohms}}. \quad \text{[T5D04 – CO] [T5D04 – AA]}$$

T5D05: What is the resistance of a circuit for which the applied voltage is 12 volts and the current flow is 1.5 amperes?

See **BASIC ELECTRICAL PRINCIPLES** at T5A. The formula for Resistance is:

$$R = \frac{E}{I} = \frac{12\text{ V}}{1.5\text{ A}} = 8\ \Omega \quad \text{Correct answer is } \underline{8\text{ ohms}}. \quad \text{[T5D05 – CO] [T5D05 – AA]}$$

T5D06: What is the resistance of a circuit that draws 4 amperes from a 12-volt source?

See **BASIC ELECTRICAL PRINCIPLES** at T5A. The formula for Resistance is:

$$R = \frac{E}{I} = \frac{12\text{ V}}{4\text{ A}} = 3\ \Omega \quad \text{Correct answer is } \underline{3\text{ ohms}}. \quad \text{[T5D06 – CO] [T5D06 – AA]}$$

T5D07: What is the current in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms?

See **BASIC ELECTRICAL PRINCIPLES** at T5A. The formula for Current is:

$$I = \frac{E}{R} = \frac{120\text{ V}}{80\ \Omega} = 1.5\text{ A} \quad \text{Correct answer is } \underline{1.5\text{ amps}}. \quad \text{[T5D07 – CO] [T5D07 – AA]}$$

T5D08: What is the current through a 100-ohm resistor connected across 200 volts?

See **BASIC ELECTRICAL PRINCIPLES** at T5A. The formula for Current is:

$$I = \frac{E}{R} = \frac{200\text{ V}}{100\ \Omega} = 2\text{ A} \quad \text{Correct answer is } \underline{2\text{ amps}}. \quad \text{[T5D08 – CO] [T5D08 – AA]}$$

T5D09: What is the current through a 24-ohm resistor connected across 240 volts?

See **BASIC ELECTRICAL PRINCIPLES** at T5A. The formula for Current is:

$$I = \frac{E}{R} = \frac{240\text{ V}}{24\ \Omega} = 10\text{ A} \quad \text{Correct answer is } \underline{10\text{ amps}}. \quad \text{[T5D09 – CO] [T5D09 – AA]}$$

T5D10: What is the voltage across a 2-ohm resistor if a current of 0.5 amperes flows through it?

See **BASIC ELECTRICAL PRINCIPLES** at T5A. The formula for Voltage is:

$$E = I \times R = 0.5\text{ A} \times 2\ \Omega = 1\text{ V} \quad \text{Correct answer is } \underline{1\text{ volt}}. \quad \text{[T5D10 – CO] [T5D10 – AA]}$$

T5D11: What is the voltage across a 10-ohm resistor if a current of 1 ampere flows through it?

See **BASIC ELECTRICAL PRINCIPLES** at T5A. The formula for Voltage is:

$$E = I \times R = 1\text{ A} \times 10\ \Omega = 10\text{ V} \quad \text{Correct answer is } \underline{10\text{ volts}}. \quad \text{[T5D11 – CO] [T5D11 – AA]}$$

T5D12: What is the voltage across a 10-ohm resistor if a current of 2 amperes flows through it?

See **BASIC ELECTRICAL PRINCIPLES** at T5A. The formula for Voltage is:

$$E = I \times R = 2\text{ A} \times 10\ \Omega = 20\text{ V} \quad \text{Correct answer is } \underline{20\text{ volts}}. \quad \text{[T5D12 – CO] [T5D12 – AA]}$$

T5D13: *In which type of circuit is DC current the same through all components?*

See **BASIC ELECTRICAL PRINCIPLES** at T5A. The same current must flow through all components in a series circuit.

[\[T5D13 – CO\]](#) [\[T5D13 – AA\]](#)

T5D14: *In which type of circuit is voltage the same across all components?*

See **BASIC ELECTRICAL PRINCIPLES** at T5A. The same voltage must flow through all components in a parallel circuit.

[\[T5D14 – CO\]](#) [\[T5D14 – AA\]](#)

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SUBLEMENT T6 — ELECTRONIC AND ELECTRICAL COMPONENTS

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

TOC

Read the following article before answering the questions in this section.

RESISTORS, CAPACITORS, AND INDUCTORS (Ref: <https://www.livescience.com/53875-resistors-capacitors-inductors.html>)

To answer questions in this section, we need an overview of resistors, capacitors, and inductors. See the reference above for more details. These are the three most basic types of electronic components you'll run into in ham radio. Resistors oppose the flow of current in both AC and DC circuits. This opposition is called *resistance*, and is measured in Ohms (symbol Ω). Resistors are generally classified as either fixed or variable. Variable resistors (also called *potentiometers* or *pots*) are used in adjustable volume controls. An inductor is an electronic component consisting of a coil of wire with an electric current running through it, creating a magnetic field. Inductors store energy in the magnetic field created by current flowing in a wire. Storing electricity in this manner is called *inductance*, and is measured in henrys (symbol H). Like resistors, inductors are available in variable models. *Transformers* are made from two or more inductors that share their stored energy. With advances in technology, microcircuits are now designed without inductors and use capacitors instead to achieve essentially the same results. *Capacitance* is the ability of a device to store electric charge, and as such, the electronic component that stores electric charge is called a capacitor. Capacitance is measured in farads (F). 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. Some circuits have both capacitive and inductive reactance. There will be some frequency in such circuits that the capacitive and inductive reactance will be equal and cancel each other out ... this is called *resonance* ... the circuit is *tuned* at this frequency. Consequently, circuits that contain both a capacitor and an inductor (connected in series or parallel) are called resonant circuits. This is the basis for antenna tuners. An integrated circuit (IC or chip) is combines many components together as a useful circuit and packaged as a single component. See **DIODE BASICS** and **TRANSISTOR BASICS** at the beginning of T6B as a continued review of electrical components.

T6A01: What electrical component opposes the flow of current in a DC circuit?

See **RESISTORS, CAPACITORS, AND INDUCTORS** at beginning of T6A. Resistors oppose the flow of electrical current in AC and DC circuits. [\[T6A01 – CO\]](#) [\[T6A01 – AA\]](#)

T6A02: What type of component is often used as an adjustable volume control?

See **RESISTORS, CAPACITORS, AND INDUCTORS** at beginning of T6A. Variable resistors or potentiometers are used as adjustable volume controls. [\[T6A02 – CO\]](#) [\[T6A02 – AA\]](#)

T6A03: What electrical parameter is controlled by a potentiometer?

See **RESISTORS, CAPACITORS, AND INDUCTORS** at beginning of T6A. Potentiometers are used for adjusting resistance. [\[T6A03 – CO\]](#) [\[T6A03 – AA\]](#)

T6A04: What electrical component stores energy in an electric field?

See **RESISTORS, CAPACITORS, AND INDUCTORS** at beginning of T6A. 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. [\[T6A04 – CO\]](#) [\[T6A04 – AA\]](#)

T6A05: What type of electrical component consists of conductive surfaces separated by an insulator?

See **RESISTORS, CAPACITORS, AND INDUCTORS** at beginning of T6A. Capacitors store electrical energy in the electric field created by a voltage between two conductive surfaces or electrodes that are separated by an insulator called a dielectric. [\[T6A05 – CO\]](#) [\[T6A05 – AA\]](#)

T6A06: What type of electrical component stores energy in a magnetic field?

See **RESISTORS, CAPACITORS, AND INDUCTORS** at beginning of T6A. Inductors store energy in the magnetic field created by current flowing in a wire. [\[T6A06 – CO\]](#) [\[T6A06 – AA\]](#)

T6A07: What electrical component is typically constructed as a coil of wire?

See **RESISTORS, CAPACITORS, AND INDUCTORS** at beginning of T6A. An inductor is an electronic component consisting of a coil of wire. [\[T6A07 – CO\]](#) [\[T6A07 – AA\]](#)

T6A08: What is the function of an SPDT switch?

See <https://en.wikipedia.org/wiki/Switch>. We describe switches by the number of *poles* and *throws*. The number of *poles* is the number of separate switches or circuits which are controlled by a single actuator. The number of *throws* is the number of separate wiring path choices that the switch can adopt for each pole. In the designation *SPDT* above, **P** stands for *poles* and **T** stands for *throws*. The **S** and **D** stand for *single* and *double*, respectively. So, an *SPDT* switch means *single pole double throw* ... a single circuit which can be switched between one of two other circuits. [\[T6A08 – CO\]](#) [\[T6A08 – AA\]](#)

T6A09: What electrical component is used to protect other circuit components from current overloads?

We use the same types of devices/components to protect circuits in radio as we do in house circuits, specifically fuses and circuit breakers. Not that the answer options for this question does not include circuit breakers. [\[T6A09 – CO\]](#) [\[T6A09 – AA\]](#)

T6A10: Which of the following battery chemistries is rechargeable?

Refer to the following table to answer this question. Rechargeable batteries (on this list) are: Nickel-Cadmium, Nickel-Metal Hydride, Lithium ion, Lead-acid, and LiFePO4. [\[T6A10 – CO\]](#) [\[T6A10 – AA\]](#)

| BATTERY TYPES & CHARACTERISTICS | | | |
|---------------------------------|--|----------------------|-----------------|
| STYLE | CHEMISTRY | VOTAGE | RATING |
| 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 | 14000 mAh |
| 9 V | Alkaline – Disposable | 9 V | 580 mAh |
| 9 V | Nickel-Cadmium (NiCd) – Rechargeable | 9 V | 110 mAh |
| 9 V | Nickel-Cadmium (NiCd) – Rechargeable | 9 V | 550 mAh |
| Coin Cells | Lithium — Disposable | 3 – 3.3 V | 25 – 1000 mAh |
| Packs | Lithium ion (Li-ion) – Rechargeable | 3.3 – 3.6 V per cell | Varies |
| Storage | Lead-acid – Rechargeable | 2 V per cell | Varies |
| Storage | LiFePO4 – Rechargeable | 12 V | Varies |

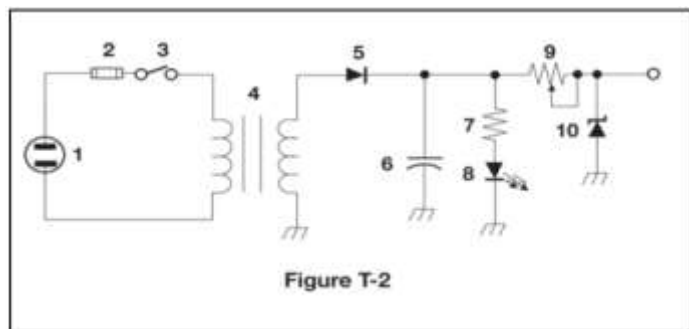
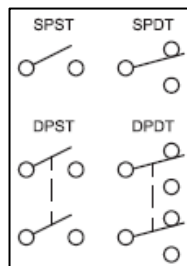
T6A11: Which of the following battery chemistries is not rechargeable?

Refer to table in question T6A10. Non-rechargeable or disposable batteries include: Alkaline, Carbon-Zinc, Lithium. [\[T6A11 – CO\]](#) [\[T6A11 – AA\]](#)

T6A12: What type of switch is represented by component 3 in figure T-2?

To answer this question, refer to the explanation of switches in T6A08, the diagram on the immediate right (types of switches), and to the schematic diagram on the far right.

[\[T6A12 – CO\]](#) [\[T6A12 – AA\]](#)

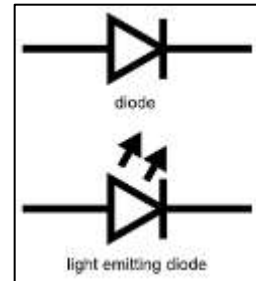


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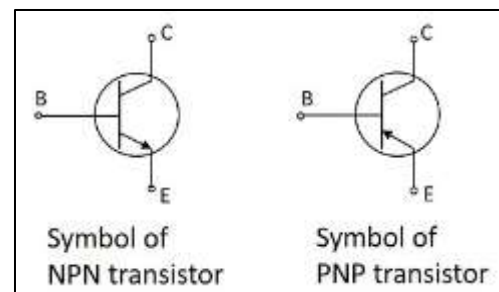
[NEXT SECTION](#)

Read the following articles before answering the questions in this section.

DIODE BASICS: Also see www.circuitbasics.com/what-is-a-diode and www.ledsupply.com/blog/what-you-need-to-know-about-leds. A diode is a specialty component that only allows current to flow in one direction. A *rectifier* is a diode constructed so that it can handle high voltage and current. Because of the diode's ability to block current flow in one direction, you can already imagine what happens if AC current is applied. We already know that AC current cycles back and forth in opposite directions. If a diode is in the circuit, when the current attempts to reverse, the diode blocks it in that direction, resulting in a *pulsing* DC current. Diodes have anodes (positive or + terminal) and cathodes (negative or – terminal). 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. This voltage drop is normal and varies based upon the diode's construction. The diode's ability to block current in one direction comes from their unique construction. They're made from *semiconductor* materials (such a silicon). Adding small amounts of certain impurities (doping) changes the semiconductor's ability to conduct current. Different types of impurities create *N-type* or *P-type* material, depending on the chemical properties of the impurity. Placing N-type and P-type material in contact with each other results in a PN junction that conducts better in one direction than the other. On a diode the cathode is usually identified by a stripe. Heavy-duty diodes that can handle large voltages and currents are called *rectifiers*. Light-emitting diodes (LED) are a special type of diode that gives off light when current flows through it in the forward direction from anode to cathode. LEDs come in a variety of colors (wavelength of light) and brightness. The accompanying diagram are schematics for a diode and LED. LEDs are often used as visual indicators.



TRANSISTOR BASICS: Also see www.tutorialspoint.com/basic_electronics/basic_electronics_transistors.htm and www.tutorialspoint.com/basic_electronics/basic_electronics_types_of_transistors.htm. Be sure to read **DIODE BASICS** first. Transistors are made by connecting two capacitors back-to-back. Thus, they have two NP junctions instead of one ... effectively 3 regions of semi-conductor materials. Because of their design, transistors use small voltages and currents to control larger ones. They consist of three terminals ... Emitter, Base, and Collector. A small voltage applied to the Base can open/close the circuit between the Emitter and Collector (a much larger current or voltage). This gives the ability for the transmitter to serve as a switch or amplifier (also called power gain). The two most common types of transistors are the bipolar junction transistor (BJT) and field effect transistor (FET). The three electrodes of a BJT are the base, collector, and emitter. The three electrodes of an FET are the gate, drain, and source. The accompanying diagram is the schematic of two different types of transistors.



T6B01: Which is true about forward voltage drop in a diode?

See **DIODE BASICS** at the beginning of T6B. These voltage drops are inherent in the design of a diode ... they're normal, and you need to take this into account (because it does impact voltage going to the load). The amount of drop varies ... it's lower on certain diode designs. [\[T6B01 – CO\]](#) [\[T6B01 – AA\]](#)

T6B02: What electronic component allows current to flow in only one direction?

See **DIODE BASICS** at the beginning of T6B. A diode is a specialty component that only allows current to flow in one direction. [\[T6B02 – CO\]](#) [\[T6B02 – AA\]](#)

T6B03: Which of these components can be used as an electronic switch?

See **TRANSISTOR BASICS** at the beginning of T6B. The design of transistor gives it the ability for the transmitter to serve as a switch or amplifier. [\[T6B03 – CO\]](#) [\[T6B03 – AA\]](#)

T6B04: Which of the following components can consist of three regions of semiconductor material?

See **TRANSISTOR BASICS** at the beginning of T6B. Transistors have two NP junctions instead of one ... effectively 3 regions of semi-conductor materials. [\[T6B04 – CO\]](#) [\[T6B04 – AA\]](#)

T6B05: What type of transistor has a gate, drain, and source?

See **TRANSISTOR BASICS** at the beginning of T6B. The three electrodes of an FET (field effect transistor) are the gate, drain, and source. [\[T6B05 – CO\]](#) [\[T6B05 – AA\]](#)

T6B06: How is the cathode lead of a semiconductor diode often marked on the package?

See **DIODE BASICS** at the beginning of T6B. On a diode the cathode is usually identified by a stripe. [\[T6B06 – CO\]](#)
[\[T6B06 – AA\]](#)

T6B07: What causes a light-emitting diode (LED) to emit light?

See **DIODE BASICS** at the beginning of T6B. Light-emitting diodes (LED) are a special type of diode that gives off light when current flows through it in the forward direction from anode to cathode. [\[T6B07 – CO\]](#) [\[T6B07 – AA\]](#)

T6B08: What does the abbreviation FET stand for?

See **TRANSISTOR BASICS** at the beginning of T6B. The two most common types of transistors are the bipolar junction transistor (BJT) and field effect transistor (FET). [\[T6B08 – CO\]](#) [\[T6B08 – AA\]](#)

T6B09: What are the names for the electrodes of a diode?

See **DIODE BASICS** at the beginning of T6B. Diodes have anodes (positive or + terminal) and cathodes (negative or – terminal). [\[T6B09 – CO\]](#) [\[T6B09 – AA\]](#)

T6B10: Which of the following can provide power gain?

See **TRANSISTOR BASICS** at the beginning of T6B. A small voltage applied to the Base can open/close the circuit between the Emitter and Collector (a much larger current or voltage). This gives the ability for the transmitter to serve as a switch or amplifier (also called power gain). [\[T6B10 – CO\]](#) [\[T6B10 – AA\]](#)

T6B11: What is the term that describes a device's ability to amplify a signal?

See **TRANSISTOR BASICS** at the beginning of T6B. A small voltage applied to the Base can open/close the circuit between the Emitter and Collector (a much larger current or voltage). This gives the ability for the transmitter to serve as a switch or amplifier (also called power gain). [\[T6B11 – CO\]](#) [\[T6B11 – AA\]](#)

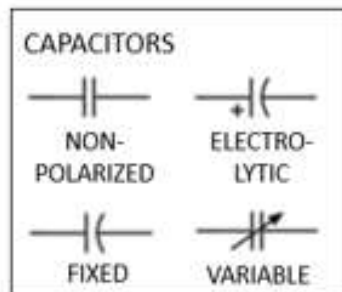
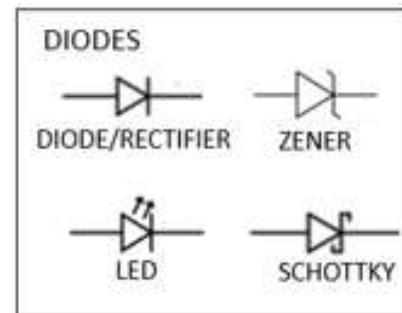
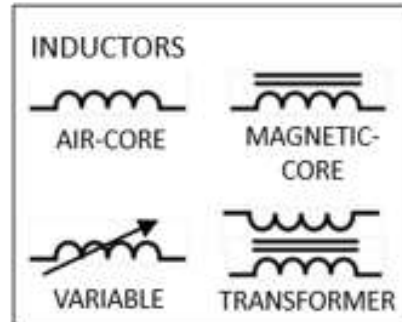
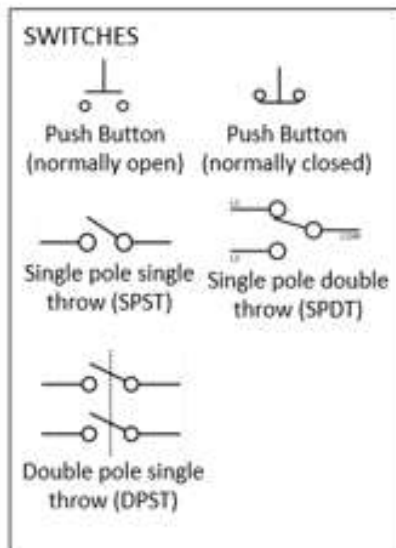
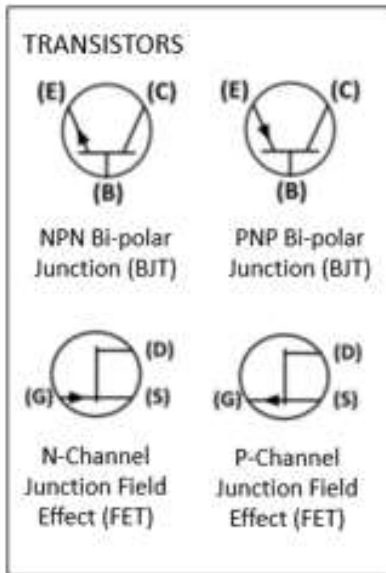
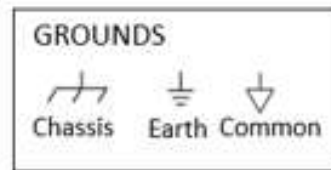
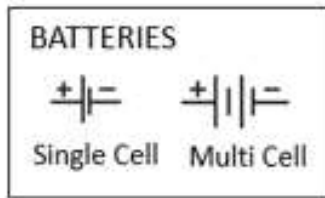
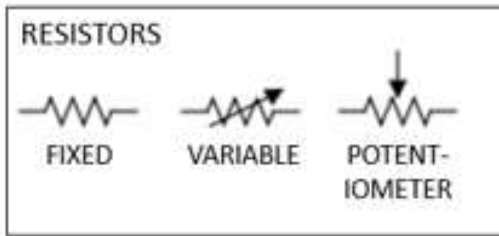
T6B12: What are the names of the electrodes of a bipolar junction transistor?

See **TRANSISTOR BASICS** at the beginning of T6B. The three electrodes of a BJT are the base, collector, and emitter. [\[T6B12 – CO\]](#) [\[T6B12 – AA\]](#)

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SCHEMATIC SYMBOLS OF COMPONENTS (Review the following symbols for questions in section T6C)

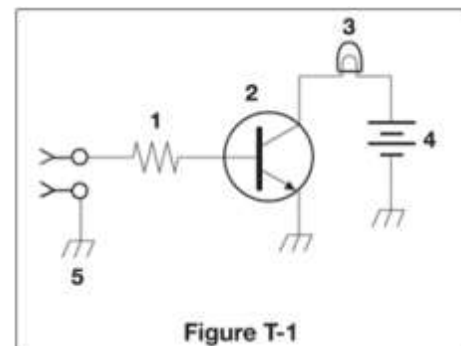


T6C01: What is the name of an electrical wiring diagram that uses standard component symbols?

As you can imagine, trying to draw a complex circuit using photographs of actual components would require a lot of space. Instead, engineers use symbols (like those in T6C ... **SCHEMATIC SYMBOLS OF COMPONENTS** ... above). A diagram created using these standard symbols is called a schematic. [\[T6C01 – CO\]](#) [\[T6C01 – AA\]](#)

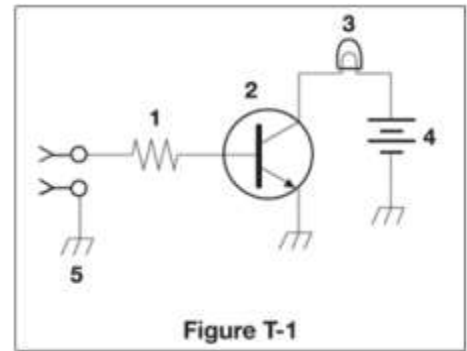
T6C02: What is component 1 in figure T-1? Refer to **SCHEMATIC SYMBOLS OF COMPONENTS** in T6C. While you're studying for the exam, you should attempt to identify every symbol in the schematic. Component #1 is a resistor.

[\[T6C02 – CO\]](#) [\[T6C02 – AA\]](#)



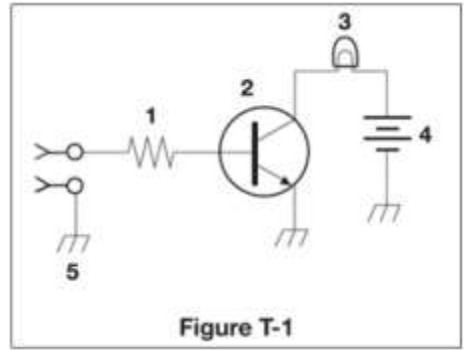
T6C03: What is component 2 in figure T-1?

Refer to **SCHEMATIC SYMBOLS OF COMPONENTS** in T6C. While you're studying for the exam, you should attempt to identify every symbol in the schematic. Component #2 is a transistor. [\[T6C03 – CO\]](#) [\[T6C03 – AA\]](#)



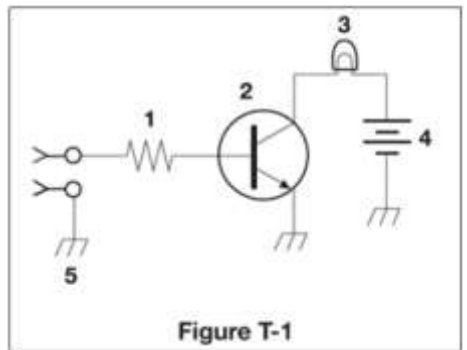
T6C04: What is component 3 in figure T-1?

Refer to **SCHEMATIC SYMBOLS OF COMPONENTS** in T6C. While you're studying for the exam, you should attempt to identify every symbol in the schematic. Component #3 is a lamp (incandescent). [\[T6A04 – CO\]](#) [\[T6A04 – AA\]](#)



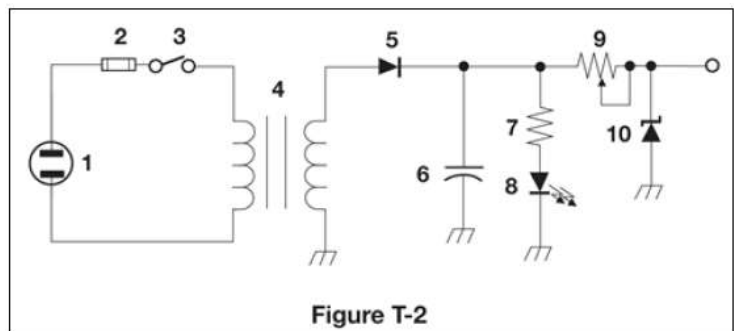
T6C05: What is component 4 in figure T-1?

Refer to **SCHEMATIC SYMBOLS OF COMPONENTS** in T6C. While you're studying for the exam, you should attempt to identify every symbol in the schematic. Component #4 is a battery. [\[T6A05 – CO\]](#) [\[T6C05 – AA\]](#)



T6C06: What is component 6 in figure T-2?

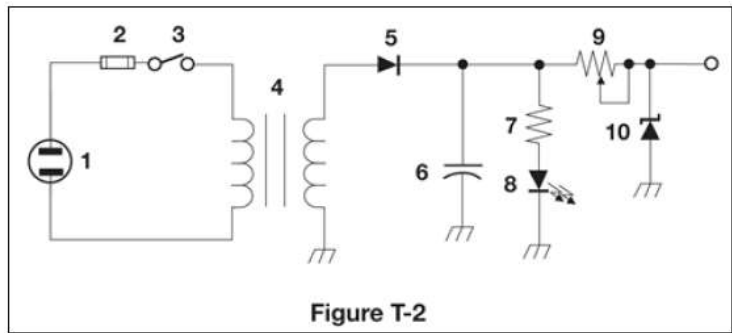
Refer to **SCHEMATIC SYMBOLS OF COMPONENTS** in T6C. While you're studying for the exam, you should attempt to identify every symbol in the schematic. Component #6 is a capacitor. [\[T6C06 – CO\]](#) [\[T6C06 – AA\]](#)



T6C07: What is component 8 in figure T-2?

Refer to **SCHEMATIC SYMBOLS OF COMPONENTS** in T6C. While you're studying for the exam, you should attempt to identify every symbol in the schematic. Component #8 is a light emitting diode (LED).

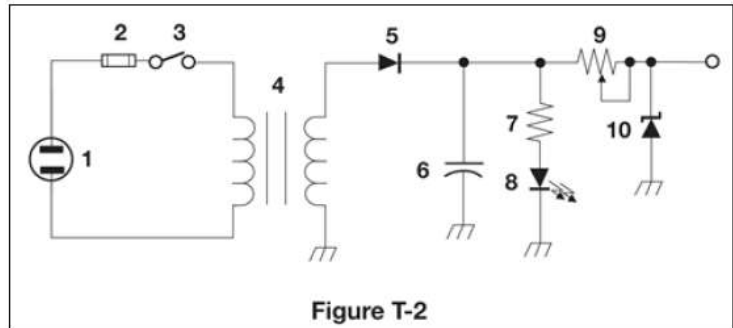
[\[T6C07 – CO\]](#) [\[T6C07 – AA\]](#)



T6C08: What is component 9 in figure T-2?

Refer to **SCHEMATIC SYMBOLS OF COMPONENTS** in T6C. While you're studying for the exam, you should attempt to identify every symbol in the schematic. Component #9 is a variable resistor.

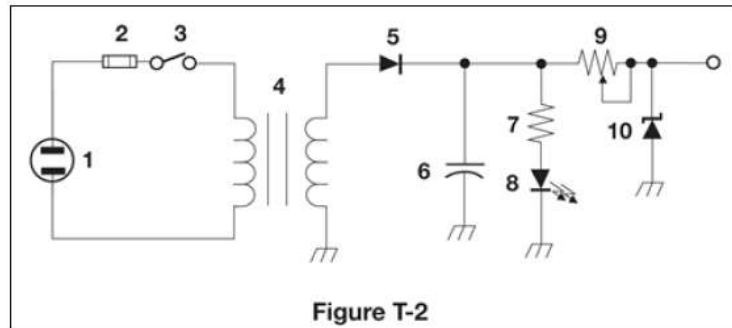
[\[T6C08 – CO\]](#)
[\[T6C08 – AA\]](#)



T6C09: What is component 4 in figure T-2?

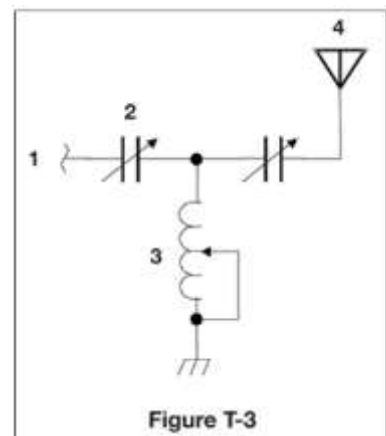
Refer to **SCHEMATIC SYMBOLS OF COMPONENTS** in T6C. While you're studying for the exam, you should attempt to identify every symbol in the schematic. Component #4 is a transformer.

[\[T6C09 – CO\]](#)
[\[T6C09 – AA\]](#)



T6C10: What is component 3 in figure T-3?

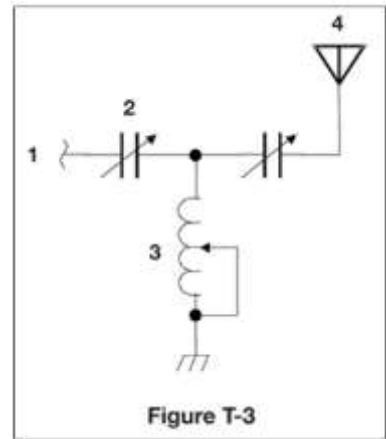
Refer to **SCHEMATIC SYMBOLS OF COMPONENTS** in T6C. While you're studying for the exam, you should attempt to identify every symbol in the schematic. Component #3 is a variable inductor.



T6C11: What is component 4 in figure T-3?

Refer to **SCHEMATIC SYMBOLS OF COMPONENTS** in T6C. While you're studying for the exam, you should attempt to identify every symbol in the schematic.

Component #4 is an antenna. [\[T6C11 – CO\]](#) [\[T6C11 – AA\]](#)



T6C12: Which of the following is accurately represented in electrical schematics?

Because of the size and complexity of actual electrical components, it's not practical to display actual component symbols or actual physical layout of large systems. However, it does show electrical connections between components. [\[T6C12 – CO\]](#)

[\[T6C12 – AA\]](#)

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[NEXT SECTION](#)

Read the following articles before answering the questions in this section.

SWITCHES & RELAYS BASICS (Ref: www.codrey.com/electrical/difference-between-relay-and-switch)

Switches and relays are devices that control and protect the system by turning voltage and current on and off. Switches are easy to understand. By simply moving the switch, you disconnect the power supply to the circuit. Relays are electrically controlled switches that can be turned ON or OFF remotely.

TRANSFORMER BASICS (Ref: www.electronics-tutorials.ws/transformer/transformer-basics.html)

Transformers are electrical devices consisting of two or more coils of wire used to transfer electrical energy by means of a changing magnetic field. Electricity is transferred from the local power station to your home at a much higher voltage than you need. This higher voltage equates to lower current for the same power, resulting in lower power loss during transmission (recall the formula for power ... $P = I^2 \times R$). Because of this, you need to convert the voltage to a LOWER voltage so that you can use it in the home ... we use voltage transformers for this. The transformer works on the principle of Faraday's law of induction by converting electrical energy from one value to another. Note that transformers may be use in BOTH directions ... converting voltage either down or up. You may also use transformers for impedance matching or the isolation of adjoining electrical circuits ... such transformers leave the voltage unchanged.

T6D01: Which of the following devices or circuits changes an alternating current into a varying direct current signal?

See **DIODE BASICS** at the beginning of T6B. We know from the discussion of diodes that diodes block current in one direction, and thus convert AC current into pulsing DC current. Since move AC current (especially at home) is relatively large voltage (120 or 240 V), we would need a rectifier for this. [\[T6D01 – CO\]](#) [\[T6D01 – AA\]](#)

T6D02: What is a relay?

See **SWITCHES & RELAYS BASICS** at section T6D. Relays are electrically controlled switches that can be turned ON or turned OFF remotely. [\[T6D02 – CO\]](#) [\[T6D02 – AA\]](#)

T6D03: Which of the following is a reason to use shielded wire?

Interference from a variety of sources can reduce the quality of your signal, and every radio amateur will run into it eventually. See the following reference: <https://vu2nsb.com/radio-propagation/noise-in-radio-communication/>
The use of shielded wire and connectors will go a long way in reducing unwanted signals and radiation (commonly referred to as RFI ... radio frequency interference. [\[T6D03 – CO\]](#) [\[T6D03 – AA\]](#)

T6D04: Which of the following displays an electrical quantity as a numeric value?

In amateur radio, indicators of all types are used for communicating information ... similar to that on the dashboard of your automobile. Indicators can be as simple as a light that comes on when some value goes beyond an established threshold to more complex instruments such as dials and meters, which display information in the form of a moving needle or numeric value. [\[T6D04 – CO\]](#) [\[T6D04 – AA\]](#)

T6D05: What type of circuit controls the amount of voltage from a power supply?

Power supplies don't always supply a constant voltage. The output voltage changes with the amount of output current, and fluctuating voltage (depending upon the amount of fluctuation) can damage sensitive equipment. Regulated power supplies use regulator circuits to reduce the amount of voltage change. [\[T6D05 – CO\]](#) [\[T6D05 – AA\]](#)

T6D06: What component changes 120 V AC power to a lower AC voltage for other uses?

See **TRANSFORMER BASICS** at the beginning of T6D. A transformer is used for converting AC power from one voltage to another. [\[T6D06 – CO\]](#) [\[T6D06 – AA\]](#)

T6D07: Which of the following is commonly used as a visual indicator?

See **DIODE BASICS** at the beginning of T6B. LEDs are often used as visual indicators. [\[T6D07 – CO\]](#) [\[T6D07 – AA\]](#)

T6D08: Which of the following is combined with an inductor to make a resonant circuit?

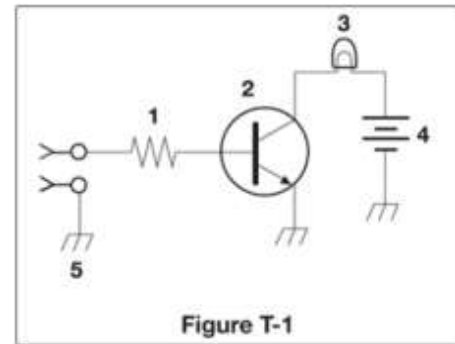
See **RESISTORS, CAPACITORS, AND INDUCTORS** at T6A. Circuits that contain both a capacitor and an inductor are called resonant circuits. [\[T6D08 – CO\]](#) [\[T6D08 – AA\]](#)

T6D09: What is the name of a device that combines several semiconductors and other components into one package?

See **RESISTORS, CAPACITORS, AND INDUCTORS** at T6A. Integrated circuits (IC's or chips) combine several electrical components into on small package. [\[T6D09 – CO\]](#) [\[T6D09 – AA\]](#)

T6D10: What is the function of component 2 in figure T-1?

See **TRANSISTOR BASICS** at the beginning of T6B. Component #2 is a transistor. While you're looking at this figure, be sure you can identify all components. Transistors use small voltages and currents to control larger ones. [\[T6D10 – CO\]](#) [\[T6D10 – AA\]](#)



T6D11: Which of the following is a resonant or tuned circuit?

See **RESISTORS, CAPACITORS, AND INDUCTORS** at T6A. Circuits that contain both a capacitor and an inductor (connected in series or parallel) are called resonant circuits. [\[T6D11 – CO\]](#) [\[T6D11 – AA\]](#)

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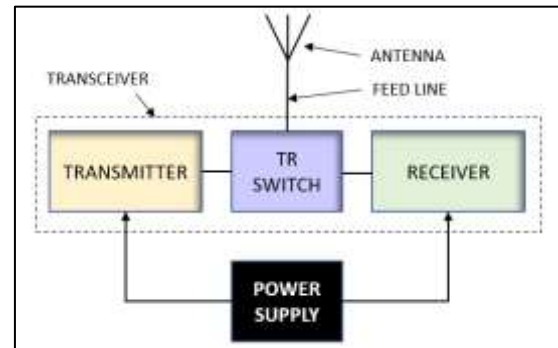
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SUBLELEMENT T7 — PRACTICAL CIRCUITS

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

Read the following article before answering the questions in this section.

RADIO STATION BASICS. Refer to the accompanying diagram. A simple radio station consists of a transmitter, receiver, antenna, and power supply. Theoretically, you need an antenna for both transmitting and receiving signals. However, if you add a transmit/receive switch, you can switch between transmit and receive on one antenna. Most new radio equipment combine the transmitter and receiver into one package, called a transceiver. The transmitter generates the signal that carries information (in the form of speech, data, Morse Code, etc.). The receiver recovers this information. The antenna converts the signal from the transmitter into energy ... radio waves and captures these radio waves and sends them to the receiver. The transmission or feed line connects the transmitter and receiver to the antenna. And, of course, you need power ... this could be a battery, solar panel, or standard power supply, as long as the current and voltage are rated correctly for your equipment.



T7A01: Which term describes the ability of a receiver to detect the presence of a signal?

Two of the most important characteristics of a receiver (see **RADIO STATION BASICS** at T7A) are selectivity and sensitivity. Selectivity is the ability of a receiver to discriminate between signals, specifically the ability to filter out unwanted signals. Sensitivity is the ability to detect signals. Some receivers use preamplifiers to boost sensitivity. [\[T7A01 – CO\]](#) [\[T7A01 – AA\]](#)

T7A02: What is a transceiver?

See **RADIO STATION BASICS** at T7A. Most new radio equipment combine the transmitter and receiver into one package, called a transceiver. [\[T7A02 – CO\]](#) [\[T7A02 – AA\]](#)

T7A03: Which of the following is used to convert a signal from one frequency to another?

See www.electronics-notes.com/articles/radio/rf-mixer/rf-mixing-basics.php. When two signals are passed through a non-linear circuit, then additional signals on new frequencies are formed, effectively converting a signal from one frequency to another. This is done using a mixer. [\[T7A03 – CO\]](#) [\[T7A03 – AA\]](#)

T7A04: Which term describes the ability of a receiver to discriminate between multiple signals?

Two of the most important characteristics of a receiver (see **RADIO STATION BASICS** at T7A) are selectivity and sensitivity. Selectivity is the ability of a receiver to discriminate between signals, specifically the ability to filter out unwanted signals. Sensitivity is the ability to detect signals. Some receivers use preamplifiers to boost sensitivity. [\[T7A04 – CO\]](#) [\[T7A04 – AA\]](#)

T7A05: What is the name of a circuit that generates a signal at a specific frequency?

See www.electronics-tutorials.ws/oscillator/oscillators.html. Oscillators are electronic circuits that generate a continuous periodic waveform at a precise frequency. They are used in both receivers and transmitters to determine the operating frequency. [\[T7A05 – CO\]](#) [\[T7A05 – AA\]](#)

T7A06: What device converts the RF input and output of a transceiver to another band?

See www.pnvwfhs.org/articles/beyondfm/beyond_fm3.html. Transverters convert both incoming and outgoing radio signals to a different frequency by mixing them with a signal from a local oscillator. In amateur radio this allows one main transceiver to be used on one or more new bands. [\[T7A06 – CO\]](#) [\[T7A06 – AA\]](#)

T7A07: What is the function of a transceiver's PTT input?

Refer to **RADIO STATION BASICS** in T7A. PTT is the acronym for *push-to-talk*. Essentially, it triggers the TR SWITCH in the diagram in **RADIO STATION BASICS**, switching between transmit and receive. [\[T7A07 – CO\]](#) [\[T7A07 – AA\]](#)

T7A08: Which of the following describes combining speech with an RF carrier signal?

RF signals alone do not contain data. Your data, voice or Morse Code information must be combined with the RF signal. This process of combining the signal with data is called modulation. [\[T7A08 – CO\]](#) [\[T7A08 – AA\]](#)

T7A09: What is the function of the SSB/CW-FM switch on a VHF power amplifier?

VHF RF power amplifiers are used on some radios to increase the power of the output RF signal. This is especially useful on handheld transceivers (HT's), where the maximum output power is usually less than 10 watts. Many power amplifiers can be used on all modes but need to be set to the right mode to operate properly. That's what the SSB/CW-FM switch is for. If you're transmitting on the 2-meter band, your amplifier must also be set for this band. [\[T7A09 – CO\]](#) [\[T7A09 – AA\]](#)

T7A10: What device increases the transmitted output power from a transceiver?

VHF RF power amplifiers are used on some radios to increase the power of the output RF signal. This is useful on handheld transceivers (HT's), where the maximum output power is usually less than 10 watts. [\[T7A10 – CO\]](#) [\[T7A10 – AA\]](#)

T7A11: Where is an RF preamplifier installed?

If a receiver isn't sensitive enough to detect a signal, a RF preamplifier may be installed. These go between the antenna and receiver. [\[T7A11 – CO\]](#) [\[T7A11 – AA\]](#)

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Read the following article before answering the questions in this section.

RADIO FREQUENCY INTERFERENCE (RFI). See www.radioing.com/eengineer/rfi.html. Radio frequency interference has become common and can arise from a variety of sources. Amateur radio operators sometimes spend hours trying to eliminate or reduce it. Filters of various types are used for blocking specific frequencies of interference. Expressions you'll hear include line filters, high-pass, low-pass, chokes, notch filters, etc. Sometimes strong interference signals will overload the ability of the filters to reject the signal. This is called fundamental overload, and is one of the most common causes of RFI. Fundamental overload is especially common when the signal is outside the frequency the receiver is intended to receive. In other words, you may hear noise across a wide range of frequencies when strong signals are present (this is a cause for picking up unwanted AM or FM radio signals on your ham radio ... you're too close to a very strong signal). Harmonics, leakage, and spurious emissions can also cause RFI. AC power line filters prevent RFI from your equipment, using the AC power and ground circuits. High- and low-pass filters are connected in line with the antenna of offending equipment (televisions, etc.), and are used for blocking unwanted RF signals. Ferrite chokes are used for reducing interference from unshielded cables (speakers, telephones, televisions, microphones, etc.). If you suspect your radio equipment or someone else's radio equipment is causing the problem, use a band-reject or notch filter to reduce it ... primarily for VHF and UHF frequencies. For televisions and other audio-visual equipment, the solution to RFI might be as simple as ensuring all the connectors are properly shielded and installed.

T7B01: What can you do if you are told your FM handheld or mobile transceiver is overdeviating?

See the following article on frequency modulation: www.electronics-notes.com/articles/radio/modulation/frequency-modulation-fm.php. Overdeviating is usually caused by excessive modulation and the most common cause is speaking too loudly into the microphone, which provides a simple solution ... speak more softly or move the microphone farther from your mouth! [\[T7B01 – CO\]](#) [\[T7B01 – AA\]](#)

T7B02: What would cause a broadcast AM or FM radio to receive an amateur radio transmission unintentionally?

See **RADIO FREQUENCY INTERFERENCE** at T7B. Your receiver (specifically the FILTERS in your receiver) aren't able to reject strong signals outside the AM or FM band. [\[T7B02 – CO\]](#) [\[T7B02 – AA\]](#)

T7B03: Which of the following can cause radio frequency interference?

See **RADIO FREQUENCY INTERFERENCE** at T7B. RFI can be caused by fundamental overload, leakage, harmonics, and spurious emissions. [\[T7B03 – CO\]](#) [\[T7B03 – AA\]](#)

T7B04: Which of the following could you use to cure distorted audio caused by RF current on the shield of a microphone cable?

See **RADIO FREQUENCY INTERFERENCE** at T7B. Ferrite chokes are used for reducing interference from unshielded cables (speakers, telephones, televisions, microphones, etc.). [\[T7B04 – CO\]](#) [\[T7B04 – AA\]](#)

T7B05: How can fundamental overload of a non-amateur radio or TV receiver by an amateur signal be reduced or eliminated?

See **RADIO FREQUENCY INTERFERENCE** at T7B. High- and low-pass filters are connected in line with the antenna of offending equipment (televisions, etc.). [\[T7B05 – CO\]](#) [\[T7B05 – AA\]](#)

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?

As licensed amateur radio operators, we're expected to keep our equipment in good working order. This includes minimizing interference. Because of this, it's likely your equipment isn't the cause of the problem. But, don't take chances. First, make sure your equipment isn't the source of the problem, and demonstrate this to your neighbor ... show him the efforts you go through to reduce interference. [\[T7B06 – CO\]](#) [\[T7B06 – AA\]](#)

T7B07: Which of the following can reduce overload of a VHF transceiver by a nearby commercial FM station?

See **RADIO FREQUENCY INTERFERENCE** at T7B. If you suspect your radio equipment or someone else's radio equipment is causing the problem, use a band-reject or notch filter to reduce it ... primarily for VHF and UHF frequencies.

[\[T7B07 – CO\]](#) [\[T7B07 – AA\]](#)

T7B08: What should you do if something in a neighbor's home is causing harmful interference to your amateur station?

If a neighbor is seeing interference in their equipment, the simple fact that you have an antenna automatically makes you a suspect, even if this is unfounded. However, be diplomatic. There are several simple and logical steps to take. (1) Make sure your equipment and procedures are in compliant. (2) Offer to help your neighbor find the source of the problem. With your amateur radio experience, you are likely more qualified at this than your neighbor ... you know where to look (reach out to other hams in the area). (3) Explain to your neighbor that the FCC requires that both of you operate equipment that's compliant. [\[T7B08 – CO\]](#) [\[T7B08 – AA\]](#)

T7B09: What should be the first step to resolve non-fiber optic cable TV interference caused by your amateur radio transmission?

See **RADIO FREQUENCY INTERFERENCE** at T7B. For televisions and other audio-visual equipment, the solution to RFI might be as simple as ensuring all the connectors are properly shielded and installed. [\[T7B09 – CO\]](#) [\[T7B09 – AA\]](#)

T7B10: What might be a problem if you receive a report that your audio signal through an FM repeater is distorted or unintelligible?

Distorted signals aren't usually caused by interference, but are usually something much simpler. For example, your receiver or the other person's transmitter may be slightly off-frequency. If the person you're speaking to is reporting distortion from your end, you may be speaking too loudly. Anyone with a background in music will tell you that low batteries or a bad connection in the microphone can distort the signal. Or, maybe you're transmitting from a location with a poor signal.

[\[T7B10 – CO\]](#) [\[T7B10 – AA\]](#)

T7B11: What is a symptom of RF feedback in a transmitter or transceiver?

It's rather common to experience RFI in your transmitter because of the proximity of your antenna to your equipment. This RFI feedback can result in a distorted signal. However, if it's in YOUR transmitter, it won't be you that hears the distortion ... it will be the person you're communicating with. So, the first symptom of a an RFI feedback problem will come from reports by others. [\[T7B11 – CO\]](#) [\[T7B11 – AA\]](#)

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Read the following article before answering the questions in this section.

STANDING WAVE RATIO (SWR). See https://en.wikipedia.org/wiki/Standing_wave_ratio. Standing wave ratio is a measure of impedance matching of loads to the characteristic impedance of a transmission line, measured by an SWR meter (if you don't have an SWR meter, you can also use a directional wattmeter). The power from the transmitter to the feed line is transferred to the antenna. If the impedances of the antenna and feed line don't match, some power is reflected back to the transmitter. This reflected power is in the form of heat, and can damage your transmitter. Many new radios protect themselves by detecting this reflected power and shut down or reduce output power if the mismatch is high enough. The ratio of forward to reflected power is the SWR. With a perfect match, the SWR is 1:1. An SWR of 2:1 or greater is considered an impedance mismatch and is usually high enough to trigger the transmitter's protection circuits. Older radios (like my back-up Kenwood TS-120S) have no such protection, and you'll have to be careful matching the antenna and feed line impedances. There are many causes for poor SWR: (1) Incorrect feedline (coax) for your system, (2) antenna the wrong length for the transmission frequency, (3) or even defective connectors. Summary: The lower the SWR, the lower the signal loss.

T7C01: *What is the primary purpose of a dummy load?*

When setting up your station for the first time, or if you're adding equipment or making significant adjustments, you'll want to run some tests. It's not considered good operating practice to transmit over and over again while you're running tests. If you key your transmitter without an antenna, there's nothing to absorb the energy. So, operators use dummy loads for this purpose. A dummy load is nothing more than a heavy duty resistor attached to your feed line to absorb the transmitter power. [\[T7C01 – CO\]](#) [\[T7C01 – AA\]](#)

T7C02: *Which of the following is used to determine if an antenna is resonant at the desired operating frequency?*

See https://en.wikipedia.org/wiki/Antenna_analyzer. Antenna analyzers have the ability to measure antenna performance without transmitting (also see question T7C01). Most analyzers run a variety of tests ... standing wave ratio (SWR) and impedance being to two most common. [\[T7C02 – CO\]](#) [\[T7C02 – AA\]](#)

T7C03: *What does a dummy load consist of?*

See question T7C01. The purpose of the dummy load is to absorb and dissipate the transmitter's power. From the explanation in T7C01 you know that you need a resistor. You'll also need a heat sink to dissipate the energy (in the form of heat). [\[T7C03 – CO\]](#) [\[T7C03 – AA\]](#)

T7C04: *What reading on an SWR meter indicates a perfect impedance match between the antenna and the feed line?*

See **STANDING WAVE RATIO** at the beginning of T7C. With a perfect match, the SWR is 1:1. [\[T7C04 – CO\]](#) [\[T7C05 – AA\]](#)

T7C05: *Why do most solid-state transmitters reduce output power as SWR increases beyond a certain level?*

See **STANDING WAVE RATIO** at the beginning of T7C. This reflected power is in the form of heat, and can damage your transmitter. Many new radios protect themselves by detecting this reflected power and shut down or reduce output power if the mismatch is high enough. [\[T7C05 – CO\]](#) [\[T7C05 – AA\]](#)

T7C06: *What does an SWR reading of 4:1 indicate?*

See **STANDING WAVE RATIO** at the beginning of T7C. An SWR of 2:1 or greater is considered an impedance mismatch. [\[T7C06 – CO\]](#) [\[T7C06 – AA\]](#)

T7C07: *What happens to power lost in a feed line?*

See **STANDING WAVE RATIO** at the beginning of T7C. If the impedances of the antenna and feed line don't match, some power is reflected back to the transmitter. This reflected power is in the form of heat. [\[T7C07 – CO\]](#) [\[T7C07 – AA\]](#)

T7C08: Which instrument can be used to determine SWR?

See **STANDING WAVE RATIO** at the beginning of T7C. Standing wave ratio is a measure of impedance matching of loads to the characteristic impedance of a transmission line, measured by an SWR meter (if you don't have an SWR meter, you can also use a directional wattmeter). [\[T7C08 – CO\]](#) [\[T7C08 – AA\]](#)

T7C09: Which of the following causes failure of coaxial cables?

See www.rfvenue.com/blog/2015/02/04/why-coaxial-cable-goes-bad. There are several causes for coax cable failure, including: physical damage, heat damage, extended exposure to ultraviolet light, and water damage. Water damage is the most common source of failure ... small nicks in the outer sheath can still cause water to enter, sometimes resulting in complete loss of functionality. [\[T7C09 – CO\]](#) [\[T7C09 – AA\]](#)

T7C10: Why should the outer jacket of coaxial cable be resistant to ultraviolet light?

Also see question T7C09. UV light can cause the jacket to breakdown chemically, creating small crevices for moisture to enter. [\[T7C10 – CO\]](#) [\[T7C10 – AA\]](#)

T7C11: What is a disadvantage of air core coaxial cable when compared to foam or solid dielectric types?

First, the advantage of air core coax is its low loss, which is especially important when running long feed lines. However, the air core is easily displaced with water (see question T7C09), and moisture in the cable can cause failures. Special precautions are required to prevent this. [\[T7C11 – CO\]](#) [\[T7C11 – AA\]](#)

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Read the following article before answering the questions in this section.

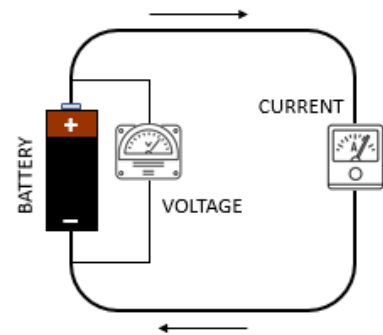
USING A MULTIMETER (Ref www.thespruce.com/how-to-use-a-multimeter-5194980). We briefly discussed voltmeters, ammeters, and ohmmeters in **BASIC ELECTRICAL PRINCIPLES** at T5A. A multimeter is a single instrument that can be used for these three measuring devices and more (continuity, for example). They're often called a VOM (volt-ohm meter) or DVM (digital volt meter). The multimeter can be damaged if not used correctly. Pay close attention to your settings and connections. For example, 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.

T7D01: Which instrument would you use to measure electric potential?

See **BASIC ELECTRICAL PRINCIPLES** at T5A. Electric potential (also called voltage or electromotive force) is measured with a volt meter. [\[T7D01 – CO\]](#) [\[T7D01 – AA\]](#)

T7D02: How is a voltmeter connected to a component to measure applied voltage?

See accompanying diagram. This diagram shows how you would connect a voltmeter to measure voltage and an ammeter to measure current. The voltmeter is connected in parallel to the power source. The ammeter is connected in series to the power source. [\[T7D02 – CO\]](#) [\[T7D02 – AA\]](#)



T7D03: When configured to measure current, how is a multimeter connected to a component?

See diagram in question T7D02. Don't allow the term *multimeter* to confuse you. In this case, the multimeter is measuring current, so it's functioning as an ammeter, and would be connected just like an ammeter. The ammeter is connected in series to the power source. [\[T7D03 – CO\]](#) [\[T7D03 – AA\]](#)

T7D04: Which instrument is used to measure electric current?

See **BASIC ELECTRICAL PRINCIPLES** at T5A. Electric current is measured with an ammeter. [\[T7D04 – CO\]](#) [\[T7D04 – AA\]](#)

T7D06: Which of the following can damage a multimeter?

See **USING A MULTIMETER** at T7D. The multimeter can be damaged if not used correctly. Pay close attention to your settings and connections. For example, 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. [\[T7D06 – CO\]](#) [\[T7D06 – AA\]](#)

T7D07: Which of the following measurements are made using a multimeter?

See **USING A MULTIMETER** at T7D. Multimeters can measure voltage, resistance, current, and continuity. [\[T7D07 – CO\]](#) [\[T7D07 – AA\]](#)

T7D08: Which of the following types of solder should not be used for radio and electronic applications?

Soldering is a useful skill for amateur radio operators. Check out this soldering tutorial on YOUTUBE. www.youtube.com/watch?v=6rmErwU5E-k. One type of solder you should NOT use around sensitive electrical components is acid-core solder. Components have a tendency to corrode when exposed to moisture and heat. Using acid-core solder can remove the corrosion and aid in soldering. But, if you don't thoroughly clean the acid after soldering, the acid can cause even worse problems (including rapid corrosion). [\[T7D08 – CO\]](#) [\[T7D08 – AA\]](#)

T7D09: What is the characteristic appearance of a cold tin-lead solder joint?

See the YOUTUBE tutorial in question T7D08. A good solder joint is characterized by a bright, shiny appearance. A poor/cold solder joint will appear frosty, lumpy, and rough. [\[T7D09 – CO\]](#) [\[T7D09 – AA\]](#)

T7D10: What reading indicates that an ohmmeter is connected across a large, discharged capacitor?

See **BASIC ELECTRICAL PRINCIPLES** in T5A. From the formula for voltage ($E = I \times R$) you know that when voltage decreases, resistance increases. Capacitors have the ability to store a charge. As they discharge, their voltage will decrease, and the resistance will increase. [\[T7D10 – CO\]](#) [\[T7D10 – AA\]](#)

T7D11: Which of the following precautions should be taken when measuring in-circuit resistance with an ohmmeter?

See **USING A MULTIMETER** at T7D. 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. [\[T7D11 – CO\]](#) [\[T7D11 – AA\]](#)

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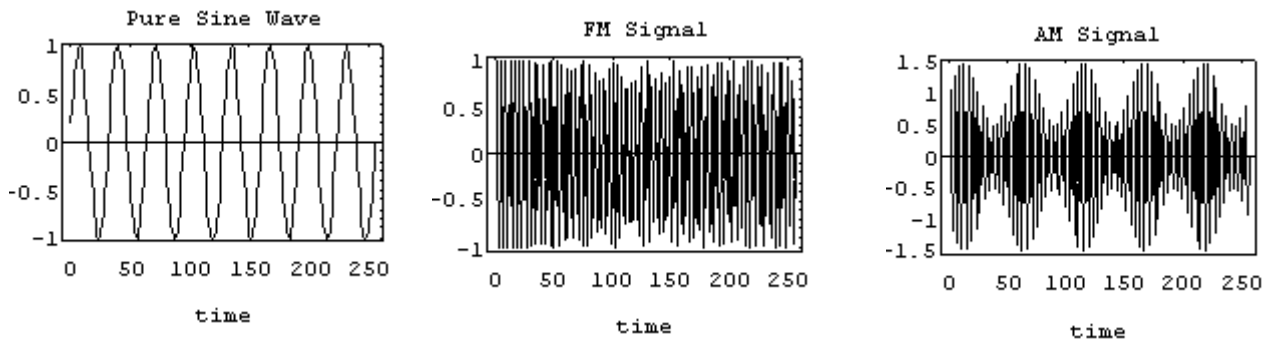
SUBLELEMENT T8 — SIGNALS AND EMISSIONS

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

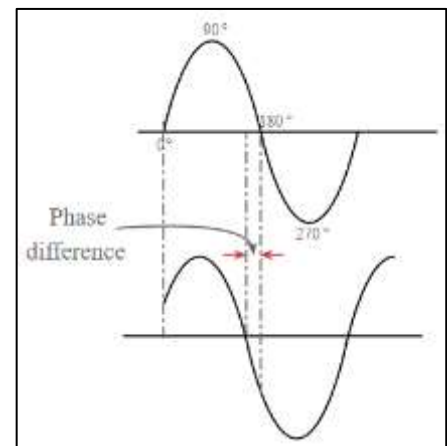
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Read the following article before answering the questions in this section.

MODULATION. See www.cwtouchkeyer.com/ham-radio-modulation and www.electronics-notes.com/articles/radio/modulation/phase-modulation-what-is-pm-tutorial.php. A radio signal by itself doesn't convey information. Modulation is the process of adding information or data to the carrier signal. You're sort of "piggy backing" information onto the signal. The receiving station picks up this signal and extracts the information from it. This is called demodulation. There are several ways to modulate the carrier signal. One of these is frequency modulation. The carrier signal is essentially a sine wave, like the first graph. Modulating the frequency effectively changes the period of the wave ... sort of an accordion effect. The amplitude (peak to peak) of the wave doesn't change. See the second diagram for an example of frequency modulation. Another type of modulation is amplitude modulation. In this case, the peak to peak distance changes, not the frequency. An example is the third graph. FM systems are far better at rejecting noise than AM systems. FM is



commonly used for packet radio on VHF and UHF. And, FM's ability to reject noise makes them the most-frequently chosen mode for use on VHF and UHF repeaters. The AM signal is made up of the carrier plus two sidebands ... an upper (USB, slightly higher in frequency than the signal) and lower (LSB, lower in frequency than the signal). The signal doesn't carry the info or data ... it's carried by the sidebands, but you only need one of them ... we refer to this a single sideband (SSB). This phenomenon enables the SSB signal's power to be concentrated into a narrow bandwidth, making it possible to communicate with SSB over much longer ranges and in poorer conditions than with FM or AM, particularly on UHF and VHF bands. By convention, ham radio uses LSB below 10 MHz and USB above 10 MHz (including VHF and UHF bands). One disadvantage of FM is that if there are multiple incoming signals, the receiver only detects the strongest one. In other words, FM can only receive one signal at a time. AM (including sideband communications) doesn't experience this disadvantage. Another form of modulation is phase modulation (PM). It's very similar to frequency modulation. Phase modulation works by modulating the phase of the signal. An example of this is the accompanying graph. The information is conveyed in the phase shift. This has opened the door for some new and exciting forms of ham communication (PM - Phase Modulation, PSK - Phase Shift Keying, BPSK - Binary Phase Shift Keying, QPSK - Quadrature Phase Shift Keying, 8 PSK - 8 Point Phase Shift Keying, etc.). Like FM, PM is also commonly used on packet radio.



T8A01: Which of the following is a form of amplitude modulation?

See **MODULATION** at T8A. The AM signal is made up of the carrier plus two sidebands ... an upper (USB, slightly higher in frequency than the signal) and lower (LSB, lower in frequency than the signal). The signal doesn't carry the info or data ... it's carried by the sidebands, but you only need one of them ... we refer to this a single sideband (SSB). [\[T8A01 – CO\]](#) [\[T8A01 – AA\]](#)

T8A02: What type of modulation is commonly used for VHF packet radio transmissions?

See **MODULATION** at T8A. Like FM, PM is also commonly used on packet radio. [\[T8A02 – CO\]](#) [\[T8A02 – AA\]](#)

T8A03: Which type of voice mode is often used for long-distance (weak signal) contacts on the VHF and UHF bands?

See **MODULATION** at T8A. This phenomenon enables the SSB signal's power to be concentrated into a narrow bandwidth, making it possible to communicate with SSB over much longer ranges and in poorer conditions than with FM or AM, particularly on UHF and VHF bands. [\[T8A03 – CO\]](#) [\[T8A03 – AA\]](#)

T8A04: Which type of modulation is commonly used for VHF and UHF voice repeaters?

See **MODULATION** at T8A. FM's ability to reject noise makes them the most-frequently chosen mode for use on VHF and UHF repeaters. [\[T8A04 – CO\]](#) [\[T8A04 – AA\]](#)

T8A05: Which of the following types of signal has the narrowest bandwidth?

See accompanying table (**Signal Bandwidths**). The narrowest bandwidth on this table is 150 kHz (CW or Morse Code). [\[T8A05 – CO\]](#) [\[T8A05 – AA\]](#)

| SIGNAL BANDWIDTHS | |
|-------------------|-------------------------|
| TYPE OF SIGNAL | BANDWIDTH |
| CW (Morse Code) | 150 Hz (0.15 kHz) |
| SSB Digital | 500-3000 Hz (0.5-3 kHz) |
| SSB Voice | 2000-3000 Hz (2-3 kHz) |
| AM Voice | 6000 Hz (6 kHz) |
| AM Fast-Scan TV | 6000 kHz (6 MHz) |
| FM Voice | 10-15 kHz |
| FM Broadcast | 150 kHz |
| Commercial Video | 6 MHz |

T8A06: Which sideband is normally used for 10 meter HF, VHF, and UHF single-sideband communications?

See **MODULATION** at T8A. By convention, ham radio uses LSB below 10 MHz and USB above 10 MHz (including VHF and UHF bands). [\[T8A06 – CO\]](#) [\[T8A06 – AA\]](#)

T8A07: What is a characteristic of single sideband (SSB) compared to FM?

Let's look at this one logically. From **MODULATION** at T8A you know that SSB is part of AM. And, you also know that AM is MORE susceptible in interference (noise). This rule out response B. It also rules out D. Now, refer to the table in question T8A05. SSB has a narrower bandwidth than FM (3000 Hz vs. 10000 Hz). [\[T8A07 – CO\]](#) [\[T8A07 – AA\]](#)

T8A08: What is the approximate bandwidth of a typical single sideband (SSB) voice signal?

Refer to the table in question T8A05. The value listed in the table for SSB Voice is 2 to 3 kHz. The closest response in the 4 answer choices is B ... 3kHz. [\[T8A08 – CO\]](#) [\[T8A08 – AA\]](#)

T8A09: What is the approximate bandwidth of a VHF repeater FM voice signal?

Refer to the table in question T8A05. The value given for FM Voice is 10-15 kHz. Don't let the additional term *VHF repeater* confuse you. [\[T8A09 – CO\]](#) [\[T8A09 – AA\]](#)

T8A10: What is the approximate bandwidth of AM fast-scan TV transmissions?

Refer to the table in question T8A05. The value given for AM fast-scan TV is 6 MHz. [\[T8A10 – CO\]](#) [\[T8A10 – AA\]](#)

T8A11: What is the approximate bandwidth required to transmit a CW signal?

Refer to the table in question T8A05. The value given for CW is 150 Hz. [\[T8A11 – CO\]](#) [\[T8A11 – AA\]](#)

T8A12: Which of the following is a disadvantage of FM compared with single sideband?

See **MODULATION** at T8A. FM receivers only detect the strongest incoming signal. As a result, they can only detect one signal at a time. [\[T8A12 – CO\]](#) [\[T8A12 – AA\]](#)

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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 TOC

Read the following article and table before answering the questions in this section.

SATELLITE COMMUNICATIONS. See <https://hamradioprep.com/ham-radio-satellites>. Before reading this section, review the accompanying table of Satellite Definitions. Some of these definitions will be test questions!

There are dozens of amateur radio satellites in space, and many of them operate on the 2-meter and 70-cm bands, meaning that licensed Technicians may communicate with them. Specifically, 146.8 to 146.0 MHz (2 meters) and 435.0 to 438.0 MHz (70 cm) frequencies have been set aside for earth-to-space communications. Many satellites use separate *uplink* and *downlink* frequencies ... sort of like a repeater in orbit. Licensed technicians can even transmit on the International Space Station's (ISS) uplink frequency. This may be rather obvious, but satellites, unlike earth-based stations, are moving! You'll need to be able to track one to communicate with it. For example, you'll only be able to contact the ISS when it's approximately directly overhead. You use a *satellite tracking program* for this, which provide data

| SATELLITE DEFINITIONS | |
|--------------------------|---|
| AMSAT | An educational organization whose mission is to foster amateur radio's participation in space research and communication |
| Apogee | The point of a satellite's orbit that is farthest from Earth |
| Beacon | A carrier or signal transmitted by a satellite which supplies the controlling engineers on the ground with a means of monitoring telemetry data and status information, including the health and status of the satellite |
| Clarke Orbit | A circular orbit in space 22,237 miles from the surface of the earth at which geosynchronous satellites are placed. |
| Downlink | The satellite to earth half of a 2 way telecommunications satellite link |
| Doppler shift | An observed change in signal frequency caused by relative motion between the satellite and the Earth station. A good way to remember this is to think about the sound you hear when a car is driving towards you blowing its horn. The horn's frequency changes as the car gets closer and as it passes by. |
| 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 |
| Terrestrial Interference | Interference to satellite reception caused by ground based microwave transmitting stations |

about the satellite's orbit (called *Keplerian elements* or KEPs, named after Johannes Kepler, known for the development of Kepler's Laws of Planetary Motion). This software will calculate real-time positioning and trajectory (including Doppler shift), allowing you to aim your beam antenna (called a Yagi). To contact a satellite, you'll also need to know its *mode*. For example, some satellites use UHF frequencies (70 cm) for uplink and VHF frequencies (2 meter) for downlink ... this is called U/V mode. The most common modes are SSB, FM, CW (Morse Code), and data. Another issue you need to be aware of when communicating with satellites is their limited power sources. You need to make sure your uplink power is correct ... not too low, not too high. A general rule of thumb is to match your downlink signal strength to that of the beacon. So, jump right in and *squirt the bird* (communicate with a satellite). But, even without a license, you're allowed to listen. Anyone on the correct frequency can monitor satellite transmissions!

T8B01: What telemetry information is typically transmitted by satellite beacons?

See the **SATELLITE DEFINITIONS** table at T8B. A carrier or signal transmitted by a satellite which supplies the controlling engineers on the ground with a means of monitoring telemetry data and status information, including the health and status of the satellite. [\[T8B01 – CO\]](#) [\[T8B01 – AA\]](#)

T8B02: What is the impact of using excessive effective radiated power on a satellite uplink?

See **SATELLITE COMMUNICATIONS** at T8B. Recall that satellites work sort of like repeaters. And, because of where they're located (orbit), their power sources are limited. If you use too much transmitted power, you can actually block access by others. [\[T8B02 – CO\]](#) [\[T8B02 – AA\]](#)

T8B03: Which of the following are provided by satellite tracking programs?

See **SATELLITE COMMUNICATIONS** at T8B. You use a *satellite tracking program* for this, which provide data about the satellite's orbit (called *Keplerian elements*, named after Johannes Kepler, known for the development of Kepler's Laws of Planetary Motion). This software will calculate real-time positioning and trajectory (including Doppler shift).

[\[T8B03 – CO\]](#) [\[T8B03 – AA\]](#)

T8B04: What mode of transmission is commonly used by amateur radio satellites?

See **SATELLITE COMMUNICATIONS** at T8B. The most common modes are SSB, FM, CW (Morse Code), and data.

[\[T8B04 – CO\]](#) [\[T8B04 – AA\]](#)

T8B05: What is a satellite beacon?

See the **SATELLITE DEFINITIONS** table at T8B. A carrier or signal transmitted by a satellite which supplies the controlling engineers on the ground with a means of monitoring telemetry data and status information, including the health and status of the satellite. [\[T8B05 – CO\]](#) [\[T8B05 – AA\]](#)

T8B06: Which of the following are inputs to a satellite tracking program?

See **SATELLITE COMMUNICATIONS** at T8B. You use a *satellite tracking program* for this, which provide data about the satellite's orbit (called *Keplerian elements*, named after Johannes Kepler, known for the development of Kepler's Laws of Planetary Motion). [\[T8B06 – CO\]](#) [\[T8B06 – AA\]](#)

T8B07: What is Doppler shift in reference to satellite communications?"

See the **SATELLITE DEFINITIONS** table at T8B. An observed change in signal frequency caused by relative motion between the satellite and the Earth station. [\[T8B07 – CO\]](#) [\[T8B07 – AA\]](#)

T8B08: What is meant by the statement that a satellite is operating in U/V mode?

See **SATELLITE COMMUNICATIONS** at T8B. For example, some satellites use UHF frequencies (70 cm) for uplink and VHF frequencies (2 meter) for downlink ... this is called U/V mode. [\[T8B08 – CO\]](#) [\[T8B08 – AA\]](#)

T8B09: What causes spin fading of satellite signals?

See the **SATELLITE DEFINITIONS** table at T8B. Signal fading caused by rotation of the satellite and its antennas. [\[T8B09 – CO\]](#) [\[T8B09 – AA\]](#)

T8B10: What is a LEO satellite?

See the **SATELLITE DEFINITIONS** table at T8B. A satellite in low-Earth orbit. [\[T8B10 – CO\]](#) [\[T8B10 – AA\]](#)

T8B11: Who may receive telemetry from a space station?

See **SATELLITE COMMUNICATIONS** at T8B. But, even without a license, you're allowed to listen. Anyone on the correct frequency can monitor satellite transmissions! [\[T8B11 – CO\]](#) [\[T8B11 – AA\]](#)

T8B12: Which of the following is a way to determine whether your satellite uplink power is neither too low nor too high?

See **SATELLITE COMMUNICATIONS** at T8B. A general rule of thumb is to match your downlink signal strength to that of the beacon. [\[T8B12 – CO\]](#) [\[T8B12 – AA\]](#)

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Read the following articles and table before answering the questions in this section.

OPERATING ACTIVITIES. Some of the more popular ham radio activities are listed in the accompanying table.

For many of the activities noted in the accompanying table, radio operators provide their location. This is often done with a grid locator, specifically the Maidenhead Locator System (www.mapability.com/ei8ic/maps/gridloc.php). Other names for the grid locator are: grid squares, QTH, or grid location. A Maidenhead locator compresses latitude and longitude into a short string of characters ... a letter/number designator assigned to a specific geographic location.

DIGITAL REPEATERS. See the following reference ... www.cwtouchkeyer.com/digital-repeater-systems-all-you-need-to-know. You read a lot about

repeaters in the question explanations in sections T1 and T2. These are *analog* repeaters. Digital repeaters operate much like analog repeaters, but the retransmit data in *binary digital signals*. In digital communication systems, repeaters overcome the attenuation/loss caused by free-space electromagnetic-field or cable loss that occur in analog repeaters. Example of digital systems:

- IRLP (Internet Radio Linking Project) links amateur radio stations around the world by using Voice over IP.
- EchoLink is a computer-based Amateur Radio system distributed free of charge that allows radio amateurs to communicate with other amateur radio operators using Voice over IP (VoIP) technology on the Internet for at least part of the path between them. VoIP is a type of phone system that uses an internet connection (digitally) to make and receive calls ... a radio is not required. All that's required for use of EchoLink is proof of your license and registration of your call sign.
- D-STAR (Digital Smart Technologies for Amateur Radio) is a digital voice and data protocol specification for amateur radio
- DMR (Digital mobile radio) is a specification for commercial products so they can interoperate. It is defined by a standard created by the European Telecommunications Standards Institute (ETSI), and is designed to be low-cost and easy to use. The DMR standard operates within the existing 12.5 kHz channel spacing used in land mobile frequency bands globally, but achieves two voice channels through two-slot TDMA (Time Division Multiple Access) technology. This last point simply means that DMR enables time-multiplexing of two digital voice signals on a single 12.5 kHz repeater channel.

Digital modes, like analog repeaters, require certain code to access them. For IRLP and EchoLink, the code is a sequence of dual-tone multi-frequency tones (called DTMF codes). DMR requires digital codes called *color codes*, similar to CTCSS or PL access tones in analog repeaters. DMR controllers organize network users into *talk groups*, which allow users to share channels at different times without being heard by others on the same channel. All the DMR codes, talk group info, etc. is contained in software called a *code plug*, making it easy to program your DMR radio. Many of today's digital transceivers are versatile (and programmable) enough to enable them to access multiple digital systems ... meaning you won't need a separate radio for each digital mode. As noted above, some of these digital modes connect radio to the internet. A digital station providing this connection is called a *gateway*.

| POPULAR HAM RADIO ACTIVITIES | |
|------------------------------|--|
| DXing | Making two-way radio contact with distant stations. A DX is a distant station. "Distant" is different, depending upon your frequency ... for HF is might be several thousand miles. For 2 meters (VHF), it might be 30-40 miles. |
| Contests | Hams are big on contests. We have Morse Code (CW) contests, distance contests (DXing), low power (QRP) contests, emergency power (solar, etc.) contests, and combinations (CW/QRP/DX). A common goal of most contests is to contact as many stations as possible within a specific time span, so you'll want to send the least amount of info you can to properly identify yourself ... just your call sign, unless asked for more. |
| Field Day | ARRL Field Day is a big deal! The event serves as an emergency preparedness test, as well as a contest between radio enthusiasts across the U.S. and Canada. After years of struggling, our little club in Murphy, NC (www.wcars-murphy.org) finished 6 th in our class in the US/Canada and 1 st in NC. For details: www.arrl.org/field-day . |
| Fox Hunts | Fox hunting, or radio direction finding, is a favorite pastime in the ham radio community where radio operators attempt to triangulate the position of a hidden radio transmission. Commonly used tools for this include a receiver, compass, and directional antenna. This is good practice for locating sources of noise interference or jamming. |
| Testing (VE) | A good way to give back to the hobby is to become a Volunteer Examiner or VE. Although the FCC (Federal Communications Commission) issues licenses, an army of volunteers give the exams. This is also a good opportunity to network with other hams and keep your own knowledge base up to date. |
| Digital Modes | See discussion of DIGITAL REPEATERS. Using digital modes have become very popular in recent years. |

T8C01: Which of the following methods is used to locate sources of noise interference or jamming?

See the **POPULAR HAM RADIO ACTIVITIES** table at T8C. Fox hunting, or radio direction finding, is a favorite pastime in the ham radio community where radio operators attempt to triangulate the position of a radio transmission. This is good practice for locating sources of noise interference or jamming. [\[T8C01 – CO\]](#) [\[T8C01 – AA\]](#)

T8C02: Which of these items would be useful for a hidden transmitter hunt?

See the **POPULAR HAM RADIO ACTIVITIES** table at T8C. Commonly used tools for this include a receiver, compass, and directional antenna. [\[T8C02 – CO\]](#) [\[T8C02 – AA\]](#)

T8C03: What operating activity involves contacting as many stations as possible during a specified period?

See the **POPULAR HAM RADIO ACTIVITIES** table at T8C. A common goal of most contests is to contact as many stations as possible within a specific time span. [\[T8C03 – CO\]](#) [\[T8C03 – AA\]](#)

T8C04: Which of the following is good procedure when contacting another station in a contest?

See the **POPULAR HAM RADIO ACTIVITIES** table at T8C. You'll want to send the least amount of info you can to properly identify yourself. [\[T8C04 – CO\]](#) [\[T8C04 – AA\]](#)

T8C05: What is a grid locator?

See **OPERATING ACTIVITIES** at T8C. A Maidenhead locator compresses latitude and longitude into a short string of characters ... a letter/number designator assigned to a specific geographic location. [\[T8C05 – CO\]](#) [\[T8C05 – AA\]](#)

T8C06: How is over the air access to IRLP nodes accomplished?

See the **DIGITAL REPEATERS** article at T8C. Digital modes, like analog repeaters, require certain code to access them. For IRLP and EchoLink, the code is a sequence of dual-tone multi-frequency tones (called DTMF codes). [\[T8C06 – CO\]](#) [\[T8C06 – AA\]](#)

T8C07: What is Voice Over Internet Protocol (VoIP)?

See the **DIGITAL REPEATERS** article at T8C. VoIP is a type of phone system that uses an internet connection (digitally) to make and receive calls. [\[T8C07 – CO\]](#) [\[T8C07 – AA\]](#)

T8C08: What is the Internet Radio Linking Project (IRLP)?

See the **DIGITAL REPEATERS** article at T8C. IRLP (Internet Radio Linking Project) links amateur radio stations around the world by using Voice over IP (Internet Protocol). [\[T8C08 – CO\]](#) [\[T8C08 – AA\]](#)

T8C09: Which of the following protocols enables an amateur station to transmit through a repeater without using a radio to initiate the transmission?

See the **DIGITAL REPEATERS** article at T8C. EchoLink is a computer-based Amateur Radio system distributed free of charge that allows radio amateurs to communicate with other amateur radio operators using Voice over IP (VoIP) technology on the Internet for at least part of the path between them. VoIP is a type of phone system that uses an internet connection (digitally) to make and receive calls ... a radio is not required. [\[T8C09 – CO\]](#) [\[T8C09 – AA\]](#)

T8C10: What is required before using the EchoLink system?

See the **DIGITAL REPEATERS** article at T8C. All that's required for use of EchoLink is proof of your license and registration of your call sign. [\[T8C10 – CO\]](#) [\[T8C10 – AA\]](#)

T8C11: What is an amateur radio station that connects other amateur stations to the internet?

See the **DIGITAL REPEATERS** article at T8C. Some of these digital modes connect radio to the internet. A digital station providing this connection is called a gateway. [\[T8C11 – CO\]](#) [\[T8C11 – AA\]](#)

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Read the following articles and table before answering the questions in this section.

DIGITAL COMMUNICATIONS. See www.onallbands.com/the-rise-of-digital-modes-the-changing-face-of-ham-radio.

You had a brief intro into digital modes in the **DIGITAL REPEATERS** article at T8C. Some of the more popular digital modes are described in the accompanying table.

In addition to what's in the table, APRS (Automatic Packet Reporting System) is a radio-based system for real time digital communications of information of immediate value in the local area. Data can include object Global Positioning System (GPS) coordinates, weather station telemetry, text messages, announcements, queries, and other telemetry. A typical application of APRS is to provide real-time tactical digital communications in conjunction with a map showing the locations of stations. A mesh network uses Wi-Fi equipment and modified firmware to operate a private, self-contained wireless computer network.

VIDEO COMMUNICATIONS. Amateur Radio operators can transmit live action color video and sound to other hams easily on UHF bands. This includes analog and digital TV signals. Various transmission standards are used, these include the broadcast transmission standards of NTSC (National Television System Committee, an analog fast-scan color TV signal) in North America and Japan, and PAL or SECAM elsewhere.

| POPULAR DIGITAL MODES | |
|-----------------------|--|
| MODE | DESCRIPTION |
| RTTY (Radio-teletype) | A telecommunications system consisting originally of two or more electromechanical teleprinters in different locations connected by radio rather than a wired link. Uses a form of transmission known as frequency shift keying. |
| PSK31 | A highly-efficient data mode that lets you work long distances, even when you can barely hear the signal. PSK31 stands for Phase Shift Keying 31 baud (or 31 bits per second/bps). Enables real-time keyboard-to-keyboard chat. |
| FT8 | A form of digital weak signal communication. It is currently the most popular digital mode on spotting. The mode offers operators the ability to communicate in unfavorable environments such as during low sun spot numbers, high RF noise, or during low power operations. FT8 is known for low signal-to-noise operation. |
| WINMOR | A radio transmission protocol intended to be used in the Winlink 2000 Global Radio E-mail System by amateur radio operators, marine radio stations, and radio stations in isolated areas. |
| JT65 | A digital protocol for Amateur Radio communication with extremely weak signals. It was designed to optimize Earth-Moon-Earth (EME) contacts on VHF bands. WSJT-X software (which stands for "Weak Signal Communication, by K1JT") offers digital protocols optimized for EME (moonbounce), meteor scatter, and ionospheric scatter (weak signal communications). |
| Packet Radio | The application of packet switching techniques to digital radio communications. Packet radio uses a packet switching protocol as opposed to circuit switching or message switching protocols to transmit digital data via a radio communication link. Packet radio has most often been used for direct, keyboard-to-keyboard connections between stations. Some advantages of packet radio over its predecessors include; (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, and (c) automatic repeat request in case of error. This checksum error detection method is called ARQ for automatic repeat request -- the receiving station detects errors and sends a request for retransmission. |
| IEEE 802.11 | The 802.11a amateur radio band consists of 30 overlapping channels in the 5.650–5.925 GHz (5 cm) band. The 802.11a standard uses OFDM or "Orthogonal Frequency Division Multiplexing" to transmit data and therefore is not classified as spread-spectrum. |
| CW (Morse Code) | Morse Code is the earliest type of digital communications, as the code is made solely from Ones and Zeros (ons and offs). Hams use Morse Code and CW interchangeably. CW stands for continuous wave ... the signal is continuous, but modulated by turning an audio tone on and off. |

T8D01: Which of the following is a digital communications mode?

See the **POPULAR DIGITAL MODES** table at T8D. The correct answer is **D ... all choices**. Packet radio, IEEE 802.11, FT8 and others are digital communications modes. [\[T8D01 – CO\]](#) [\[T8D01 – AA\]](#)

T8D02: What is a Talkgroup on a DMR repeater?

See the **DIGITAL REPEATERS** article at T8C. DMR controllers organize network users into talk groups, which allow users to share channels at different times without being heard by others on the same channel. [\[T8D02 – CO\]](#) [\[T8D02 – AA\]](#)

T8D03: What kind of data can be transmitted by APRS?

See the **DIGITAL COMMUNICATIONS** article at T8D. APRS data can include object Global Positioning System (GPS) coordinates, weather station telemetry, text messages, announcements, queries, and other telemetry. The correct answer is **D ... all choices correct**. [\[T8D03 – CO\]](#) [\[T8D03 – AA\]](#)

T8D04: What type of transmission is indicated by the term “NTSC?”

See the **VIDEO COMMUNICATIONS** article at T8D. Various transmission standards are used, these include the broadcast transmission standards of NTSC (National Television System Committee, an analog fast-scan color TV signal) in North America and Japan, and PAL or SECAM elsewhere. [\[T8D04 – CO\]](#) [\[T8D04 – AA\]](#)

T8D05: Which of the following is an application of APRS?

See the **DIGITAL COMMUNICATIONS** article at T8D. A typical application of APRS is to provide real-time tactical digital communications in conjunction with a map showing the locations of stations. [\[T8D05 – CO\]](#) [\[T8D05 – AA\]](#)

T8D06: What does the abbreviation “PSK” mean?

See the **POPULAR DIGITAL MODES** table at T8D. PSK31 stands for Phase Shift Keying 31 baud. [\[T8D06 – CO\]](#) [\[T8D06 – AA\]](#)

T8D07: Which of the following describes DMR?

See the **DIGITAL REPEATERS** article at T8C. The DMR standard operates within the existing 12.5 kHz channel spacing used in land mobile frequency bands globally, but achieves two voice channels through two-slot TDMA (Time Division Multiple Access) technology. This last point simply means that DMR enables time-multiplexing of two digital voice signals on a single 12.5 kHz repeater channel. [\[T8D07 – CO\]](#) [\[T8D07 – AA\]](#)

T8D08: Which of the following is included in packet radio transmissions?

See the **POPULAR DIGITAL MODES** table at T8D. Some advantages of packet radio over its predecessors include; (a) a checksum that permits error detection, (b) a header that contains the call sign of the station to which the information is being sent, and (c) automatic repeat request in case of error. The correct answer is **D ... all choices correct**. [\[T8D08 – CO\]](#) [\[T8D08 – AA\]](#)

T8D09: What is CW?

See the **POPULAR DIGITAL MODES** table at T8D. Hams use Morse Code and CW interchangeably. CW stands for continuous wave ... the signal is continuous, but modulated by turning an audio tone on and off. [\[T8D09 – CO\]](#) [\[T8D09 – AA\]](#)

T8D10: Which of the following operating activities is supported by digital mode software in the WSJT-X software suite?

See the **POPULAR DIGITAL MODES** table at T8D. WSJT-X software (which stands for "Weak Signal Communication, by K1JT") offers digital protocols optimized for EME (moonbounce), meteor scatter, and ionospheric scatter (weak signal communications). The correct answer is **D ... all choices correct**. [\[T8D10 – CO\]](#) [\[T8D10 – AA\]](#)

T8D11: What is an ARQ transmission system?

See the **POPULAR DIGITAL MODES** table at T8D. This checksum error detection method is called ARQ for automatic repeat request -- the receiving station detects errors and sends a request for retransmission. [\[T8D11 – CO\]](#) [\[T8D11 – AA\]](#)

T8D12: Which of the following best describes an amateur radio mesh network?

See the **DIGITAL COMMUNICATIONS** article at T8D. A mesh network uses Wi-Fi equipment and modified firmware to operate a private, self-contained wireless computer network. [\[T8D12 – CO\]](#) [\[T8D21 – AA\]](#)

T8D13: What is FT8?

See the **POPULAR DIGITAL MODES** table at T8D. FT8 is known for low signal-to-noise operation. [\[T8D13 – CO\]](#) [\[T8D13 – AA\]](#)

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SUBELEMENT T9 — ANTENNAS AND FEED LINES

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



Read the following article and table before answering the questions in this section.

ANTENNAS. See www.iw5edi.com/ham-radio/2437/antenna-basics. Also refer to the article on **STANDING WAVE RATIO** at T7C. Also refer to the **ANTENNA TYPES** table accompanying this article.

Antennas work by converting the signal from the transmitter to an electromagnetic field or wave. When this wave hits another antenna connected to a receiver, it creates a current in that antenna. This current is converted by the receiver into data (in the form of voice, Morse Code, etc.). The length of the antenna is related to the frequency of the signal you're transmitting. A mismatch in the length and frequency results in unacceptable standing wave ratio ... a loss of transmission power, converted to heat. The radiation pattern from the antenna depends significantly upon the antenna type. Radio waves contain both an electric and magnetic field. These are perpendicular to each other. But, it's the electric field that interests us. The electric field is oriented in the same plane as the antenna's element. Ideally (for optimum reception), the receiving antenna should be oriented in the same place as the transmitting antenna. A horizontal dipole antenna will have its element aligned with or parallel to the surface of the earth. A vertical dipole will have its element 90° to the earth's surface. This antenna orientation is called

| ANTENNA TYPES | |
|--------------------|--|
| ANTENNA | DESCRIPTION |
| Single-band | Designed for use on a single ham band |
| Dual-band | Typically, can send and receive ham radio signals on both VHF and UHF ham bands |
| Rubber duck | The one you get with your cheap handheld transceiver (HT); you'll want to upgrade quickly because they're much less efficient than a typical quarter-wave antenna. Advantages – they're compact and flexible. Signal strength is significantly impaired when used inside a vehicle (due to shielding), so you want to connect it to an external antenna. |
| Dipole | Most common ham radio antennas, essentially means <i>two electrical parts</i> ; made from a straight conductor of wire or tubing one-half wavelength long with feed-point in the middle; dipoles are single element antennas. Dipoles radiate strongest broadside to the antenna and weakest 90° away from broadside. |
| Trap dipole | Mostly used in ham radio repeater systems; consists of ham radio traps and coils and it can be adjusted to various ham radio frequencies by changing the length of the wire |
| Yagi / Directional | Also called a beam antenna; used to increase signal level at a distant station or to reject interference or noise; has multiple elements arranged in front of it for optimal transmission and reception; beams are designed to concentrate signals in one direction; have more gain or signal strength in their preferred direction than other antenna types |
| Ground plane | Sometimes called a vertical antenna; acts like one-half of a dipole with the missing portion made up by the electrical mirror formed by the ground plane (remember this when calculating antenna length – divide by 2); made from sheet metal or a screen of wires called radials that extend out from the base of the antenna |
| End Fed | Sometimes called End Fed Half Wave; a in the shape of a dipole ham radio antenna with one leg longer than the other |

polarization. Because of space limitations, it may not be possible to construct an antenna as long as needed for a specific frequency. To reduce the physical antenna size, it's possible to insert a coil or inductor into the antenna which effectively increases its electrical length. This is called inductive loading. This is common when building codes restrict antenna size. The approximate length of a dipole antenna is calculated as: **Length (feet) = 468 / frequency (MHz)** (you'll see test questions using this formula). However, because the actual resonance is affected by height above ground and the antenna's electrical properties, you need to increase this calculated length of the antenna (which lowers its resonant frequency) by 5 to 10%, then fine-tune the SWR with an antenna analyzer. Similarly, shortening the antenna will increase the resonant frequency. Regarding antenna length, it's not necessary to use a full wavelength antenna. For example, you don't need an 80 meter ((more than 250 feet) antenna to transmit on the 80-meter band. But, to be resonant (and minimize SWR), you need discrete increments of the wavelength (½ wavelength, ¼ wavelength, 5/8 wavelength, even 1/8 wavelength) ... the longer the antenna, the higher the gain or signal strength.

T9A01: What is a beam antenna?

See the **ANTENNA TYPES** table at T9A. Beams are designed to concentrate signals in one direction. [\[T9A01 – CO\]](#) [\[T9A01 – AA\]](#)

T9A02: Which of the following describes a type of antenna loading?

See the **ANTENNAS** article at T9A. To reduce the physical antenna size, it's possible to insert a coil or inductor into the antenna which effectively increases its electrical length. [\[T9A02 – CO\]](#) [\[T9A02 – AA\]](#)

T9A03: Which of the following describes a simple dipole oriented parallel to Earth's surface?

See the **ANTENNAS** article at T9A. A horizontal dipole antenna will have its element aligned with or parallel to the surface of the earth. [\[T9A03 – CO\]](#) [\[T9A03 – AA\]](#)

T9A04: What is a disadvantage of the short, flexible antenna supplied with most handheld radio transceivers, compared to a full-sized quarter-wave antenna?

See the **ANTENNA TYPES** table at T9A. Referring to the "rubber duck" antenna ... The one you get with your cheap handheld transceiver (HT); you'll want to upgrade quickly because they're much less efficient than a typical quarter-wave antenna. Advantages – they're compact and flexible. [\[T9A04 – CO\]](#) [\[T9A04 – AA\]](#)

T9A05: Which of the following increases the resonant frequency of a dipole antenna?

See the **ANTENNAS** article at T9A. However, because the actual resonance is affected by height above ground and its electrical properties, we've found that you need to increase this calculated length of the antenna (which lowers its resonant frequency) by 5 to 10% then fine-tune the SWR with an antenna analyzer. Similarly, shortening the antenna will increase the resonant frequency. [\[T9A05 – CO\]](#) [\[T9A05 – AA\]](#)

T9A06: Which of the following types of antenna offers the greatest gain?

See the **ANTENNA TYPES** table at T9A. Yagi / Directional antennas ... have more gain or signal strength in their preferred direction than other antenna types. [\[T9A06 – CO\]](#) [\[T9A06 – AA\]](#)

T9A07: What is a disadvantage of using a handheld VHF transceiver with a flexible antenna inside a vehicle?

See the **ANTENNA TYPES** table at T9A. Signal strength is significantly impaired when used inside a vehicle (due to shielding), so you want to connect it to an external antenna. [\[T9A07 – CO\]](#) [\[T9A07 – AA\]](#)

T9A08: What is the approximate length, in inches, of a quarter-wavelength vertical antenna for 146 MHz?

See the **ANTENNAS** article and the **ANTENNA TYPES** table at T9A. The formula for the length of a dipole antenna is ...

$$\text{Length (feet)} = 468 / \text{frequency (MHz)}$$

But, remember a vertical antenna is a ground plane, and you'll need to divide the length of the antenna by 2. So, we get ...

$$\text{Length (feet)} = 468 / \text{frequency (MHz)} / 2 = 468 / 146 / 2 = 1.603 \text{ ft} = \underline{19.23 \text{ in}} \quad \text{[T9A08 – CO] [T9A08 – AA]}$$

T9A09: What is the approximate length, in inches, of a half-wavelength 6 meter dipole antenna?

See the **ANTENNAS** article at T9A for the formula for the length of a dipole antenna. You'll also need to know that the voice portion of the 6-meter band starts at 50.1 MHz (see the graphic band plan screen shot in T1B05).

$$\text{Length (feet)} = 468 / \text{frequency (MHz)} = 468 / 50.1 = 9.34 \text{ ft} = \underline{112.1 \text{ in}}$$

If you use 50 MHz for the start of the 6-meter band (available for CW), you'll get an answer of $468 / 50 = 9.36 \text{ ft} = 112.3 \text{ in}$. This difference (0.2 in) isn't enough to affect the answer choice. [\[T9A09 – CO\]](#) [\[T9A09 – AA\]](#)

T9A10: In which direction does a half-wave dipole antenna radiate the strongest signal?

See the **ANTENNA TYPES** table at T9A. Dipoles radiate strongest broadside to the antenna and weakest 90° away from broadside. [\[T9A10 – CO\]](#) [\[T9A10 – AA\]](#)

T9A11: What is antenna gain?

See the **ANTENNA TYPES** table at T9A. Referring to a Yagi antenna, they have more gain or signal strength in their preferred direction than other antenna types. [\[T9A11 – CO\]](#) [\[T9A11 – AA\]](#)

T9A12: What is an advantage of a 5/8 wavelength whip antenna for VHF or UHF mobile service?

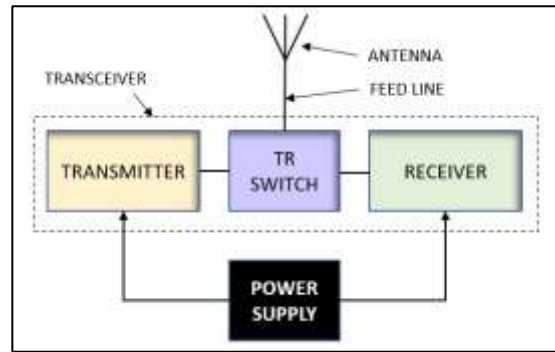
See the **ANTENNAS** article at T9A. To be resonant (and minimize SWR), you need discrete increments of the wavelength ($\frac{1}{2}$ wavelength, $\frac{1}{4}$ wavelength, $\frac{5}{8}$ wavelength, even $\frac{1}{8}$ wavelength) ... the longer the antenna, the higher the gain or signal strength. [\[T9A12 – CO\]](#) [\[T912 – AA\]](#)

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Read the following articles and table before answering the questions in this section.

FEEDLINES. As you can see in the accompanying diagram, the feedline connects the radio (transceiver) to the antenna. There are several types of construction or design for feedlines. The most common is coax. Coax is a round cable with an insulated conducting wire in the center. Over the insulation is a shield, usually made of braided wire or conducting foil. The shield is protected by a sheath or jacket. Coax is easy to work with and presents few installation issues. A coax variation is called hardline, which has a much less flexible sheath (usually made of aluminum or copper) than standard coax. It has less signal loss, but more difficult to work with (because it doesn't bend easily), than other types of coax. It's often referred to as *air insulated hardline*. Open cell foam insulation is sometimes used in coax designs to improve flexibility, but be aware that is susceptible to absorbing water. Open wire line uses 2 parallel conductors, separated by insulation. It's less expensive than coax, and has less signal loss, but is harder to work with and can be affected by nearby signals or conducting surfaces (because there's no shielding). Window line is a type of open wire line. The conductors tend to be spaced further apart than the open wire line. The "windows" in the insulation make it a little more flexible than open wire line (easier to work with). Impedance of the feedline must be considered because you need to match the impedance (symbol Z_0) of the feedline and antenna with your transmitter. Most coax and hardline designed for amateur radio have an impedance of 50 ohms



(symbol Ω), which matches most of today's transmitters (TV coax is usually 75 Ω). Open wire line is usually 300 Ω , while window line is 450 Ω or more. It's important to remember that your antenna SYSTEM consists of the antenna (see the **ANTENNAS** article at T9A) AND your feedline. (Refer to the accompanying **COAX CABLE**

| COAX CABLE CHARACTERISTICS | | | | |
|----------------------------|------------------|---------------------------|-----------------------------|------------------------------|
| TYPE | IMPEDANCE (ohms) | LOSS/100 FT (dB) @ 30 MHz | LOSS/100 FT (dB) @ 1500 MHz | RELATIVE COST (As of 2/1/23) |
| RG-6 | 75 | 1.4 | 3.3 | \$300/1000 ft |
| RG-8 | 50 | 1.1 | 2.5 | |
| RG-8X | 50 | 2.0 | 4.5 | \$1900/1000 ft |
| RG-58 | 50 | 2.5 | 5.6 | \$600/1000 ft |
| RG-174 | 50 | 4.6 | 10.3 | \$350/1000 ft |
| RG-213 | 50 | 1.1 | 2.5 | \$350/1000 ft |
| LMR-400 | 50 | 0.7 | 1.5 | \$2000/1000 ft |

CHARACTERICS table for important cable

info.) You need to match the impedance of your transmitter with that of the antenna system. It's difficult to design your antenna system to match perfectly, so we use *antenna tuners* (also called *antenna couplers*) to accomplish this. You adjust the tuner until the standing wave ratio at the transmitter is close to 1:1. This tuning or matching doesn't really tune the antenna ... it just matches the impedance of the antenna system to that of the transmitter's output, and this must be done for each frequency you're transmitting on. In other words, it's important to DESIGN your system up front to obtain the lowest possible SWR and then tune as close as you can to 1:1 SWR. The higher the SWR, the more the signal loss. A few final points about signal loss; (1) feedlines used at radio frequencies are constructed from special materials to minimize loss, (2) regardless of the type of feedline, signal loss increases with frequency ... the higher the frequency, the more the loss, (3) avoid multiple connections, where possible, such as using several short cable segments with multiple connectors ... the more connectors, the more loss.

CONNECTORS (for coaxial cables). Connectors are used to connect cables to radios and related equipment ... even for cable-to-cable connections. PL-259 (male, plug) and SO-239 (female, receptacle) are one of the most common sets for HF and VHF equipment (see accompanying diagram). You'll also hear about "Type N" connectors. This is essentially a higher performance version of "standard" connectors. It's designed for use above 400 MHz, but can operate up to 11 GHz. One thing you'll need to be careful of is exposure of the connectors to the elements. Water will degrade the connection (causing corrosion) and the protective shield, resulting in loss of signal. So, you'll have to take precautions to make your



connections as waterproof as possible. Connectors can contribute to SWR. Specifically, loose connections are often the source of erratic SWR, and connectors can become loose over time, especially in areas with high winds.

T9B01: What is a benefit of low SWR?

See the **STANDING WAVE RATIO** article at T7C. The lower the SWR, the lower the signal loss. [\[T9B01 – CO\]](#) [\[T9B01 – AA\]](#)

T9B02: What is the most common impedance of coaxial cables used in amateur radio?

See the **FEEDLINES** article at T9B. Most coax and hardline designed for amateur radio have an impedance of 50 ohms. [\[T9B02 – CO\]](#) [\[T9B02 – AA\]](#)

T9B03: Why is coaxial cable the most common feed line for amateur radio antenna systems?

See the **FEEDLINES** article at T9B. Coax is easy to work with and presents few installation issues. [\[T9B03 – CO\]](#) [\[T9B03 – AA\]](#)

T9B04: What is the major function of an antenna tuner (antenna coupler)?

See the **FEEDLINES** article at T9B. This tuning or matching doesn't really tune the antenna ... it just matches the impedance of the antenna system to that of the transmitter's output. [\[T9B04 – CO\]](#) [\[T9B04 – AA\]](#)

T9B05: What happens as the frequency of a signal in coaxial cable is increased?

See the **FEEDLINES** article at T9B. Regardless of the type of feedline, signal loss increases with frequency ... the higher the frequency, the more the loss. [\[T9B05 – CO\]](#) [\[T9B05 – AA\]](#)

T9B06: Which of the following RF connector types is most suitable for frequencies above 400 MHz?

See the **CONNECTORS** article at T9B. You'll also hear about "Type N" connectors. This is essentially a higher performance version of "standard" connectors. It's designed for use above 400 MHz, but can operate up to 11 GHz. [\[T9B06 – CO\]](#) [\[T9B06 – AA\]](#)

T9B07: Which of the following is true of PL-259 type coax connectors?

See the **CONNECTORS** article at T9B. PL-259 (male, plug) and SO-239 (female, receptacle) are one of the most common sets for HF and VHF equipment. [\[T9B07 – CO\]](#) [\[T9B07 – AA\]](#)

T9B08: Which of the following is a source of loss in coaxial feed line?

See the **FEEDLINES** article at T9B. Several issues pointed out in the article cause signal loss; high SWR, use of multiple connections, and cable degradation by water. [\[T9B08 – CO\]](#) [\[T9B08 – AA\]](#)

T9B09: What can cause erratic changes in SWR?

See the **CONNECTORS** article at T9B. ... loose connections are often the source of erratic SWR. [\[T9B09 – CO\]](#) [\[T9B09 – AA\]](#)

T9B10: What is the electrical difference between RG-58 and RG-213 coaxial cable?

See the **COAX CABLE CHARACTERISTICS** table at T9B. RG-213 has less signal loss. [\[T9B10 – CO\]](#) [\[T9B10 – AA\]](#)

T9B11: Which of the following types of feed line has the lowest loss at VHF and UHF?

See the **FEEDLINES** article at T9B. A coax variation is called hardline, which has a much less flexible sheath (usually made of aluminum or copper) than standard coax. It has less signal loss, but more difficult to work with (because it doesn't bend easily), than other types of coax. It's often referred to as air insulated hardline. [\[T9B11 – CO\]](#) [\[T9B11 – AA\]](#)

T9B12: What is standing wave ratio (SWR)?

See the **STANDING WAVE RATIO** article at T7C. Standing wave ratio is a measure of impedance matching of loads to the characteristic impedance of a transmission line. [\[T9B12 – CO\]](#) [\[T9B12 – AA\]](#)

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SUBLELEMENT TO — SAFETY

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

TOC

Read the following article before answering the questions in this section.

ELECTRICAL SAFETY & HAM RADIO. See www.cwtouchkeyer.com/ham-radio-safety. Electrical hazards in ham radio are primarily shocks and burns. However, any electrical injuries that might occur are usually minor due to the relatively low voltage and current used in amateur radio. Even small currents can result in muscle contractions. Larger currents can cause burns or even cause cellular electrical activity to malfunction. Individuals with internal electrical devices, like pacemakers and defibrillators, need to be especially careful. Anyone who has worked on automobiles knows the risks of shorting terminals on 12-volt storage batteries ... burns, fires, or even explosions, and radio operators use these types of batteries, as well. Storage batteries can also pose non-electrical hazards. For example, charging or discharging too rapidly can result in over-heating or outgassing, and the gas is hydrogen (very flammable). Remember that many power supplies contain filter capacitors in their circuitry. Capacitors can retain their charge for significant periods of time, so these power supplies can still be a hazard for some time after turning them off. Some basic guidelines to follow to protect yourself and your equipment are; (a) use grounded ... 3-wire ... plugs for all circuits, (b) make sure all electrical equipment is connected to a common ground, (c) use properly sized fuses, and (d) use mechanical interlocks for high voltage circuits. Because of antenna heights and their conductive nature, it's also important to use lightning arrestors. You should connect these where feedlines enter the house, connected to an external ground rod. All ground rods should be bonded together (use heavy wire or conductive strap).

TOA01: Which of the following is a safety hazard of a 12-volt storage battery?

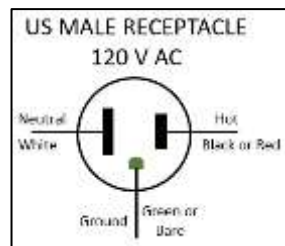
See the article **ELECTRICAL SAFETY & HAM RADIO** at T0A. Anyone who has worked on automobiles knows the risks of shorting terminals on 12-volt storage batteries ... burns, fires, or even explosions, and radio operators use these types of batteries, as well. [\[TOA01 – CO\]](#) [\[TOA01 – AA\]](#)

TOA02: What health hazard is presented by electrical current flowing through the body?

See the article **ELECTRICAL SAFETY & HAM RADIO** at T0A. Even small currents can result in muscle contractions. Larger currents can cause burns or even cause cellular electrical activity to malfunction. [\[TOA02 – CO\]](#) [\[TOA02 – AA\]](#)

TOA03: In the United States, what circuit does black wire insulation indicate in a three-wire 120 V cable?

See accompanying diagram showing a 3-wire receptacle. Black (or Red) is the insulation color for the hot lead. [\[TOA03 – CO\]](#) [\[TOA03 – AA\]](#)



TOA04: What is the purpose of a fuse in an electrical circuit?

Fuses and circuit breakers protect the circuit from overload. The fuse is designed with a small piece of metal (usually a tin/lead alloy) that melts at temperatures much lower than the melting point of the copper wire, and often even lower than the melting point of the insulation. The melted metal breaks the circuit, removing power in case of overload. Fuses and breakers are installed in series with the hot conductor. [\[TOA04 – CO\]](#) [\[TOA04 – AA\]](#)

TOA05: Why should a 5-ampere fuse never be replaced with a 20-ampere fuse?

See discussion in question TOA04. If you replace a small fuse with a much larger one than the circuit is designed for, it's possible that the larger fuse won't melt. In other words, it might not break the circuit. The circuit could overheat and even result in a fire. [\[TOA05 – CO\]](#) [\[TOA05 – AA\]](#)

TOA06: What is a good way to guard against electrical shock at your station?

See the article **ELECTRICAL SAFETY & HAM RADIO** at T0A. Some basic guidelines to follow to protect yourself and your equipment are; (a) use grounded ... 3-wire ... plugs for all circuits, (b) make sure all electrical equipment is connected to a

common ground, (c) use properly sized fuses, and (d) use mechanical interlocks for high voltage circuits. [\[T0A06 – CO\]](#)
[\[T0A06 – AA\]](#)

T0A07: Where should a lightning arrester be installed in a coaxial feed line?

See the article **ELECTRICAL SAFETY & HAM RADIO** at T0A. Because of antenna heights and their conductive nature, it's also important to use lightning arrestors. You should connect these where feedlines enter the house, connected to an external ground rod. [\[T0A07 – CO\]](#) [\[T0A07 – AA\]](#)

T0A08: Where should a fuse or circuit breaker be installed in a 120V AC power circuit?

See the discussion in question T0A04. Fuses and breakers are installed in series with the hot conductor. [\[T0A08 – CO\]](#)
[\[T0A08 – AA\]](#)

T0A09: What should be done to all external ground rods or earth connections?

See the article **ELECTRICAL SAFETY & HAM RADIO** at T0A. All ground rods should be bonded together (use heavy wire or conductive strap). [\[T0A09 – CO\]](#) [\[T0A09 – AA\]](#)

T0A10: What hazard is caused by charging or discharging a battery too quickly?

See the article **ELECTRICAL SAFETY & HAM RADIO** at T0A. For example, charging or discharging too rapidly can result in over-heating or outgassing, and the gas is hydrogen (very flammable). [\[T0A10 – CO\]](#) [\[T0A10 – AA\]](#)

T0A11: What hazard exists in a power supply immediately after turning it off?

See the article **ELECTRICAL SAFETY & HAM RADIO** at T0A. Capacitors can retain their charge for significant periods of time, so these power supplies can still be a hazard for some time after turning them off. [\[T0A11 – CO\]](#) [\[T0A11 – AA\]](#)

T0A12: Which of the following precautions should be taken when measuring high voltages with a voltmeter?

See <https://assets.tequipment.net/assets/3/7/ABC-meter-safety.PDF>. If you attempt to use a voltmeter for voltages higher than its rating, the excess voltage may damage nearby equipment or even result in electrical shock. Be sure both the meter and its leads are rated for the voltage being measured. [\[T0A12 – CO\]](#) [\[T0A12 – AA\]](#)

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Read the following article before answering the questions in this section.

ANTENNA & TOWER SAFETY. Reference www.vk5pas.com/uploads/1/3/9/8/13982788/up_the_tower.pdf.

Don't overlook information on towers. You may never own a tower yourself, but your local club may have a repeater, where members have the opportunity to participate in set up, adjustment, etc. Before attempting to climb a tower, make sure you've been trained. The above reference provides written tips and instruction, but you'll need some hands on training in climbing techniques, including use of tie-offs and climbing harnesses. One type of tower you should become familiar with is a crank up type. These tend to be portable and lightweight ... often used for transmitting from temporary locations. Climbing them should be avoided ... they're usually not strong enough to support the weight. Installation and grounding of towers should follow local regulations and manufacturer's instructions. Each leg of the tower should be grounded separately using 8 foot ground rods bonded to the tower and to each other. Guy wires (when required by the height or the antenna or tower) should include turn buckles for proper tensioning.

TOB01: Which of the following is good practice when installing ground wires on a tower for lightning protection?

Regardless of whether the ground wires are for a tower, small antenna, or just a piece of equipment, they should follow common sense electrical principles. For grounding, you need as little electrical resistance as practical. Ground wires should be short, direct (few bends and the bends ... if any ... should be slight), and made from solid wire or strap. [\[TOB01 – CO\]](#) [\[TOB01 – AA\]](#)

TOB02: What is required when climbing an antenna tower?

See article on **ANTENNA & TOWER SAFETY** at TOB. Before attempting to climb a tower, make sure you've been trained. The above reference provides written tips and instruction, but you'll need some hands on training in climbing techniques, including use of tie-offs and climbing harnesses. [\[TOB02 – CO\]](#) [\[TOB02 – AA\]](#)

TOB03: Under what circumstances is it safe to climb a tower without a helper or observer?

See the reference for the article on **ANTENNA & TOWER SAFETY** at TOB. You ALWAYS use an observer when climbing towers. [\[TOB03 – CO\]](#) [\[TOB03 – AA\]](#)

TOB04: Which of the following is an important safety precaution to observe when putting up an antenna tower?

See the reference for the article on **ANTENNA & TOWER SAFETY** at TOB. There are many important safety precautions to observe when installing towers or even short antennas around the home. But, the single most important is probably avoiding overhead electrical wires. [\[TOB04 – CO\]](#) [\[TOB04 – AA\]](#)

TOB05: What is the purpose of a safety wire through a turnbuckle used to tension guy lines?

Turnbuckles on guy wires serve the same purpose as turnbuckles anywhere. They take up slack and provide for the proper tension. The safety wire provides a way to VERIFY or measure if the tension is correct. [\[TOB05 – CO\]](#) [\[TOB05 – AA\]](#)

TOB06: What is the minimum safe distance from a power line to allow when installing an antenna?

See the reference for the article on **ANTENNA & TOWER SAFETY** at TOB. In the event an antenna falls, it must be far enough away from the power line that no part of it can come within 10 feet. [\[TOB06 – CO\]](#) [\[TOB06 – AA\]](#)

TOB07: Which of the following is an important safety rule to remember when using a crank-up tower?

See article on **ANTENNA & TOWER SAFETY** at TOB. One type of tower you should become familiar with is a crank up type. These tend to be portable and lightweight ... often used for transmitting from temporary locations. Climbing them should be avoided ... they're usually not strong enough to support the weight. [\[TOB07 – CO\]](#) [\[TOB07 – AA\]](#)

TOB08: Which is a proper grounding method for a tower?

See article on **ANTENNA & TOWER SAFETY** at TOB. Each leg of the tower should be grounded separately using 8 foot ground rods bonded to the tower and to each other. [\[TOB08 – CO\]](#) [\[TOB08 – AA\]](#)

TOB09: Why should you avoid attaching an antenna to a utility pole?

See question TOB04. You must absolutely avoid contact with electrical wires. If the antenna falls or cable breaks, you may come into contact with high-voltage wires ... usually much higher than the 120 or 240 volts you see in the home.

[\[TOB09 – CO\]](#) [\[TOB09 – AA\]](#)

TOB10: Which of the following is true when installing grounding conductors used for lightning protection?

See question TOB01. For grounding, you need as little electrical resistance as practical. Ground wires should be short, direct (few bends and the bends ... if any ... should be slight), and made from solid wire or strap. [\[TOB10 – CO\]](#) [\[TOB10 – AA\]](#)

TOB11: Which of the following establishes grounding requirements for an amateur radio tower or antenna?

See article on **ANTENNA & TOWER SAFETY** at TOB. Installation and grounding of towers should follow local regulations and manufacturer's instructions. [\[TOB11 – CO\]](#) [\[TOB11 – AA\]](#)

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RF RADIATION. References: (1) www.fcc.gov/engineering-technology/electromagnetic-compatibility-division/radio-frequency-safety/faq/rf-safety, (2) www.govinfo.gov/content/pkg/CFR-2020-title47-vol1/xml/CFR-2020-title47-vol1-sec1-1310.xml and (3) www.barnstablearc.org/sites/default/files/ARRL-RF-Exposure-2021_W1DAN-rev1.pdf

Radio signals are *non-ionizing radiation*. Unlike ionizing radiation, the energy levels associated with RF and microwave radiation are not great enough to cause the ionization of atoms and molecules. Non-ionizing radiation is not strong enough to cause damage in biological tissue, including effects on DNA. Ionizing radiation (gamma rays, X-rays, etc.), on the other hand, can cause this sort of damage. Ionizing radiation is strong enough to displace electrons from atoms (even DNA molecules). The federal government has established exposure limits to RF radiation ... see the accompanying table.

Limits for Maximum Permissible Exposure (MPE) to radiofrequency electromagnetic fields (see reference 2 above)

Table 1 to § 1.1310(e)(1)—Limits for Maximum Permissible Exposure (MPE)

| Frequency range (MHz) | Electric field strength (V/m) | Magnetic field strength (A/m) | Power density (mW/cm ²) | Averaging time (minutes) |
|---|-------------------------------|-------------------------------|-------------------------------------|--------------------------|
| (i) Limits for Occupational/Controlled Exposure | | | | |
| 0.3-3.0 | 614 | 1.63 | * (100) | ≤ 6 |
| 3.0-30 | 1842/f | 4.89/f | * (900/f ²) | <6 |
| 30-300 | 61.4 | 0.163 | 1.0 | <6 |
| 300-1,500 | | | f/300 | <6 |
| 1,500-100,000 | | | 5 | <6 |
| (ii) Limits for General Population/Uncontrolled Exposure | | | | |
| 0.3-1.34 | 614 | 1.63 | * (100) | <30 |
| 1.34-30 | 824/f | 2.19/f | * (180/f ²) | <30 |
| 30-300 | 27.5 | 0.073 | 0.2 | <30 |
| 300-1,500 | | | f/1500 | <30 |
| 1,500-100,000 | | | 1.0 | <30 |

f = frequency in MHz. * = Plane-wave equivalent power density.

In the table, you’ll see the terms *controlled* and *uncontrolled exposure*. Per reference #2, “Occupational/controlled exposure limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure.” Radio operators would fall into the *controlled exposure* definition because (theoretically) we know the risk. You can see from the table that limits vary with frequency. That’s because the rate the body absorbs radiation varies with frequency. Different body parts are resonant at different frequencies ... the higher the frequency, the faster the absorption rate. You’ll note the last column of this table refers to “Averaging time.” This means the exposure limit is based on an average amount of time or the percent of time a transmitter is transmitting ... referred to as *duty cycle* (also called *duty factor*). If you’re at the transmitter for one hour, but it’s only transmitting half the time (because you’re receiving the other half the time), the AVERAGE exposure time is thirty minutes ... the duty cycle is 50%. In this case, you may multiply the signal power by 2. If the duty cycle were 25%, you could multiply the signal exposure by 4, etc. Other factors affecting exposure (in addition to frequency and signal power) are; distance from the antenna and the antenna transmission pattern (recall that some antennas have stronger signals in certain directions). One of the simplest ways to reduce exposure is to move your antenna as far from people as practical.

Licensed operators are required to stay in compliance with RF exposure limits. The best way to do this is to evaluate your station any time anything in your transmission system (transmitter, antenna, and feedlines) changes. FCC OET Bulletin 65 provides details for measuring RF ... see link in question TOC06.

In addition to radiation, RF voltages generate heat. Physically touching a surface conducting RF voltage (such as antenna) can cause RF burns. If the power is high enough and you’re close enough, you don’t even need to touch it! You can avoid this by good grounding (bonding) and simply staying away from antennas while transmitting. If you do get an RF burn, you won’t forget it quickly!

Bottom line: You, the station licensee, are responsible for RF radiation compliance at your station.

TOC01: What type of radiation are radio signals?

See the **RF RADIATION** article at T0C. Radio signals are *non-ionizing radiation*. [\[TOC01 – CO\]](#) [\[TOC01 – AA\]](#)

TOC02: At which of the following frequencies does maximum permissible exposure have the lowest value?

See the **RF RADIATION** article at T0C, specifically the limits table. From the table the lowest MPE value is from 30-300 MHz. However, the answer choices do not include this range. The choices are; 3.5 MHz, 50 MHz, 440 MHz, and 1296 MHz. The only acceptable choice is 50 MHz. [\[TOC02 – CO\]](#) [\[TOC02 – AA\]](#)

TOC03: How does the allowable power density for RF safety change if duty cycle changes from 100 percent to 50 percent?

See the **RF RADIATION** article at T0C. If you're at the transmitter for one hour, but it's only transmitting half the time (because you're receiving the other half the time), the AVERAGE exposure time is thirty minutes ... the duty cycle is 50%. In this case, you may multiple the signal power by 2. The answer is that you can increase the power density by a factor of 2. [\[TOC03 – CO\]](#) [\[TOC03 – AA\]](#)

TOC04: What factors affect the RF exposure of people near an amateur station antenna?

See the **RF RADIATION** article at T0C. Other factors affecting exposure (in addition to frequency and signal power) are: distance from the antenna and the antenna transmission pattern (recall that some antennas have stronger signals in certain directions). [\[TOC04 – CO\]](#) [\[TOC04 – AA\]](#)

TOC05: Why do exposure limits vary with frequency?

See the **RF RADIATION** article at T0C. Different body parts are resonant at different frequencies ... the higher the frequency, the faster the absorption rate. [\[TOC05 – CO\]](#) [\[TOC05 – AA\]](#)

TOC06: Which of the following is an acceptable method to determine whether your station complies with FCC RF exposure regulations?

See the **RF RADIATION** article at T0C, specifically Reference #1. There are 3 methods for measuring compliance with the regulation; (1) you can measure it per FCC OET Bulletin 65 ... see link below this question, (2) you can use computer modeling to calculate it, or (3) you can take a direct measurement of field strength. [\[TOC06 – CO\]](#) [\[TOC06 – AA\]](#)
FCC OET Bulletin 65; https://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65.pdf

TOC07: What hazard is created by touching an antenna during a transmission?

See the **RF RADIATION** article at T0C. Physically touching a surface conducting RF voltage (such as antenna) can cause RF burns. [\[TOC07 – CO\]](#) [\[TOC07 – AA\]](#)

TOC08: Which of the following actions can reduce exposure to RF radiation?

See the **RF RADIATION** article at T0C. One of the simplest ways to reduce exposure is to move your antenna as far from people as practical. [\[TOC08 – CO\]](#) [\[TOC08 – AA\]](#)

TOC09: How can you make sure your station stays in compliance with RF safety regulations?

See the **RF RADIATION** article at T0C. The best way to do this is to evaluate your station any time anything in your transmission system (transmitter, antenna, and feedlines) changes. FCC OET Bulletin 65 provides details for measuring RF ... see link in question TOC06. [\[TOC09 – CO\]](#) [\[TOC09 – AA\]](#)

TOC10: Why is duty cycle one of the factors used to determine safe RF radiation exposure levels?

See the **RF RADIATION** article at T0C. The exposure limit is based on an average amount of time ... referred to as *duty cycle*. [\[TOC10 – CO\]](#) [\[TOC10 – AA\]](#)

TOC11: What is the definition of duty cycle during the averaging time for RF exposure?

See the **RF RADIATION** article at T0C. This means the exposure limit is based on an average amount of time or the percent of time a transmitter is transmitting ... referred to as *duty cycle*. [\[TOC11 – CO\]](#) [\[TOC11 – AA\]](#)

TOC12: How does RF radiation differ from ionizing radiation (radioactivity)?

See the **RF RADIATION** article at TOC. Unlike ionizing radiation, the energy levels associated with RF and microwave radiation, are not great enough to cause the ionization of atoms and molecules. Ionizing radiation is strong enough to displace electrons from atoms (even DNA molecules). [\[TOC12 – CO\]](#) [\[TOC12 – AA\]](#)

TOC13: Who is responsible for ensuring that no person is exposed to RF energy above the FCC exposure limits?

See the **RF RADIATION** article at TOC. You, the station licensee, are responsible for RF radiation at your station. [\[TOC13 – CO\]](#)
[\[TOC13 – AA\]](#)

END OF QUESTIONS! Now, go pass that exam!

TOC

LINKS

*NOTE: If you're scrolling through the questions & answers, don't use the **BACK** buttons below. Just keep scrolling forward.*

T1: COMMISSION RULES

T1A01: Which of the following is part of the Basis and Purpose of the Amateur Radio Service? [BACK](#)

C. Advancing skills in the technical and communication phases of the radio art

T1A02: Which agency regulates and enforces the rules for the Amateur Radio Service in the United States? [BACK](#)

C. The FCC

T1A03: What do the FCC rules state regarding the use of a phonetic alphabet for station identification in the Amateur Radio Service? [BACK](#)

B. It is encouraged

T1A04: How many operator/primary station license grants may be held by any one person? [BACK](#)

A. One

T1A05: What proves that the FCC has issued an operator/primary license grant? [BACK](#)

C. The license appears in the FCC ULS database

T1A06: What is the FCC Part 97 definition of a beacon? [BACK](#)

D. An amateur station transmitting communications for the purposes of observing propagation or related experimental activities

T1A07: What is the FCC Part 97 definition of a space station? [BACK](#)

C. An amateur station located more than 50 km above Earth's surface

T1A08: Which of the following entities recommends transmit/receive channels and other parameters for auxiliary and repeater stations? [BACK](#)

B. Volunteer Frequency Coordinator recognized by local amateurs

T1A09: Who selects a Frequency Coordinator? [BACK](#)

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

T1A10: What is the Radio Amateur Civil Emergency Service (RACES)? [BACK](#)

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 these choices are correct

T1A11: When is willful interference to other amateur radio stations permitted? [BACK](#)

B. At no time

T1B01: Which of the following frequency ranges are available for phone operation by Technician licensees? [BACK](#)

C. 28.300 MHz to 28.500 MHz

T1B02: Which amateurs may contact the International Space Station (ISS) on VHF bands? [BACK](#)

B. Any amateur holding a Technician class or higher license

T1B03: Which frequency is in the 6 meter amateur band? [BACK](#)

B. 52.525 MHz

T1B04: Which amateur band includes 146.52 MHz? [BACK](#)

D. 2 meters

T1B05: How may amateurs use the 219 to 220 MHz segment of 1.25 meter band? [BACK](#)

D. Fixed digital message forwarding systems only

T1B06: On which HF bands does a Technician class operator have phone privileges? [BACK](#)

B. 10 meter band only

T1B07: Which of the following VHF/UHF band segments are limited to CW only? [BACK](#)

A. 50.0 MHz to 50.1 MHz and 144.0 MHz to 144.1 MHz

T1B08: How are US amateurs restricted in segments of bands where the Amateur Radio Service is secondary? [BACK](#)

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

T1B09: Why should you not set your transmit frequency to be exactly at the edge of an amateur band or sub-band? [BACK](#)

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 these choices are correct

T1B10: Where may SSB phone be used in amateur bands above 50 MHz? [BACK](#)

C. In at least some segment of all these bands

T1B11: What is the maximum peak envelope power output for Technician class operators in their HF band segments? [BACK](#)

A. 200 watts

T1B12: Except for some specific restrictions, what is the maximum peak envelope power output for Technician class operators using frequencies above 30 MHz? [BACK](#)

D. 1500 watts

T1C01: For which license classes are new licenses currently available from the FCC? [BACK](#)

D. Technician, General, Amateur Extra

T1C02: Who may select a desired call sign under the vanity call sign rules? [BACK](#)

D. Any licensed amateur

T1C03: What types of international communications are an FCC-licensed amateur radio station permitted to make? [BACK](#)

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

T1C04: What may happen if the FCC is unable to reach you by email? [BACK](#)

B. Revocation of the station license or suspension of the operator license

T1C05: Which of the following is a valid Technician class call sign format? [BACK](#)

A. KF1XXX

- T1C06: From which of the following locations may an FCC-licensed amateur station transmit? [BACK](#)
D. From any vessel or craft located in international waters and documented or registered in the United States
- T1C07: Which of the following can result in revocation of the station license or suspension of the operator license? [BACK](#)
B. Failure to provide and maintain a correct email address with the FCC
- T1C08: What is the normal term for an FCC-issued amateur radio license? [BACK](#)
C. Ten years
- T1C09: What is the grace period for renewal if an amateur license expires? [BACK](#)
A. Two years
- T1C10: How soon after passing the examination for your first amateur radio license may you transmit on the amateur radio bands? [BACK](#)
C. As soon as your operator/station license grant appears in the FCC's license database
- T1C11: If your license has expired and is still within the allowable grace period, may you continue to transmit on the amateur radio bands? [BACK](#)
D. No, you must wait until the license has been renewed
- T1D01: With which countries are FCC-licensed amateur radio stations prohibited from exchanging communications? [BACK](#)
A. Any country whose administration has notified the International Telecommunication Union (ITU) that it objects to such communications
- T1D02: Under which of the following circumstances are one-way transmissions by an amateur station prohibited? [BACK](#)
B. Broadcasting
- T1D03: When is it permissible to transmit messages encoded to obscure their meaning? [BACK](#)
C. Only when transmitting control commands to space stations or radio control craft
- T1D04: Under what conditions is an amateur station authorized to transmit music using a phone emission? [BACK](#)
A. When incidental to an authorized retransmission of manned spacecraft communications
- T1D05: When may amateur radio operators use their stations to notify other amateurs of the availability of equipment for sale or trade? [BACK](#)
D. When selling amateur radio equipment and not on a regular basis
- T1D06: What, if any, are the restrictions concerning transmission of language that may be considered indecent or obscene? [BACK](#)
B. Any such language is prohibited
- T1D07: What types of amateur stations can automatically retransmit the signals of other amateur stations? [BACK](#)
D. Repeater, auxiliary, or space stations
- T1D08: In which of the following circumstances may the control operator of an amateur station receive compensation for operating that station? [BACK](#)
B. When the communication is incidental to classroom instruction at an educational institution
- T1D09: When may amateur stations transmit information in support of broadcasting, program production, or news gathering, assuming no other means is available? [BACK](#)
A. When such communications are directly related to the immediate safety of human life or protection of property

T1D10: How does the FCC define broadcasting for the Amateur Radio Service? [BACK](#)

D. Transmissions intended for reception by the general public

T1D11: When may an amateur station transmit without identifying on the air? [BACK](#)

D. When transmitting signals to control model craft

T1E01: When may an amateur station transmit without a control operator? [BACK](#)

D. Never

T1E02: Who may be the control operator of a station communicating through an amateur satellite or space station? [BACK](#)

D. Any amateur allowed to transmit on the satellite uplink frequency

T1E03: Who must designate the station control operator? [BACK](#)

A. The station licensee

T1E04: What determines the transmitting frequency privileges of an amateur station? [BACK](#)

D. The class of operator license held by the control operator

T1E05: What is an amateur station's control point? [BACK](#)

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

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? [BACK](#)

A. At no time

T1E07: When the control operator is not the station licensee, who is responsible for the proper operation of the station? [BACK](#)

D. The control operator and the station licensee

T1E08: Which of the following is an example of automatic control? [BACK](#)

A. Repeater operation

T1E09: Which of the following are required for remote control operation? [BACK](#)

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 these choices are correct

T1E10: Which of the following is an example of remote control as defined in Part 97? [BACK](#)

B. Operating the station over the internet

T1E11: Who does the FCC presume to be the control operator of an amateur station, unless documentation to the contrary is in the station records? [BACK](#)

D. The station licensee

T1F01: When must the station and its records be available for FCC inspection? [BACK](#)

B. At any time upon request by an FCC representative

T1F02: How often must you identify with your FCC-assigned call sign when using tactical call signs such as "Race Headquarters"? [BACK](#)

C. At the end of each communication and every ten minutes during a communication

T1F03: When are you required to transmit your assigned call sign? [BACK](#)

D. At least every 10 minutes during and at the end of a communication

T1F04: What language may you use for identification when operating in a phone sub-band? [BACK](#)

C. English

T1F05: What method of call sign identification is required for a station transmitting phone signals? [BACK](#)

B. Send the call sign using a CW or phone emission

T1F06: Which of the following self-assigned indicators are acceptable when using a phone transmission? [BACK](#)

A. KL7CC stroke W3

B. KL7CC slant W3

C. KL7CC slash W3

D. All these choices are correct

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? [BACK](#)

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

T1F08: What is the definition of third party communications? [BACK](#)

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

T1F09: What type of amateur station simultaneously retransmits the signal of another amateur station on a different channel or channels? [BACK](#)

C. Repeater station

T1F10: Who is accountable if a repeater inadvertently retransmits communications that violate the FCC rules? [BACK](#)

A. The control operator of the originating station

T1F11: Which of the following is a requirement for the issuance of a club station license grant? [BACK](#)

B. The club must have at least four members

NOTE: If you're scrolling through the questions & answers, don't use the [BACK](#) buttons below. Just keep scrolling forward.

T2: OPERATING PROCEDURES

T2A01: What is a common repeater frequency offset in the 2 meter band? [BACK](#)

B. Plus or minus 600 kHz

T2A02: What is the national calling frequency for FM simplex operations in the 2 meter band? [BACK](#)

A. 146.520 MHz

T2A03: What is a common repeater frequency offset in the 70 cm band? [BACK](#)

A. Plus or minus 5 MHz

T2A04: What is an appropriate way to call another station on a repeater if you know the other station's call sign? [BACK](#)

B. Say the station's call sign, then identify with your call sign

T2A05: How should you respond to a station calling CQ? [BACK](#)

C. Transmit the other station's call sign followed by your call sign

T2A06: Which of the following is required when making on-the-air test transmissions? [BACK](#)

A. Identify the transmitting station

T2A07: What is meant by "repeater offset"? [BACK](#)

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

T2A08: What is the meaning of the procedural signal "CQ"? [BACK](#)

D. Calling any station

T2A09: Which of the following indicates that a station is listening on a repeater and looking for a contact? [BACK](#)

B. The station's call sign followed by the word "monitoring"

T2A10: What is a band plan, beyond the privileges established by the FCC? [BACK](#)

A. A voluntary guideline for using different modes or activities within an amateur band

T2A11: What term describes an amateur station that is transmitting and receiving on the same frequency? [BACK](#)

C. Simplex

T2A12: What should you do before calling CQ? [BACK](#)

A. Listen first to be sure that no one else is using the frequency

B. Ask if the frequency is in use

C. Make sure you are authorized to use that frequency

D. All these choices are correct

T2B01: How is a VHF/UHF transceiver's "reverse" function used? [BACK](#)

C. To listen on a repeater's input frequency

T2B02: What term describes the use of a sub-audible tone transmitted along with normal voice audio to open the squelch of a receiver? [BACK](#)

D. CTCSS

T2B03: Which of the following describes a linked repeater network? [BACK](#)

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

T2B04: Which of the following could be the reason you are unable to access a repeater whose output you can hear? [BACK](#)

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

T2B05: What would cause your FM transmission audio to be distorted on voice peaks? [BACK](#)

C. You are talking too loudly

T2B06: What type of signaling uses pairs of audio tones? [BACK](#)

A. DTMF

T2B07: How can you join a digital repeater's "talkgroup"? [BACK](#)

C. Program your radio with the group's ID or code

T2B08: Which of the following applies when two stations transmitting on the same frequency interfere with each other? [BACK](#)

A. The stations should negotiate continued use of the frequency

T2B09: Why are simplex channels designated in the VHF/UHF band plans? [BACK](#)

A. So stations within range of each other can communicate without tying up a repeater

T2B10: Which Q signal indicates that you are receiving interference from other stations? [BACK](#)

A. QRM

T2B11: Which Q signal indicates that you are changing frequency? [BACK](#)

B. QSY

T2B12: What is the purpose of the color code used on DMR repeater systems? [BACK](#)

A. Must match the repeater color code for access

T2B13: What is the purpose of a squelch function? [BACK](#)

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

T2C01: When do FCC rules NOT apply to the operation of an amateur station? [BACK](#)

D. FCC rules always apply

T2C02: Which of the following are typical duties of a Net Control Station? [BACK](#)

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

T2C03: What technique is used to ensure that voice messages containing unusual words are received correctly? [BACK](#)

C. Spell the words using a standard phonetic alphabet

T2C04: What is RACES? [BACK](#)

D. An FCC part 97 amateur radio service for civil defense communications during national emergencies

T2C05: What does the term "traffic" refer to in net operation? [BACK](#)

A. Messages exchanged by net stations

T2C06: What is the Amateur Radio Emergency Service (ARES)? [BACK](#)

Kin the public service

T2C07: Which of the following is standard practice when you participate in a net? [BACK](#)

C. Unless you are reporting an emergency, transmit only when directed by the net control station

T2C08: Which of the following is a characteristic of good traffic handling? [BACK](#)

A. Passing messages exactly as received

T2C09: Are amateur station control operators ever permitted to operate outside the frequency privileges of their license class? [BACK](#)

D. Yes, but only in situations involving the immediate safety of human life or protection of property

T2C10: What information is contained in the preamble of a formal traffic message? [BACK](#)

D. Information needed to track the message

T2C11: What is meant by “check” in a radiogram header? [BACK](#)

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

NOTE: If you're scrolling through the questions & answers, don't use the [BACK](#) buttons below. Just keep scrolling forward.

T3: RADIO WAVE PROPAGATION

T3A01: Why do VHF signal strengths sometimes vary greatly when the antenna is moved only a few feet? [BACK](#)

C. Multipath propagation cancels or reinforces signals

T3A02: What is the effect of vegetation on UHF and microwave signals? [BACK](#)

B. Absorption

T3A03: What antenna polarization is normally used for long-distance CW and SSB contacts on the VHF and UHF bands? [BACK](#)

C. Horizontal

T3A04: What happens when antennas at opposite ends of a VHF or UHF line of sight radio link are not using the same polarization? [BACK](#)

B. Received signal strength is reduced

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? [BACK](#)

B. Try to find a path that reflects signals to the repeater

T3A06: What is the meaning of the term "picket fencing"? [BACK](#)

B. Rapid flutter on mobile signals due to multipath propagation

T3A07: What weather condition might decrease range at microwave frequencies? [BACK](#)

C. Precipitation

T3A08: What is a likely cause of irregular fading of signals propagated by the ionosphere? [BACK](#)

D. Random combining of signals arriving via different paths

T3A09: Which of the following results from the fact that signals propagated by the ionosphere are elliptically polarized? [BACK](#)

B. Either vertically or horizontally polarized antennas may be used for transmission or reception

T3A10: What effect does multi-path propagation have on data transmissions? [BACK](#)

D. Error rates are likely to increase

T3A11: Which region of the atmosphere can refract or bend HF and VHF radio waves? [BACK](#)

C. The ionosphere

T3A12: What is the effect of fog and rain on signals in the 10 meter and 6 meter bands? [BACK](#)

B. There is little effect

T3B01: What is the relationship between the electric and magnetic fields of an electromagnetic wave? [BACK](#)

D. They are at right angles

T3B02: What property of a radio wave defines its polarization? [BACK](#)

A. The orientation of the electric field

T3B03: What are the two components of a radio wave? [BACK](#)

C. Electric and magnetic fields

T3B04: What is the velocity of a radio wave traveling through free space? [BACK](#)

A. Speed of light

T3B05: What is the relationship between wavelength and frequency? [BACK](#)

B. Wavelength gets shorter as frequency increases

T3B06: What is the formula for converting frequency to approximate wavelength in meters? [BACK](#)

D. Wavelength in meters equals 300 divided by frequency in megahertz

T3B07: In addition to frequency, which of the following is used to identify amateur radio bands? [BACK](#)

A. The approximate wavelength in meters

T3B08: What frequency range is referred to as VHF? [BACK](#)

B. 30 MHz to 300 MHz

T3B09: What frequency range is referred to as UHF? [BACK](#)

D. 300 to 3000 MHz

T3B10: What frequency range is referred to as HF? [BACK](#)

C. 3 to 30 MHz

T3B11: What is the approximate velocity of a radio wave in free space? [BACK](#)

B. 300,000,000 meters per second

T3C01: Why are simplex UHF signals rarely heard beyond their radio horizon? [BACK](#)

C. UHF signals are usually not propagated by the ionosphere

T3C02: What is a characteristic of HF communication compared with communications on VHF and higher frequencies? [BACK](#)

C. Long-distance ionospheric propagation is far more common on HF

T3C03: What is a characteristic of VHF signals received via auroral backscatter? [BACK](#)

B. They are distorted and signal strength varies considerably

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? [BACK](#)

B. Sporadic E

T3C05: Which of the following effects may allow radio signals to travel beyond obstructions between the transmitting and receiving stations? [BACK](#)

A. Knife-edge diffraction

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? [BACK](#)

A. Tropospheric ducting

T3C07: What band is best suited for communicating via meteor scatter? [BACK](#)

B. 6 meters

T3C08: What causes tropospheric ducting? [BACK](#)

D. Temperature inversions in the atmosphere

T3C09: What is generally the best time for long-distance 10 meter band propagation via the F region? [BACK](#)

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

T3C10: Which of the following bands may provide long-distance communications via the ionosphere's F region during the peak of the sunspot cycle? [BACK](#)

A. 6 and 10 meters

T3C11: Why is the radio horizon for VHF and UHF signals more distant than the visual horizon? [BACK](#)

C. The atmosphere refracts radio waves slightly

NOTE: If you're scrolling through the questions & answers, don't use the [BACK](#) buttons below. Just keep scrolling forward.

T4: AMATEUR RADIO PRACTICES

T4A01: Which of the following is an appropriate power supply rating for a typical 50 watt output mobile FM transceiver? [BACK](#)

D. 13.8 volts at 12 amperes

T4A02: Which of the following should be considered when selecting an accessory SWR meter? [BACK](#)

A. The frequency and power level at which the measurements will be made

T4A03: Why are short, heavy-gauge wires used for a transceiver's DC power connection? [BACK](#)

A. To minimize voltage drop when transmitting

T4A04: How are the transceiver audio input and output connected in a station configured to operate using FT8? [BACK](#)

B. To the audio input and output of a computer running WSJT-X software

T4A05: Where should an RF power meter be installed? [BACK](#)

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

T4A06: What signals are used in a computer-radio interface for digital mode operation? [BACK](#)

C. Receive audio, transmit audio, and transmitter keying

T4A07: Which of the following connections is made between a computer and a transceiver to use computer software when operating digital modes? [BACK](#)

C. Computer "line in" to transceiver speaker connector

T4A08: Which of the following conductors is preferred for bonding at RF? [BACK](#)

D. Flat copper strap

T4A09: How can you determine the length of time that equipment can be powered from a battery? [BACK](#)

B. Divide the battery ampere-hour rating by the average current draw of the equipment

T4A10: What function is performed with a transceiver and a digital mode hot spot? [BACK](#)

A. Communication using digital voice or data systems via the internet

T4A11: Where should the negative power return of a mobile transceiver be connected in a vehicle? [BACK](#)

A. At the 12 volt battery chassis ground

T4A12: What is an electronic keyer? [BACK](#)

C. A device that assists in manual sending of Morse code

T4B01: What is the effect of excessive microphone gain on SSB transmissions? [BACK](#)

B. Distorted transmitted audio

T4B02: Which of the following can be used to enter a transceiver's operating frequency? [BACK](#)

A. The keypad or VFO knob

T4B03: How is squelch adjusted so that a weak FM signal can be heard? [BACK](#)

A. Set the squelch threshold so that receiver output audio is on all the time

T4B04: What is a way to enable quick access to a favorite frequency or channel on your transceiver? [BACK](#)

B. Store it in a memory channel

T4B05: What does the scanning function of an FM transceiver do? [BACK](#)

C. Tunes through a range of frequencies to check for activity

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? [BACK](#)

D. The RIT or Clarifier

T4B07: What does a DMR “code plug” contain? [BACK](#)

B. Access information for repeaters and talkgroups

T4B08: What is the advantage of having multiple receive bandwidth choices on a multimode transceiver? [BACK](#)

B. Permits noise or interference reduction by selecting a bandwidth matching the mode

T4B09: How is a specific group of stations selected on a digital voice transceiver? [BACK](#)

C. By entering the group’s identification code

T4B10: Which of the following receiver filter bandwidths provides the best signal-to-noise ratio for SSB reception? [BACK](#)

C. 2400 Hz

T4B11: Which of the following must be programmed into a D-STAR digital transceiver before transmitting? [BACK](#)

A. Your call sign

T4B12: What is the result of tuning an FM receiver above or below a signal’s frequency? [BACK](#)

D. Distortion of the signal’s audio

*NOTE: If you're scrolling through the questions & answers, don't use the **BACK** buttons below. Just keep scrolling forward.*

T5: ELECTRICAL PRINCIPLES

T5A01: Electrical current is measured in which of the following units? [BACK](#)

D. Amperes

T5A02: Electrical power is measured in which of the following units? [BACK](#)

B. Watts

T5A03: What is the name for the flow of electrons in an electric circuit? [BACK](#)

D. Current

T5A04: What are the units of electrical resistance? [BACK](#)

C. Ohms

T5A05: What is the electrical term for the force that causes electron flow? [BACK](#)

A. Voltage

T5A06: What is the unit of frequency? [BACK](#)

A. Hertz

T5A07: Why are metals generally good conductors of electricity? [BACK](#)

B. They have many free electrons

T5A08: Which of the following is a good electrical insulator? [BACK](#)

B. Glass

T5A09: Which of the following describes alternating current? [BACK](#)

C. Current that alternates between positive and negative directions

T5A10: Which term describes the rate at which electrical energy is used? [BACK](#)

C. Power

T5A11: What type of current flow is opposed by resistance? [BACK](#)

A. Direct current

B. Alternating current

C. RF current

D. All these choices are correct

T5A12: What describes the number of times per second that an alternating current makes a complete cycle? [BACK](#)

D. Frequency

T5B01: How many milliamperes is 1.5 amperes? [BACK](#)

C. 1500 milliamperes

T5B02: Which is equal to 1,500,000 hertz? [BACK](#)

A. 1500 kHz

T5B03: Which is equal to one kilovolt? [BACK](#)

C. One thousand volts

T5B04: Which is equal to one microvolt? [BACK](#)

A. One one-millionth of a volt

T5B05: Which is equal to 500 milliwatts? [BACK](#)

B. 0.5 watts

T5B06: Which is equal to 3000 milliamperes? [BACK](#)

D. 3 amperes

T5B07: Which is equal to 3.525 MHz? [BACK](#)

C. 3525 kHz

T5B08: Which is equal to 1,000,000 picofarads? [BACK](#)

B. 1 microfarad

T5B09: Which decibel value most closely represents a power increase from 5 watts to 10 watts? [BACK](#)

B. 3 dB

T5B10: Which decibel value most closely represents a power decrease from 12 watts to 3 watts? [BACK](#)

C. -6 dB

T5B11: Which decibel value represents a power increase from 20 watts to 200 watts? [BACK](#)

A. 10 dB

T5B12: Which is equal to 28400 kHz? [BACK](#)

D. 28.400 MHz

T5B13: Which is equal to 2425 MHz? [BACK](#)

C. 2.425 GHz

T5C01: What describes the ability to store energy in an electric field? [BACK](#)

D. Capacitance

T5C02: What is the unit of capacitance? [BACK](#)

A. The farad

T5C03: What describes the ability to store energy in a magnetic field? [BACK](#)

D. Inductance

T5C04: What is the unit of inductance? [BACK](#)

C. The henry

T5C05: What is the unit of impedance? [BACK](#)

D. The ohm

T5C06: What does the abbreviation "RF" mean? [BACK](#)

A. Radio frequency signals of all types

T5C07: What is the abbreviation for megahertz? [BACK](#)

D. MHz

T5C08: What is the formula used to calculate electrical power (P) in a DC circuit? [BACK](#)

A. $P = I \times E$

- T5C09: How much power is delivered by a voltage of 13.8 volts DC and a current of 10 amperes? [BACK](#)
A. 138 watts
- T5C10: How much power is delivered by a voltage of 12 volts DC and a current of 2.5 amperes? [BACK](#)
B. 30 watts
- T5C11: How much current is required to deliver 120 watts at a voltage of 12 volts DC? [BACK](#)
B. 10 amperes
- T5C12: What is impedance? [BACK](#)
A. The opposition to AC current flow
- T5C13: What is the abbreviation for kilohertz? [BACK](#)
D. kHz
- T5D01: What formula is used to calculate current in a circuit? [BACK](#)
B. $I = E / R$
- T5D02: What formula is used to calculate voltage in a circuit? [BACK](#)
A. $E = I \times R$
- T5D03: What formula is used to calculate resistance in a circuit? [BACK](#)
B. $R = E / I$
- T5D04: What is the resistance of a circuit in which a current of 3 amperes flows when connected to 90 volts? [BACK](#)
B. 30 ohms
- T5D05: What is the resistance of a circuit for which the applied voltage is 12 volts and the current flow is 1.5 amperes? [BACK](#)
C. 8 ohms
- T5D06: What is the resistance of a circuit that draws 4 amperes from a 12-volt source? [BACK](#)
A. 3 ohms
- T5D07: What is the current in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms? [BACK](#)
D. 1.5 amperes
- T5D08: What is the current through a 100-ohm resistor connected across 200 volts? [BACK](#)
C. 2 amperes
- T5D09: What is the current through a 24-ohm resistor connected across 240 volts? [BACK](#)
C. 10 amperes
- T5D10: What is the voltage across a 2-ohm resistor if a current of 0.5 amperes flows through it? [BACK](#)
A. 1 volt
- T5D11: What is the voltage across a 10-ohm resistor if a current of 1 ampere flows through it? [BACK](#)
B. 10 volts
- T5D12: What is the voltage across a 10-ohm resistor if a current of 2 amperes flows through it? [BACK](#)
D. 20 volts

T5D13: In which type of circuit is DC current the same through all components? [BACK](#)

A. Series

T5D14: In which type of circuit is voltage the same across all components? [BACK](#)

B. Parallel

*NOTE: If you're scrolling through the questions & answers, don't use the **BACK** buttons below. Just keep scrolling forward.*

T6: ELECTRONIC AND ELECTRICAL COMPONENTS

T6A01: What electrical component opposes the flow of current in a DC circuit? [BACK](#)

B. Resistor

T6A02: What type of component is often used as an adjustable volume control? [BACK](#)

C. Potentiometer

T6A03: What electrical parameter is controlled by a potentiometer? [BACK](#)

B. Resistance

T6A04: What electrical component stores energy in an electric field? [BACK](#)

B. Capacitor

T6A05: What type of electrical component consists of conductive surfaces separated by an insulator? [BACK](#)

D. Capacitor

T6A06: What type of electrical component stores energy in a magnetic field? [BACK](#)

C. Inductor

T6A07: What electrical component is typically constructed as a coil of wire? [BACK](#)

D. Inductor

T6A08: What is the function of an SPDT switch? [BACK](#)

C. A single circuit is switched between one of two other circuits

T6A09: What electrical component is used to protect other circuit components from current overloads? [BACK](#)

A. Fuse

T6A10: Which of the following battery chemistries is rechargeable? [BACK](#)

A. Nickel-metal hydride

B. Lithium-ion

C. Lead-acid

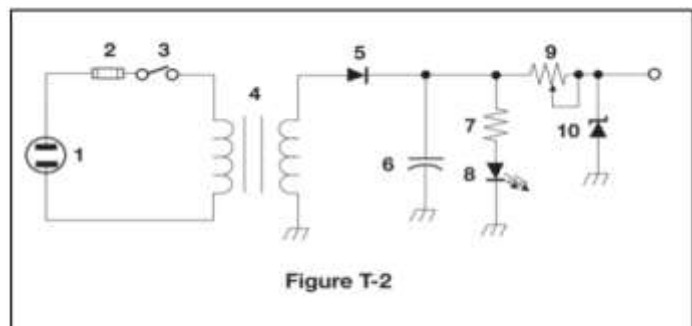
D. All these choices are correct

T6A11: Which of the following battery chemistries is not rechargeable? [BACK](#)

B. Carbon-zinc

T6A12: What type of switch is represented by component 3 in figure T-2? [BACK](#)

A. Single-pole single-throw



T6B01: Which is true about forward voltage drop in a diode? [BACK](#)

A. It is lower in some diode types than in others

T6B02: What electronic component allows current to flow in only one direction? [BACK](#)

C. Diode

T6B03: Which of these components can be used as an electronic switch? [BACK](#)

C. Transistor

T6B04: Which of the following components can consist of three regions of semiconductor material? [BACK](#)

B. Transistor

T6B05: What type of transistor has a gate, drain, and source? [BACK](#)

B. Field-effect

T6B06: How is the cathode lead of a semiconductor diode often marked on the package? [BACK](#)

B. With a stripe

T6B07: What causes a light-emitting diode (LED) to emit light? [BACK](#)

A. Forward current

T6B08: What does the abbreviation FET stand for? [BACK](#)

D. Field Effect Transistor

T6B09: What are the names for the electrodes of a diode? [BACK](#)

C. Anode and cathode

T6B10: Which of the following can provide power gain? [BACK](#)

B. Transistor

T6B11: What is the term that describes a device's ability to amplify a signal? [BACK](#)

A. Gain

T6B12: What are the names of the electrodes of a bipolar junction transistor? [BACK](#)

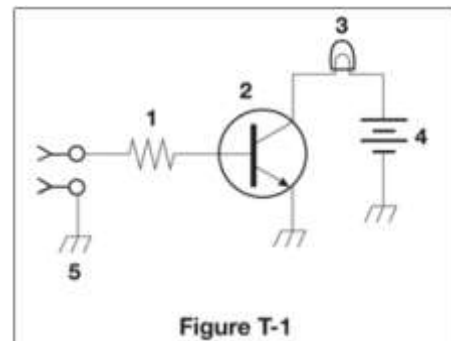
B. Emitter, base, collector

T6C01: What is the name of an electrical wiring diagram that uses standard component symbols? [BACK](#)

C. Schematic

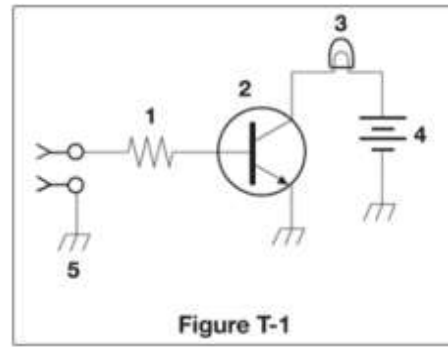
T6C02: What is component 1 in figure T-1? [BACK](#)

A. Resistor



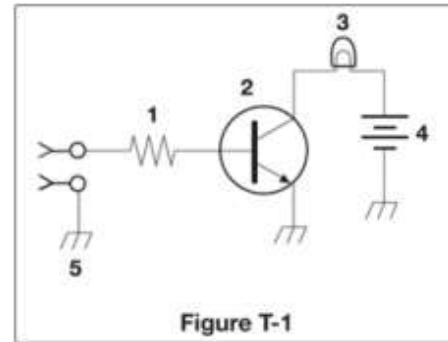
T6C03: What is component 2 in figure T-1? [BACK](#)

B. Transistor



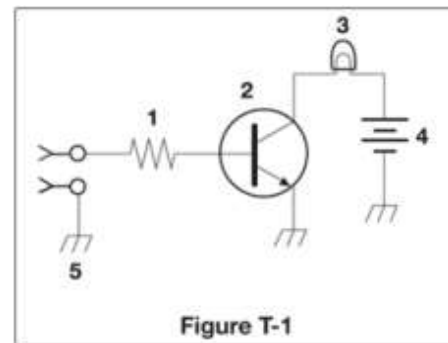
T6C04: What is component 3 in figure T-1? [BACK](#)

C. Lamp



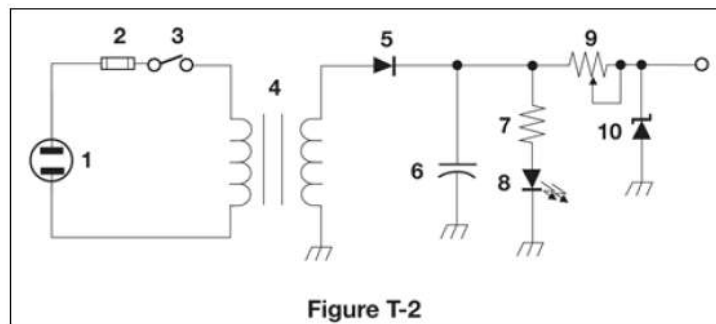
T6C05: What is component 4 in figure T-1? [BACK](#)

D. Battery



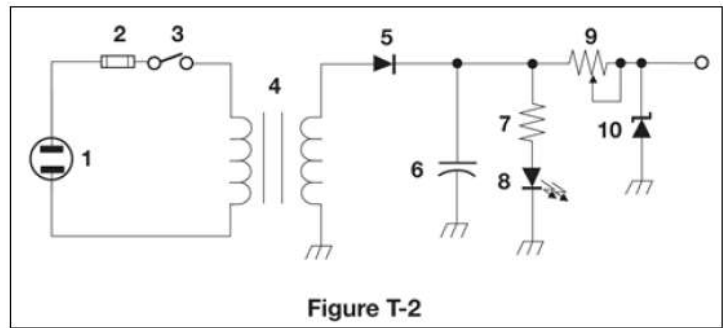
T6C06: What is component 6 in figure T-2? [BACK](#)

B. Capacitor



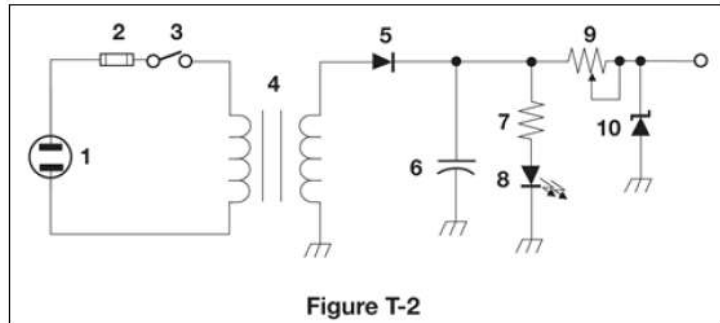
T6C07: What is component 8 in figure T-2? [BACK](#)

D. Light emitting diode



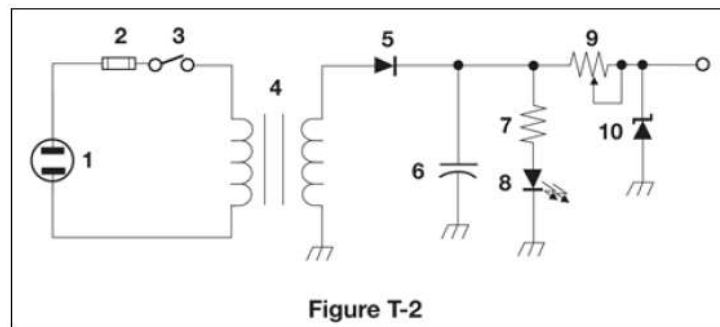
T6C08: What is component 9 in figure T-2? [BACK](#)

C. Variable resistor



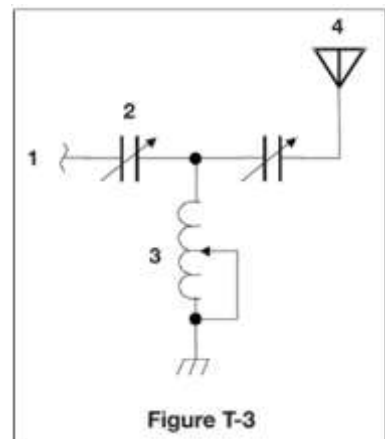
T6C09: What is component 4 in figure T-2? [BACK](#)

D. Transformer



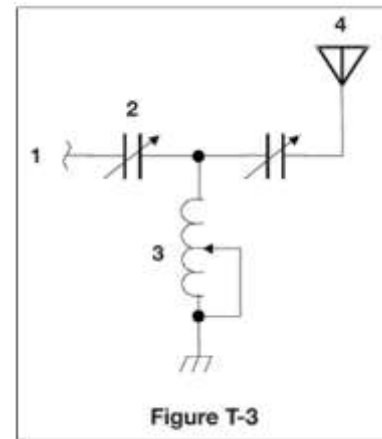
T6C10: What is component 3 in figure T-3? [BACK](#)

D. Variable inductor



T6C11: What is component 4 in figure T-3? [BACK](#)

A. Antenna



T6C12: Which of the following is accurately represented in electrical schematics? [BACK](#)

C. Component connections

T6D01: Which of the following devices or circuits changes an alternating current into a varying direct current signal? [BACK](#)

B. Rectifier

T6D02: What is a relay? [BACK](#)

A. An electrically-controlled switch

T6D03: Which of the following is a reason to use shielded wire? [BACK](#)

C. To prevent coupling of unwanted signals to or from the wire

T6D04: Which of the following displays an electrical quantity as a numeric value? [BACK](#)

C. Meter

T6D05: What type of circuit controls the amount of voltage from a power supply? [BACK](#)

A. Regulator

T6D06: What component changes 120 V AC power to a lower AC voltage for other uses? [BACK](#)

B. Transformer

T6D07: Which of the following is commonly used as a visual indicator? [BACK](#)

A. LED

T6D08: Which of the following is combined with an inductor to make a resonant circuit? [BACK](#)

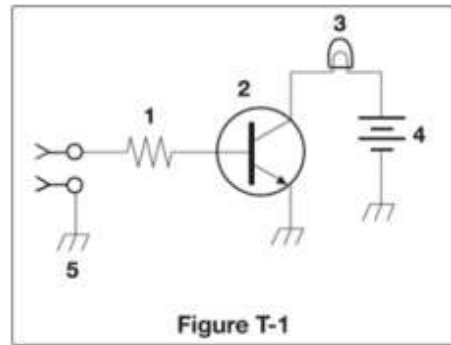
D. Capacitor

T6D09: What is the name of a device that combines several semiconductors and other components into one package? [BACK](#)

C. Integrated circuit

T6D10: What is the function of component 2 in figure T-1? [BACK](#)

C. Control the flow of current



T6D11: Which of the following is a resonant or tuned circuit? [BACK](#)

A. An inductor and a capacitor in series or parallel

*NOTE: If you're scrolling through the questions & answers, don't use the **BACK** buttons below. Just keep scrolling forward.*

T7: PRACTICAL CIRCUITS

T7A01: Which term describes the ability of a receiver to detect the presence of a signal? [BACK](#)

B. Sensitivity

T7A02: What is a transceiver? [BACK](#)

A. A device that combines a receiver and transmitter

T7A03: Which of the following is used to convert a signal from one frequency to another? [BACK](#)

B. Mixer

T7A04: Which term describes the ability of a receiver to discriminate between multiple signals? [BACK](#)

C. Selectivity

T7A05: What is the name of a circuit that generates a signal at a specific frequency? [BACK](#)

D. Oscillator

T7A06: What device converts the RF input and output of a transceiver to another band? [BACK](#)

C. Transverter

T7A07: What is the function of a transceiver's PTT input? [BACK](#)

B. Switches transceiver from receive to transmit when grounded

T7A08: Which of the following describes combining speech with an RF carrier signal? [BACK](#)

C. Modulation

T7A09: What is the function of the SSB/CW-FM switch on a VHF power amplifier? [BACK](#)

B. Set the amplifier for proper operation in the selected mode

T7A10: What device increases the transmitted output power from a transceiver? [BACK](#)

B. An RF power amplifier

T7A11: Where is an RF preamplifier installed? [BACK](#)

A. Between the antenna and receiver

T7B01: What can you do if you are told your FM handheld or mobile transceiver is overdeviating? [BACK](#)

D. Talk farther away from the microphone

T7B02: What would cause a broadcast AM or FM radio to receive an amateur radio transmission unintentionally? [BACK](#)

A. The receiver is unable to reject strong signals outside the AM or FM band

T7B03: Which of the following can cause radio frequency interference? [BACK](#)

A. Fundamental overload

B. Harmonics

C. Spurious emissions

D. All these choices are correct

T7B04: Which of the following could you use to cure distorted audio caused by RF current on the shield of a microphone cable? [BACK](#)

D. Ferrite choke

T7B05: How can fundamental overload of a non-amateur radio or TV receiver by an amateur signal be reduced or eliminated? [BACK](#)

A. Block the amateur signal with a filter at the antenna input of the affected receiver

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? [BACK](#)

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

T7B07: Which of the following can reduce overload of a VHF transceiver by a nearby commercial FM station? [BACK](#)

D. Installing a band-reject filter

T7B08: What should you do if something in a neighbor's home is causing harmful interference to your amateur station? [BACK](#)

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

T7B09: What should be the first step to resolve non-fiber optic cable TV interference caused by your amateur radio transmission? [BACK](#)

D. Be sure all TV feed line coaxial connectors are installed properly

T7B10: What might be a problem if you receive a report that your audio signal through an FM repeater is distorted or unintelligible? [BACK](#)

A. Your transmitter is slightly off frequency

B. Your batteries are running low

C. You are in a bad location

D. All these choices are correct

T7B11: What is a symptom of RF feedback in a transmitter or transceiver? [BACK](#)

C. Reports of garbled, distorted, or unintelligible voice transmissions

T7C01: What is the primary purpose of a dummy load? [BACK](#)

A. To prevent transmitting signals over the air when making tests

T7C02: Which of the following is used to determine if an antenna is resonant at the desired operating frequency? [BACK](#)

B. An antenna analyzer

T7C03: What does a dummy load consist of? [BACK](#)

B. A non-inductive resistor mounted on a heat sink

T7C04: What reading on an SWR meter indicates a perfect impedance match between the antenna and the feed line? [BACK](#)

C. 1:1

T7C05: Why do most solid-state transmitters reduce output power as SWR increases beyond a certain level? [BACK](#)

A. To protect the output amplifier transistors

T7C06: What does an SWR reading of 4:1 indicate? [BACK](#)

D. Impedance mismatch

T7C07: What happens to power lost in a feed line? [BACK](#)

C. It is converted into heat

T7C08: Which instrument can be used to determine SWR? [BACK](#)

D. Directional wattmeter

T7C09: Which of the following causes failure of coaxial cables? [BACK](#)

A. Moisture contamination

T7C10: Why should the outer jacket of coaxial cable be resistant to ultraviolet light? [BACK](#)

D. Ultraviolet light can damage the jacket and allow water to enter the cable

T7C11: What is a disadvantage of air core coaxial cable when compared to foam or solid dielectric types? [BACK](#)

C. It requires special techniques to prevent moisture in the cable

T7D01: Which instrument would you use to measure electric potential? [BACK](#)

B. A voltmeter

T7D02: How is a voltmeter connected to a component to measure applied voltage? [BACK](#)

B. In parallel

T7D03: When configured to measure current, how is a multimeter connected to a component? [BACK](#)

A. In series

T7D04: Which instrument is used to measure electric current? [BACK](#)

D. An ammeter

T7D06: Which of the following can damage a multimeter? [BACK](#)

C. Attempting to measure voltage when using the resistance setting

T7D07: Which of the following measurements are made using a multimeter? [BACK](#)

C. Voltage and resistance

T7D08: Which of the following types of solder should not be used for radio and electronic applications? [BACK](#)

A. Acid-core solder

T7D09: What is the characteristic appearance of a cold tin-lead solder joint? [BACK](#)

C. A rough or lumpy surface

T7D10: What reading indicates that an ohmmeter is connected across a large, discharged capacitor? [BACK](#)

A. Increasing resistance with time

T7D11: Which of the following precautions should be taken when measuring in-circuit resistance with an ohmmeter? [BACK](#)

B. Ensure that the circuit is not powered

NOTE: If you're scrolling through the questions & answers, don't use the [BACK](#) buttons below. Just keep scrolling forward.

T8: SIGNALS AND EMISSIONS

T8A01: Which of the following is a form of amplitude modulation? [BACK](#)

C. Single sideband

T8A02: What type of modulation is commonly used for VHF packet radio transmissions? [BACK](#)

A. FM or PM

T8A03: Which type of voice mode is often used for long-distance (weak signal) contacts on the VHF and UHF bands? [BACK](#)

C. SSB

T8A04: Which type of modulation is commonly used for VHF and UHF voice repeaters? [BACK](#)

D. FM or PM

T8A05: Which of the following types of signal has the narrowest bandwidth? [BACK](#)

C. CW

T8A06: Which sideband is normally used for 10 meter HF, VHF, and UHF single-sideband communications? [BACK](#)

A. Upper sideband

T8A07: What is a characteristic of single sideband (SSB) compared to FM? [BACK](#)

C. SSB signals have narrower bandwidth

T8A08: What is the approximate bandwidth of a typical single sideband (SSB) voice signal? [BACK](#)

B. 3 kHz

T8A09: What is the approximate bandwidth of a VHF repeater FM voice signal? [BACK](#)

C. Between 10 and 15 kHz

T8A10: What is the approximate bandwidth of AM fast-scan TV transmissions? [BACK](#)

B. About 6 MHz

T8A11: What is the approximate bandwidth required to transmit a CW signal? [BACK](#)

B. 150 Hz

T8A12: Which of the following is a disadvantage of FM compared with single sideband? [BACK](#)

B. Only one signal can be received at a time

T8B01: What telemetry information is typically transmitted by satellite beacons? [BACK](#)

C. Health and status of the satellite

T8B02: What is the impact of using excessive effective radiated power on a satellite uplink? [BACK](#)

B. Blocking access by other users

T8B03: Which of the following are provided by satellite tracking programs? [BACK](#)

- A. Maps showing the real-time position of the satellite track over Earth
- B. The time, azimuth, and elevation of the start, maximum altitude, and end of a pass
- C. The apparent frequency of the satellite transmission, including effects of Doppler shift
- D. All these choices are correct

T8B04: What mode of transmission is commonly used by amateur radio satellites? [BACK](#)

- A. SSB
- B. FM
- C. CW/data
- D. All these choices are correct

T8B05: What is a satellite beacon? [BACK](#)

- D. A transmission from a satellite that contains status information

T8B06: Which of the following are inputs to a satellite tracking program? [BACK](#)

- B. The Keplerian elements

T8B07: What is Doppler shift in reference to satellite communications? [BACK](#)

- C. An observed change in signal frequency caused by relative motion between the satellite and Earth station

T8B08: What is meant by the statement that a satellite is operating in U/V mode? [BACK](#)

- B. The satellite uplink is in the 70 centimeter band and the downlink is in the 2 meter band

T8B09: What causes spin fading of satellite signals? [BACK](#)

- B. Rotation of the satellite and its antennas

T8B10: What is a LEO satellite? [BACK](#)

- D. A satellite in low earth orbit

T8B11: Who may receive telemetry from a space station? [BACK](#)

- A. Anyone

T8B12: Which of the following is a way to determine whether your satellite uplink power is neither too low nor too high? [BACK](#)

- C. Your signal strength on the downlink should be about the same as the beacon

T8C01: Which of the following methods is used to locate sources of noise interference or jamming? [BACK](#)

- C. Radio direction finding

T8C02: Which of these items would be useful for a hidden transmitter hunt? [BACK](#)

- B. A directional antenna

T8C03: What operating activity involves contacting as many stations as possible during a specified period? [BACK](#)

- D. Contesting

T8C04: Which of the following is good procedure when contacting another station in a contest? [BACK](#)

- C. Send only the minimum information needed for proper identification and the contest exchange

T8C05: What is a grid locator? [BACK](#)

- A. A letter-number designator assigned to a geographic location

T8C06: How is over the air access to IRLP nodes accomplished? [BACK](#)

B. By using DTMF signals

T8C07: What is Voice Over Internet Protocol (VoIP)? [BACK](#)

D. A method of delivering voice communications over the internet using digital techniques

T8C08: What is the Internet Radio Linking Project (IRLP)? [BACK](#)

A. A technique to connect amateur radio systems, such as repeaters, via the internet using Voice Over Internet Protocol (VoIP)

T8C09: Which of the following protocols enables an amateur station to transmit through a repeater without using a radio to initiate the transmission? [BACK](#)

D. EchoLink

T8C10: What is required before using the EchoLink system? [BACK](#)

C. Register your call sign and provide proof of license

T8C11: What is an amateur radio station that connects other amateur stations to the internet? [BACK](#)

A. A gateway

T8D01: Which of the following is a digital communications mode? [BACK](#)

A. Packet radio

B. IEEE 802.11

C. FT8

D. All these choices are correct

T8D02: What is a Talkgroup on a DMR repeater? [BACK](#)

B. A way for groups of users to share a channel at different times without hearing other users on the channel

T8D03: What kind of data can be transmitted by APRS? [BACK](#)

A. GPS position data

B. Text messages

C. Weather data

D. All these choices are correct

T8D04: What type of transmission is indicated by the term "NTSC?" [BACK](#)

C. An analog fast-scan color TV signal

T8D05: Which of the following is an application of APRS? [BACK](#)

A. Providing real-time tactical digital communications in conjunction with a map showing the locations of stations

T8D06: What does the abbreviation "PSK" mean? [BACK](#)

B. Phase Shift Keying

T8D07: Which of the following describes DMR? [BACK](#)

A. A technique for time-multiplexing two digital voice signals on a single 12.5 kHz repeater channel

T8D08: Which of the following is included in packet radio transmissions? [BACK](#)

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 these choices are correct

T8D09: What is CW? [BACK](#)

D. Another name for a Morse code transmission

T8D10: Which of the following operating activities is supported by digital mode software in the WSJT-X software suite? [BACK](#)

A. Earth-Moon-Earth

B. Weak signal propagation beacons

C. Meteor scatter

D. All these choices are correct

T8D11: What is an ARQ transmission system? [BACK](#)

C. An error correction method in which the receiving station detects errors and sends a request for retransmission

T8D12: Which of the following best describes an amateur radio mesh network? [BACK](#)

A. An amateur-radio based data network using commercial Wi-Fi equipment with modified firmware

T8D13: What is FT8? [BACK](#)

B. A digital mode capable of low signal-to-noise operation

*NOTE: If you're scrolling through the questions & answers, don't use the **BACK** buttons below. Just keep scrolling forward.*

T9: ANTENNAS AND FEED LINES

T9A01: What is a beam antenna? [BACK](#)

C. An antenna that concentrates signals in one direction

T9A02: Which of the following describes a type of antenna loading? [BACK](#)

A. Electrically lengthening by inserting inductors in radiating elements

T9A03: Which of the following describes a simple dipole oriented parallel to Earth's surface? [BACK](#)

B. A horizontally polarized antenna

T9A04: What is a disadvantage of the short, flexible antenna supplied with most handheld radio transceivers, compared to a full-sized quarter-wave antenna? [BACK](#)

A. It has low efficiency

T9A05: Which of the following increases the resonant frequency of a dipole antenna? [BACK](#)

C. Shortening it

T9A06: Which of the following types of antenna offers the greatest gain? [BACK](#)

D. Yagi

T9A07: What is a disadvantage of using a handheld VHF transceiver with a flexible antenna inside a vehicle? [BACK](#)

A. Signal strength is reduced due to the shielding effect of the vehicle

T9A08: What is the approximate length, in inches, of a quarter-wavelength vertical antenna for 146 MHz? [BACK](#)

C. 19

T9A09: What is the approximate length, in inches, of a half-wavelength 6 meter dipole antenna? [BACK](#)

C. 112

T9A10: In which direction does a half-wave dipole antenna radiate the strongest signal? [BACK](#)

D. Broadside to the antenna

T9A11: What is antenna gain? [BACK](#)

C. The increase in signal strength in a specified direction compared to a reference antenna

T9A12: What is an advantage of a 5/8 wavelength whip antenna for VHF or UHF mobile service? [BACK](#)

A. It has more gain than a 1/4-wavelength antenna

T9B01: What is a benefit of low SWR? [BACK](#)

B. Reduced signal loss

T9B02: What is the most common impedance of coaxial cables used in amateur radio? [BACK](#)

B. 50 ohms

T9B03: Why is coaxial cable the most common feed line for amateur radio antenna systems? [BACK](#)

A. It is easy to use and requires few special installation considerations

T9B04: What is the major function of an antenna tuner (antenna coupler)? [BACK](#)

A. It matches the antenna system impedance to the transceiver's output impedance

T9B05: What happens as the frequency of a signal in coaxial cable is increased? [BACK](#)

D. The loss increases

T9B06: Which of the following RF connector types is most suitable for frequencies above 400 MHz? [BACK](#)

B. Type N

T9B07: Which of the following is true of PL-259 type coax connectors? [BACK](#)

C. They are commonly used at HF and VHF frequencies

T9B08: Which of the following is a source of loss in coaxial feed line? [BACK](#)

A. Water intrusion into coaxial connectors

B. High SWR

C. Multiple connectors in the line

D. All these choices are correct

T9B09: What can cause erratic changes in SWR? [BACK](#)

B. Loose connection in the antenna or feed line

T9B10: What is the electrical difference between RG-58 and RG-213 coaxial cable? [BACK](#)

C. RG-213 cable has less loss at a given frequency

T9B11: Which of the following types of feed line has the lowest loss at VHF and UHF? [BACK](#)

C. Air-insulated hardline

T9B12: What is standing wave ratio (SWR)? [BACK](#)

A. A measure of how well a load is matched to a transmission line

*NOTE: If you're scrolling through the questions & answers, don't use the **BACK** buttons below. Just keep scrolling forward.*

T0: SAFETY

T0A01: Which of the following is a safety hazard of a 12-volt storage battery? [BACK](#)

B. Shorting the terminals can cause burns, fire, or an explosion

T0A02: What health hazard is presented by electrical current flowing through the body? [BACK](#)

A. It may cause injury by heating tissue

B. It may disrupt the electrical functions of cells

C. It may cause involuntary muscle contractions

D. All these choices are correct

T0A03: In the United States, what circuit does black wire insulation indicate in a three-wire 120 V cable? [BACK](#)

B. Hot

T0A04: What is the purpose of a fuse in an electrical circuit? [BACK](#)

B. To remove power in case of overload

T0A05: Why should a 5-ampere fuse never be replaced with a 20-ampere fuse? [BACK](#)

C. Excessive current could cause a fire

T0A06: What is a good way to guard against electrical shock at your station? [BACK](#)

A. Use three-wire cords and plugs for all AC powered equipment

B. Connect all AC powered station equipment to a common safety ground

C. Install mechanical interlocks in high-voltage circuits

D. All these choices are correct

T0A07: Where should a lightning arrester be installed in a coaxial feed line? [BACK](#)

D. On a grounded panel near where feed lines enter the building

T0A08: Where should a fuse or circuit breaker be installed in a 120V AC power circuit? [BACK](#)

A. In series with the hot conductor only

T0A09: What should be done to all external ground rods or earth connections? [BACK](#)

C. Bond them together with heavy wire or conductive strap

T0A10: What hazard is caused by charging or discharging a battery too quickly? [BACK](#)

A. Overheating or out-gassing

T0A11: What hazard exists in a power supply immediately after turning it off? [BACK](#)

D. Charge stored in filter capacitors

T0A12: Which of the following precautions should be taken when measuring high voltages with a voltmeter? [BACK](#)

B. Ensure that the voltmeter and leads are rated for use at the voltages to be measured

T0B01: Which of the following is good practice when installing ground wires on a tower for lightning protection? [BACK](#)

C. Ensure that connections are short and direct

T0B02: What is required when climbing an antenna tower? [BACK](#)

- 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

T0B03: Under what circumstances is it safe to climb a tower without a helper or observer? [BACK](#)

- D. Never

T0B04: Which of the following is an important safety precaution to observe when putting up an antenna tower? [BACK](#)

- C. Look for and stay clear of any overhead electrical wires

T0B05: What is the purpose of a safety wire through a turnbuckle used to tension guy lines? [BACK](#)

- B. Prevent loosening of the turnbuckle from vibration

T0B06: What is the minimum safe distance from a power line to allow when installing an antenna? [BACK](#)

- D. Enough so that if the antenna falls, no part of it can come closer than 10 feet to the power wires

T0B07: Which of the following is an important safety rule to remember when using a crank-up tower? [BACK](#)

- C. This type of tower must not be climbed unless it is retracted, or mechanical safety locking devices have been installed

T0B08: Which is a proper grounding method for a tower? [BACK](#)

- D. Separate eight-foot ground rods for each tower leg, bonded to the tower and each Other

T0B09: Why should you avoid attaching an antenna to a utility pole? [BACK](#)

- C. The antenna could contact high-voltage power lines

T0B10: Which of the following is true when installing grounding conductors used for lightning protection? [BACK](#)

- C. Sharp bends must be avoided

T0B11: Which of the following establishes grounding requirements for an amateur radio tower or antenna? [BACK](#)

- B. Local electrical codes

T0C01: What type of radiation are radio signals? [BACK](#)

- D. Non-ionizing radiation

T0C02: At which of the following frequencies does maximum permissible exposure have the lowest value? [BACK](#)

- B. 50 MHz

T0C03: How does the allowable power density for RF safety change if duty cycle changes from 100 percent to 50 percent? [BACK](#)

- C. It increases by a factor of 2

T0C04: What factors affect the RF exposure of people near an amateur station antenna? [BACK](#)

- A. Frequency and power level of the RF field
- B. Distance from the antenna to a person
- C. Radiation pattern of the antenna
- D. All these choices are correct

T0C05: Why do exposure limits vary with frequency? [BACK](#)

D. The human body absorbs more RF energy at some frequencies than at others

T0C06: Which of the following is an acceptable method to determine whether your station complies with FCC RF exposure regulations? [BACK](#)

A. By calculation based on FCC OET Bulletin 65

B. By calculation based on computer modeling

C. By measurement of field strength using calibrated equipment

D. All these choices are correct

T0C07: What hazard is created by touching an antenna during a transmission? [BACK](#)

B. RF burn to skin

T0C08: Which of the following actions can reduce exposure to RF radiation? [BACK](#)

A. Relocate antennas

T0C09: How can you make sure your station stays in compliance with RF safety regulations? [BACK](#)

B. By re-evaluating the station whenever an item in the transmitter or antenna system is changed

T0C10: Why is duty cycle one of the factors used to determine safe RF radiation exposure levels? [BACK](#)

A. It affects the average exposure to radiation

T0C11: What is the definition of duty cycle during the averaging time for RF exposure? [BACK](#)

C. The percentage of time that a transmitter is transmitting

T0C12: How does RF radiation differ from ionizing radiation (radioactivity)? [BACK](#)

A. RF radiation does not have sufficient energy to cause chemical changes in cells and damage DNA

T0C13: Who is responsible for ensuring that no person is exposed to RF energy above the FCC exposure limits? [BACK](#)

B. The station licensee

*NOTE: If you're scrolling through the questions & answers, don't use the **BACK** buttons below. Just keep scrolling forward.*

T1: COMISSION RULES

T1A01: Which of the following is part of the Basis and Purpose of the Amateur Radio Service? [BACK](#)

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

T1A02: Which agency regulates and enforces the rules for the Amateur Radio Service in the United States? [BACK](#)

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

T1A03: What do the FCC rules state regarding the use of a phonetic alphabet for station identification in the Amateur Radio Service? [BACK](#)

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

T1A04: How many operator/primary station license grants may be held by any one person? [BACK](#)

- 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

T1A05: What proves that the FCC has issued an operator/primary license grant? [BACK](#)

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

T1A06: What is the FCC Part 97 definition of a beacon? [BACK](#)

- 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**

T1A07: What is the FCC Part 97 definition of a space station? [BACK](#)

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

T1A08: Which of the following entities recommends transmit/receive channels and other parameters for auxiliary and repeater stations? [BACK](#)

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

T1A09: Who selects a Frequency Coordinator? [BACK](#)

- 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

T1A10: What is the Radio Amateur Civil Emergency Service (RACES)? [BACK](#)

- 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 these choices are correct**

T1A11: When is willful interference to other amateur radio stations permitted? [BACK](#)

- 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

T1B01: Which of the following frequency ranges are available for phone operation by Technician licensees? [BACK](#)

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

T1B02: Which amateurs may contact the International Space Station (ISS) on VHF bands? [BACK](#)

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

T1B03: Which frequency is in the 6 meter amateur band? [BACK](#)

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

T1B04: Which amateur band includes 146.52 MHz? [BACK](#)

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

T1B05: How may amateurs use the 219 to 220 MHz segment of 1.25 meter band? [BACK](#)

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

T1B06: On which HF bands does a Technician class operator have phone privileges? [BACK](#)

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

T1B07: Which of the following VHF/UHF band segments are limited to CW only? [BACK](#)

- 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 these choices are correct

T1B08: How are US amateurs restricted in segments of bands where the Amateur Radio Service is secondary? [BACK](#)

- 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

T1B09: Why should you not set your transmit frequency to be exactly at the edge of an amateur band or sub-band? [BACK](#)

- 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 these choices are correct

T1B10: Where may SSB phone be used in amateur bands above 50 MHz? [BACK](#)

- 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

T1B11: What is the maximum peak envelope power output for Technician class operators in their HF band segments? [BACK](#)

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

T1B12: Except for some specific restrictions, what is the maximum peak envelope power output for Technician class operators using frequencies above 30 MHz? [BACK](#)

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

T1C01: For which license classes are new licenses currently available from the FCC? [BACK](#)

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

T1C02: Who may select a desired call sign under the vanity call sign rules? [BACK](#)

- 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

T1C03: What types of international communications are an FCC-licensed amateur radio station permitted to make? [BACK](#)

- 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

T1C04: What may happen if the FCC is unable to reach you by email? [BACK](#)

- 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

T1C05: Which of the following is a valid Technician class call sign format? [BACK](#)

- A. KF1XXX
- B. KA1X
- C. W1XX
- D. All these choices are correct

T1C06: From which of the following locations may an FCC-licensed amateur station transmit? [BACK](#)

- 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

T1C07: Which of the following can result in revocation of the station license or suspension of the operator license? [BACK](#)

- 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

T1C08: What is the normal term for an FCC-issued amateur radio license? [BACK](#)

- A. Five years
- B. Life
- C. Ten years
- D. Eight years

T1C09: What is the grace period for renewal if an amateur license expires? [BACK](#)

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

T1C10: How soon after passing the examination for your first amateur radio license may you transmit on the amateur radio bands? [BACK](#)

- 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

T1C11: If your license has expired and is still within the allowable grace period, may you continue to transmit on the amateur radio bands? [BACK](#)

- 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

T1D01: With which countries are FCC-licensed amateur radio stations prohibited from exchanging communications? [BACK](#)

- 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)

T1D02: Under which of the following circumstances are one-way transmissions by an amateur station prohibited? [BACK](#)

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

T1D03: When is it permissible to transmit messages encoded to obscure their meaning? [BACK](#)

- 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

T1D04: Under what conditions is an amateur station authorized to transmit music using a phone emission? [BACK](#)

- 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

T1D05: When may amateur radio operators use their stations to notify other amateurs of the availability of equipment for sale or trade? [BACK](#)

- 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

T1D06: What, if any, are the restrictions concerning transmission of language that may be considered indecent or obscene? [BACK](#)

- 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

T1D07: What types of amateur stations can automatically retransmit the signals of other amateur stations? [BACK](#)

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

T1D08: In which of the following circumstances may the control operator of an amateur station receive compensation for operating that station? [BACK](#)

- 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

T1D09: When may amateur stations transmit information in support of broadcasting, program production, or news gathering, assuming no other means is available? [BACK](#)

- 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

T1D10: How does the FCC define broadcasting for the Amateur Radio Service? [BACK](#)

- 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

T1D11: When may an amateur station transmit without identifying on the air? [BACK](#)

- 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

T1E01: When may an amateur station transmit without a control operator? [BACK](#)

- 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

T1E02: Who may be the control operator of a station communicating through an amateur satellite or space station? [BACK](#)

- 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

T1E03: Who must designate the station control operator? [BACK](#)

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

T1E04: What determines the transmitting frequency privileges of an amateur station? [BACK](#)

- 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

T1E05: What is an amateur station's control point? [BACK](#)

- 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

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? [BACK](#)

- 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

T1E07: When the control operator is not the station licensee, who is responsible for the proper operation of the station? [BACK](#)

- 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

T1E08: Which of the following is an example of automatic control? [BACK](#)

- 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

T1E09: Which of the following are required for remote control operation? [BACK](#)

- 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 these choices are correct

T1E10: Which of the following is an example of remote control as defined in Part 97? [BACK](#)

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

T1E11: Who does the FCC presume to be the control operator of an amateur station, unless documentation to the contrary is in the station records? [BACK](#)

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

T1F01: When must the station and its records be available for FCC inspection? [BACK](#)

- 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

T1F02: How often must you identify with your FCC-assigned call sign when using tactical call signs such as "Race Headquarters"? [BACK](#)

- 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

T1F03: When are you required to transmit your assigned call sign? [BACK](#)

- 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

T1F04: What language may you use for identification when operating in a phone sub-band? [BACK](#)

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

T1F05: What method of call sign identification is required for a station transmitting phone signals? [BACK](#)

- 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

T1F06: Which of the following self-assigned indicators are acceptable when using a phone transmission? [BACK](#)

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

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? [BACK](#)

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

T1F08: What is the definition of third party communications? [BACK](#)

- 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

T1F09: What type of amateur station simultaneously retransmits the signal of another amateur station on a different channel or channels? [BACK](#)

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

T1F10: Who is accountable if a repeater inadvertently retransmits communications that violate the FCC rules? [BACK](#)

- 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

T1F11: Which of the following is a requirement for the issuance of a club station license grant? [BACK](#)

- 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 these choices are correct

*NOTE: If you're scrolling through the questions & answers, don't use the **BACK** buttons below. Just keep scrolling forward.*

T2: OPERATING PROCEDURES

T2A01: What is a common repeater frequency offset in the 2 meter band? [BACK](#)

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

T2A02: What is the national calling frequency for FM simplex operations in the 2 meter band? [BACK](#)

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

T2A03: What is a common repeater frequency offset in the 70 cm band? [BACK](#)

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

T2A04: What is an appropriate way to call another station on a repeater if you know the other station's call sign? [BACK](#)

- 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

T2A05: How should you respond to a station calling CQ? [BACK](#)

- 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

T2A06: Which of the following is required when making on-the-air test transmissions? [BACK](#)

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

T2A07: What is meant by "repeater offset"? [BACK](#)

- 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

T2A08: What is the meaning of the procedural signal "CQ"? [BACK](#)

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

T2A09: Which of the following indicates that a station is listening on a repeater and looking for a contact? [BACK](#)

- 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

T2A10: What is a band plan, beyond the privileges established by the FCC? [BACK](#)

- 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

T2A11: What term describes an amateur station that is transmitting and receiving on the same frequency? [BACK](#)

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

T2A12: What should you do before calling CQ? [BACK](#)

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

T2B01: How is a VHF/UHF transceiver's "reverse" function used? [BACK](#)

- 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

T2B02: What term describes the use of a sub-audible tone transmitted along with normal voice audio to open the squelch of a receiver? [BACK](#)

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

T2B03: Which of the following describes a linked repeater network? [BACK](#)

- 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

T2B04: Which of the following could be the reason you are unable to access a repeater whose output you can hear? [BACK](#)

- 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

T2B05: What would cause your FM transmission audio to be distorted on voice peaks? [BACK](#)

- 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

T2B06: What type of signaling uses pairs of audio tones? [BACK](#)

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

T2B07: How can you join a digital repeater's "talkgroup"? [BACK](#)

- 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

T2B08: Which of the following applies when two stations transmitting on the same frequency interfere with each other? [BACK](#)

- 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

T2B09: Why are simplex channels designated in the VHF/UHF band plans? [BACK](#)

- 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

T2B10: Which Q signal indicates that you are receiving interference from other stations? [BACK](#)

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

T2B11: Which Q signal indicates that you are changing frequency? [BACK](#)

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

T2B12: What is the purpose of the color code used on DMR repeater systems? [BACK](#)

- 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

T2B13: What is the purpose of a squelch function? [BACK](#)

- 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

T2C01: When do FCC rules NOT apply to the operation of an amateur station? [BACK](#)

- 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

T2C02: Which of the following are typical duties of a Net Control Station? [BACK](#)

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

T2C03: What technique is used to ensure that voice messages containing unusual words are received correctly? [BACK](#)

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

T2C04: What is RACES? [BACK](#)

- 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

T2C05: What does the term "traffic" refer to in net operation? [BACK](#)

- 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

T2C06: What is the Amateur Radio Emergency Service (ARES)? [BACK](#)

- 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

T2C07: Which of the following is standard practice when you participate in a net? [BACK](#)

- 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

T2C08: Which of the following is a characteristic of good traffic handling? [BACK](#)

- 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 these choices are correct

T2C09: Are amateur station control operators ever permitted to operate outside the frequency privileges of their license class? [BACK](#)

- 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

T2C10: What information is contained in the preamble of a formal traffic message? [BACK](#)

- 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

T2C11: What is meant by "check" in a radiogram header? [BACK](#)

- 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

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T3: RADIO WAVE PROPAGATION

T3A01: Why do VHF signal strengths sometimes vary greatly when the antenna is moved only a few feet? [BACK](#)

- 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

T3A02: What is the effect of vegetation on UHF and microwave signals? [BACK](#)

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

T3A03: What antenna polarization is normally used for long-distance CW and SSB contacts on the VHF and UHF bands? [BACK](#)

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

T3A04: What happens when antennas at opposite ends of a VHF or UHF line of sight radio link are not using the same polarization? [BACK](#)

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

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? [BACK](#)

- 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

T3A06: What is the meaning of the term “picket fencing”? [BACK](#)

- 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

T3A07: What weather condition might decrease range at microwave frequencies? [BACK](#)

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

T3A08: What is a likely cause of irregular fading of signals propagated by the ionosphere? [BACK](#)

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

T3A09: Which of the following results from the fact that signals propagated by the ionosphere are elliptically polarized? [BACK](#)

- 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

T3A10: What effect does multi-path propagation have on data transmissions? [BACK](#)

- 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**

T3A11: Which region of the atmosphere can refract or bend HF and VHF radio waves? [BACK](#)

- A. The stratosphere
- B. The troposphere
- C. The ionosphere**
- D. The mesosphere

T3A12: What is the effect of fog and rain on signals in the 10 meter and 6 meter bands? [BACK](#)

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

T3B01: What is the relationship between the electric and magnetic fields of an electromagnetic wave? [BACK](#)

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

T3B02: What property of a radio wave defines its polarization? [BACK](#)

- 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

T3B03: What are the two components of a radio wave? [BACK](#)

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

T3B04: What is the velocity of a radio wave traveling through free space? [BACK](#)

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

T3B05: What is the relationship between wavelength and frequency? [BACK](#)

- 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

T3B06: What is the formula for converting frequency to approximate wavelength in meters? [BACK](#)

- 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

T3B07: In addition to frequency, which of the following is used to identify amateur radio bands? [BACK](#)

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

T3B08: What frequency range is referred to as VHF? [BACK](#)

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

T3B09: What frequency range is referred to as UHF? [BACK](#)

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

T3B10: What frequency range is referred to as HF? [BACK](#)

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

T3B11: What is the approximate velocity of a radio wave in free space? [BACK](#)

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

T3C01: Why are simplex UHF signals rarely heard beyond their radio horizon? [BACK](#)

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

T3C02: What is a characteristic of HF communication compared with communications on VHF and higher frequencies? [BACK](#)

- 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

T3C03: What is a characteristic of VHF signals received via auroral backscatter? [BACK](#)

- 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

T3B04: 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? [BACK](#)

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

T3C05: Which of the following effects may allow radio signals to travel beyond obstructions between the transmitting and receiving stations? [BACK](#)

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

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? [BACK](#)

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

T3C07: What band is best suited for communicating via meteor scatter? [BACK](#)

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

T3C08: What causes tropospheric ducting? [BACK](#)

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

T3C09: What is generally the best time for long-distance 10 meter band propagation via the F region? [BACK](#)

- 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

T3C10: Which of the following bands may provide long-distance communications via the ionosphere's F region during the peak of the sunspot cycle? [BACK](#)

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

T3C11: Why is the radio horizon for VHF and UHF signals more distant than the visual horizon? [BACK](#)

- 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

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T4: AMATEUR RADIO PRACTICES

T4A01: Which of the following is an appropriate power supply rating for a typical 50 watt output mobile FM transceiver? [BACK](#)

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

T4A02: Which of the following should be considered when selecting an accessory SWR meter? [BACK](#)

- 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

T4A03: Why are short, heavy-gauge wires used for a transceiver's DC power connection? [BACK](#)

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

T4A04: How are the transceiver audio input and output connected in a station configured to operate using FT8? [BACK](#)

- 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

T4A05: Where should an RF power meter be installed? [BACK](#)

- 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

T4A06: What signals are used in a computer-radio interface for digital mode operation? [BACK](#)

- 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

T4A07: Which of the following connections is made between a computer and a transceiver to use computer software when operating digital modes? [BACK](#)

- 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

T4A08: Which of the following conductors is preferred for bonding at RF? [BACK](#)

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

T4A09: How can you determine the length of time that equipment can be powered from a battery? [BACK](#)

- 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

T4A10: What function is performed with a transceiver and a digital mode hot spot? [BACK](#)

- 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

T4A11: Where should the negative power return of a mobile transceiver be connected in a vehicle? [BACK](#)

- 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

T4A12: What is an electronic keyer? [BACK](#)

- 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

T4B01: What is the effect of excessive microphone gain on SSB transmissions? [BACK](#)

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

T4B02: Which of the following can be used to enter a transceiver's operating frequency? [BACK](#)

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

T4B03: How is squelch adjusted so that a weak FM signal can be heard? [BACK](#)

- 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

T4B04: What is a way to enable quick access to a favorite frequency or channel on your transceiver? [BACK](#)

- 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

T4B05: What does the scanning function of an FM transceiver do? [BACK](#)

- 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

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? [BACK](#)

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

T4B07: What does a DMR “code plug” contain? [BACK](#)

- 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

T4B08: What is the advantage of having multiple receive bandwidth choices on a multimode transceiver? [BACK](#)

- 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

T4B09: How is a specific group of stations selected on a digital voice transceiver? [BACK](#)

- 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

T4B10: Which of the following receiver filter bandwidths provides the best signal-to-noise ratio for SSB reception? [BACK](#)

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

T4B11: Which of the following must be programmed into a D-STAR digital transceiver before transmitting? [BACK](#)

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

T4B12: What is the result of tuning an FM receiver above or below a signal's frequency? [BACK](#)

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

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T5: ELECTRICAL PRINCIPLES

T5A01: Electrical current is measured in which of the following units? [BACK](#)

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

T5A02: Electrical power is measured in which of the following units? [BACK](#)

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

T5A03: What is the name for the flow of electrons in an electric circuit? [BACK](#)

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

T5A04: What are the units of electrical resistance? [BACK](#)

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

T5A05: What is the electrical term for the force that causes electron flow? [BACK](#)

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

T5A06: What is the unit of frequency? [BACK](#)

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

T5A07: Why are metals generally good conductors of electricity? [BACK](#)

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

T5A08: Which of the following is a good electrical insulator? [BACK](#)

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

T5A09: Which of the following describes alternating current? [BACK](#)

- 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

T5A10: Which term describes the rate at which electrical energy is used? [BACK](#)

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

T5A11: What type of current flow is opposed by resistance? [BACK](#)

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

T5A12: What describes the number of times per second that an alternating current makes a complete cycle? [BACK](#)

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

T5B01: How many milliamperes is 1.5 amperes? [BACK](#)

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

T5B02: Which is equal to 1,500,000 hertz? [BACK](#)

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

T5B03: Which is equal to one kilovolt? [BACK](#)

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

T5B04: Which is equal to one microvolt? [BACK](#)

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

T5B05: Which is equal to 500 milliwatts? [BACK](#)

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

T5B06: Which is equal to 3000 milliamperes? [BACK](#)

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

T5B07: Which is equal to 3.525 MHz? [BACK](#)

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

T5B08: Which is equal to 1,000,000 picofarads? [BACK](#)

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

T5B09: Which decibel value most closely represents a power increase from 5 watts to 10 watts? [BACK](#)

- A. 2 dB
- B. 3 dB
- C. 5 dB
- D. 10 dB

T5B10: Which decibel value most closely represents a power decrease from 12 watts to 3 watts? [BACK](#)

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

T5B11: Which decibel value represents a power increase from 20 watts to 200 watts? [BACK](#)

- A. 10 dB
- B. 12 dB
- C. 18 dB
- D. 28 dB

T5B12: Which is equal to 28400 kHz? [BACK](#)

- A. 28.400 kHz
- B. 2.800 MHz
- C. 284.00 MHz
- D. 28.400 MHz

T5B13: Which is equal to 2425 MHz? [BACK](#)

- A. 0.002425 GHz
- B. 24.25 GHz
- C. 2.425 GHz
- D. 2425 GHz

T5C01: What describes the ability to store energy in an electric field? [BACK](#)

- A. Inductance
- B. Resistance
- C. Tolerance
- D. Capacitance

T5C02: What is the unit of capacitance? [BACK](#)

- A. The farad
- B. The ohm
- C. The volt
- D. The henry

T5C03: What describes the ability to store energy in a magnetic field? [BACK](#)

- A. Admittance
- B. Capacitance
- C. Resistance
- D. Inductance

T5C04: What is the unit of inductance? [BACK](#)

- A. The coulomb
- B. The farad
- C. The henry
- D. The ohm

T5C05: What is the unit of impedance? [BACK](#)

- A. The volt
- B. The ampere
- C. The coulomb
- D. The ohm

T5C06: What does the abbreviation "RF" mean? [BACK](#)

- 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

T5C07: What is the abbreviation for megahertz? [BACK](#)

- A. MH
- B. mh
- C. Mhz
- D. MHz

T5C08: What is the formula used to calculate electrical power (P) in a DC circuit? [BACK](#)

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

T5C09: How much power is delivered by a voltage of 13.8 volts DC and a current of 10 amperes? [BACK](#)

- A. 138 watts
- B. 0.7 watts
- C. 23.8 watts
- D. 3.8 watts

T5C10: How much power is delivered by a voltage of 12 volts DC and a current of 2.5 amperes? [BACK](#)

- A. 4.8 watts
- B. 30 watts
- C. 14.5 watts
- D. 0.208 watts

T5C11: How much current is required to deliver 120 watts at a voltage of 12 volts DC? [BACK](#)

- A. 0.1 amperes
- B. 10 amperes
- C. 12 amperes
- D. 132 amperes

T5C12: What is impedance? [BACK](#)

- 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

T5C13: What is the abbreviation for kilohertz? [BACK](#)

- A. KHZ
- B. khz
- C. khZ
- D. kHz

T5D01: What formula is used to calculate current in a circuit? [BACK](#)

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

T5D02: What formula is used to calculate voltage in a circuit? [BACK](#)

A. $E = I \times R$

B. $E = I / R$

C. $E = I + R$

D. $E = I - R$

T5D03: What formula is used to calculate resistance in a circuit? [BACK](#)

A. $R = E \times I$

B. $R = E / I$

C. $R = E + I$

D. $R = E - I$

T5D04: What is the resistance of a circuit in which a current of 3 amperes flows when connected to 90 volts? [BACK](#)

A. 3 ohms

B. 30 ohms

C. 93 ohms

D. 270 ohms

T5D05: What is the resistance of a circuit for which the applied voltage is 12 volts and the current flow is 1.5 amperes? [BACK](#)

A. 18 ohms

B. 0.125 ohms

C. 8 ohms

D. 13.5 ohms

T5D06: What is the resistance of a circuit that draws 4 amperes from a 12-volt source? [BACK](#)

A. 3 ohms

B. 16 ohms

C. 48 ohms

D. 8 ohms

T5D07: What is the current in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms? [BACK](#)

A. 9600 amperes

B. 200 amperes

C. 0.667 amperes

D. 1.5 amperes

T5D08: What is the current through a 100-ohm resistor connected across 200 volts? [BACK](#)

A. 20,000 amperes

B. 0.5 amperes

C. 2 amperes

D. 100 amperes

T5D09: What is the current through a 24-ohm resistor connected across 240 volts? [BACK](#)

A. 24,000 amperes

B. 0.1 amperes

C. 10 amperes

D. 216 amperes

T5D10: What is the voltage across a 2-ohm resistor if a current of 0.5 amperes flows through it? [BACK](#)

A. 1 volt

B. 0.25 volts

C. 2.5 volts

D. 1.5 volts

T5D11: What is the voltage across a 10-ohm resistor if a current of 1 ampere flows through it? [BACK](#)

A. 1 volt

B. 10 volts

C. 11 volts

D. 9 volts

T5D12: What is the voltage across a 10-ohm resistor if a current of 2 amperes flows through it? [BACK](#)

A. 8 volts

B. 0.2 volts

C. 12 volts

D. 20 volts

T5D13: In which type of circuit is DC current the same through all components? [BACK](#)

A. Series

B. Parallel

C. Resonant

D. Branch

T5D14: In which type of circuit is voltage the same across all components? [BACK](#)

A. Series

B. Parallel

C. Resonant

D. Branch

NOTE: If you're scrolling through the questions & answers, don't use the [BACK](#) buttons below. Just keep scrolling forward.

T6: ELECTRONIC AND ELECTRICAL COMPONENTS

T6A01: What electrical component opposes the flow of current in a DC circuit? [BACK](#)

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

T6A02: What type of component is often used as an adjustable volume control? [BACK](#)

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

T6A03: What electrical parameter is controlled by a potentiometer? [BACK](#)

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

T6A04: What electrical component stores energy in an electric field? [BACK](#)

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

T6A05: What type of electrical component consists of conductive surfaces separated by an insulator? [BACK](#)

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

T6A06: What type of electrical component stores energy in a magnetic field? [BACK](#)

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

T6A07: What electrical component is typically constructed as a coil of wire? [BACK](#)

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

T6A08: What is the function of an SPDT switch? [BACK](#)

- 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

T6A09: What electrical component is used to protect other circuit components from current overloads? [BACK](#)

- A. Fuse
- B. Thyatron
- C. Varactor
- D. All these choices are correct

T6A10: Which of the following battery chemistries is rechargeable? [BACK](#)

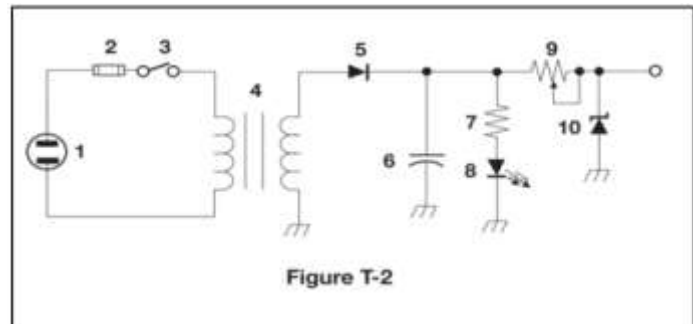
- A. Nickel-metal hydride
- B. Lithium-ion
- C. Lead-acid
- D. All these choices are correct

T6A11: Which of the following battery chemistries is not rechargeable? [BACK](#)

- A. Nickel-cadmium
- B. Carbon-zinc
- C. Lead-acid
- D. Lithium-ion

T6A12: What type of switch is represented by component 3 in figure T-2? [BACK](#)

- A. Single-pole single-throw
- B. Single-pole double-throw
- C. Double-pole single-throw
- D. Double-pole double-throw



T6B01: Which is true about forward voltage drop in a diode? [BACK](#)

- 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

T6B02: What electronic component allows current to flow in only one direction? [BACK](#)

- A. Resistor
- B. Fuse
- C. Diode
- D. Driven element

T6B03: Which of these components can be used as an electronic switch? [BACK](#)

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

T6B04: Which of the following components can consist of three regions of semiconductor material? [BACK](#)

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

T6B05: What type of transistor has a gate, drain, and source? [BACK](#)

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

T6B06: How is the cathode lead of a semiconductor diode often marked on the package? [BACK](#)

- A. With the word "cathode"
- B. With a stripe**
- C. With the letter C
- D. With the letter K

T6B07: What causes a light-emitting diode (LED) to emit light? [BACK](#)

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

T6B08: What does the abbreviation FET stand for? [BACK](#)

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

T6B09: What are the names for the electrodes of a diode? [BACK](#)

- A. Plus and minus
- B. Source and drain
- C. Anode and cathode**
- D. Gate and base

T6B10: Which of the following can provide power gain? [BACK](#)

- A. Transformer
- B. Transistor**
- C. Reactor
- D. Resistor

T6B11: What is the term that describes a device's ability to amplify a signal? [BACK](#)

A. Gain

- B. Forward resistance
- C. Forward voltage drop
- D. On resistance

T6B12: What are the names of the electrodes of a bipolar junction transistor? [BACK](#)

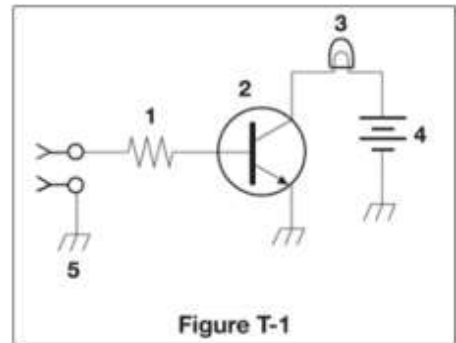
- A. Signal, bias, power
- B. Emitter, base, collector**
- C. Input, output, supply
- D. Pole one, pole two, output

T6C01: What is the name of an electrical wiring diagram that uses standard component symbols? [BACK](#)

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

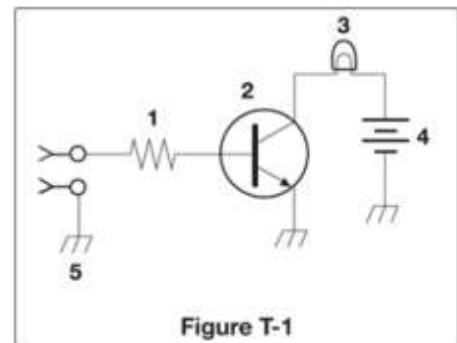
T6C02: What is component 1 in figure T-1? [BACK](#)

- A. Resistor**
- B. Transistor
- C. Battery
- D. Connector



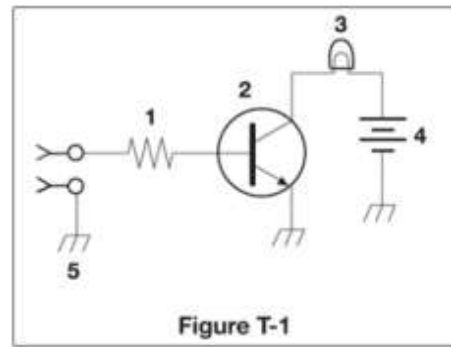
T6C03: What is component 2 in figure T-1? [BACK](#)

- A. Resistor
- B. Transistor**
- C. Indicator lamp
- D. Connector



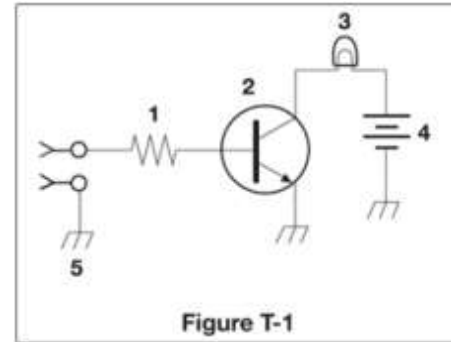
T6C04: What is component 3 in figure T-1? [BACK](#)

- A. Resistor
- B. Transistor
- C. Lamp
- D. Ground symbol



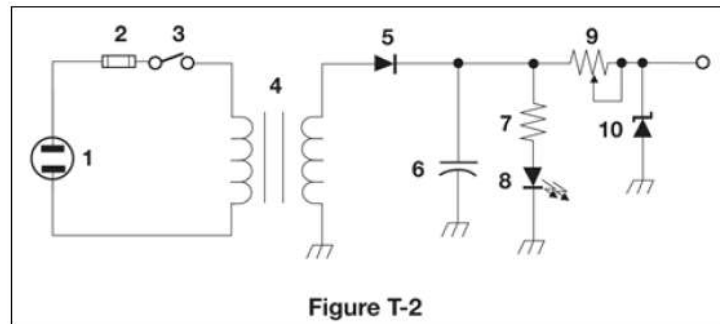
T6C05: What is component 4 in figure T-1? [BACK](#)

- A. Resistor
- B. Transistor
- C. Ground symbol
- D. Battery



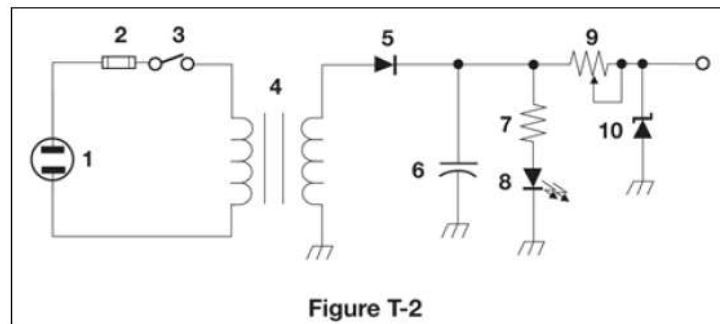
T6C06: What is component 6 in figure T-2? [BACK](#)

- A. Resistor
- B. Capacitor
- C. Regulator IC
- D. Transistor



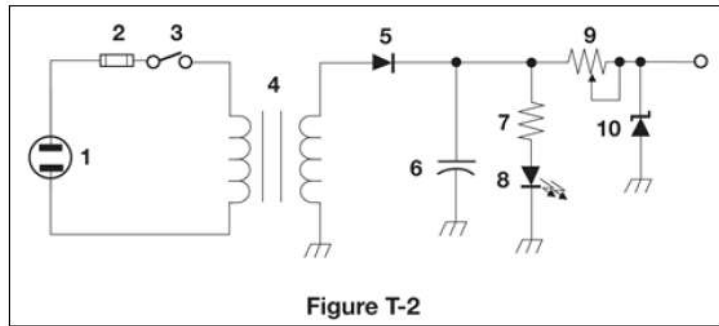
T6C07: What is component 8 in figure T-2? [BACK](#)

- A. Resistor
- B. Inductor
- C. Regulator IC
- D. Light emitting diode



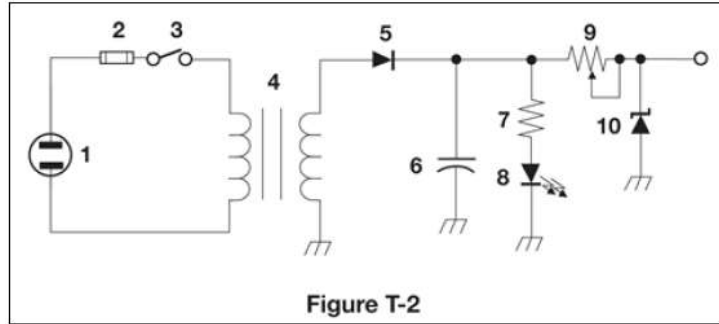
T6C08: What is component 9 in figure T-2? [BACK](#)

- A. Variable capacitor
- B. Variable inductor
- C. Variable resistor
- D. Variable transformer



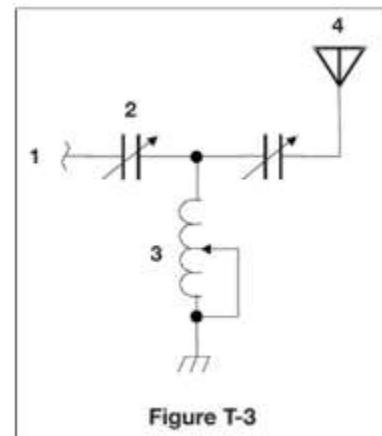
T6C09: What is component 4 in figure T-2? [BACK](#)

- A. Variable inductor
- B. Double-pole switch
- C. Potentiometer
- D. Transformer



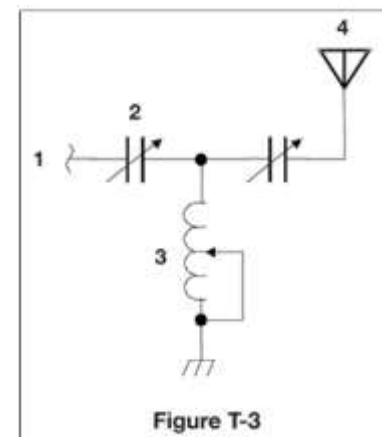
T6C10: What is component 3 in figure T-3? [BACK](#)

- A. Connector
- B. Meter
- C. Variable capacitor
- D. Variable inductor



T6C11: What is component 4 in figure T-3? [BACK](#)

- A. Antenna
- B. Transmitter
- C. Dummy load
- D. Ground



T6C12: Which of the following is accurately represented in electrical schematics? [BACK](#)

- A. Wire lengths
- B. Physical appearance of components
- C. Component connections
- D. All these choices are correct

T6D01: Which of the following devices or circuits changes an alternating current into a varying direct current signal? [BACK](#)

- A. Transformer
- B. Rectifier
- C. Amplifier
- D. Reflector

T6D02: What is a relay? [BACK](#)

- A. An electrically-controlled switch
- B. A current controlled amplifier
- C. An inverting amplifier
- D. A pass transistor

T6D03: Which of the following is a reason to use shielded wire? [BACK](#)

- 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

T6D04: Which of the following displays an electrical quantity as a numeric value? [BACK](#)

- A. Potentiometer
- B. Transistor
- C. Meter
- D. Relay

T6D05: What type of circuit controls the amount of voltage from a power supply? [BACK](#)

- A. Regulator
- B. Oscillator
- C. Filter
- D. Phase inverter

T6D06: What component changes 120 V AC power to a lower AC voltage for other uses? [BACK](#)

- A. Variable capacitor
- B. Transformer
- C. Transistor
- D. Diode

T6D07: Which of the following is commonly used as a visual indicator? [BACK](#)

- A. LED
- B. FET
- C. Zener diode
- D. Bipolar transistor

T6D08: Which of the following is combined with an inductor to make a resonant circuit? [BACK](#)

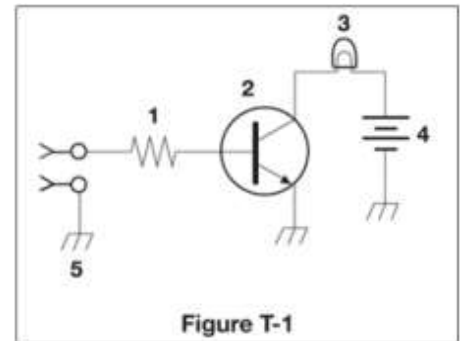
- A. Resistor
- B. Zener diode
- C. Potentiometer
- D. Capacitor**

T6D09: What is the name of a device that combines several semiconductors and other components into one package? [BACK](#)

- A. Transducer
- B. Multi-pole relay
- C. Integrated circuit**
- D. Transformer

T6D10: What is the function of component 2 in figure T-1? [BACK](#)

- 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



T6D11: Which of the following is a resonant or tuned circuit? [BACK](#)

- 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

*NOTE: If you're scrolling through the questions & answers, don't use the **BACK** buttons below. Just keep scrolling forward.*

T7: PRACTICAL CIRCUITS

T7A01: Which term describes the ability of a receiver to detect the presence of a signal? [BACK](#)

- A. Linearity
- B. Sensitivity**
- C. Selectivity
- D. Total Harmonic Distortion

T7A02: What is a transceiver? [BACK](#)

- 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

T7A03: Which of the following is used to convert a signal from one frequency to another? [BACK](#)

- A. Phase splitter
- B. Mixer**
- C. Inverter
- D. Amplifier

T7A04: Which term describes the ability of a receiver to discriminate between multiple signals? [BACK](#)

- A. Discrimination ratio
- B. Sensitivity
- C. Selectivity**
- D. Harmonic distortion

T7A05: What is the name of a circuit that generates a signal at a specific frequency? [BACK](#)

- A. Reactance modulator
- B. Phase modulator
- C. Low-pass filter
- D. Oscillator**

T7A06: What device converts the RF input and output of a transceiver to another band? [BACK](#)

- A. High-pass filter
- B. Low-pass filter
- C. Transverter**
- D. Phase converter

T7A07: What is the function of a transceiver's PTT input? [BACK](#)

- A. Input for a key used to send CW
- B. Switches transceiver from receive to transmit when grounded**
- C. Provides a transmit tuning tone when grounded
- D. Input for a preamplifier tuning tone

T7A08: Which of the following describes combining speech with an RF carrier signal? [BACK](#)

- A. Impedance matching
- B. Oscillation
- C. Modulation**
- D. Low-pass filtering

T7A09: What is the function of the SSB/CW-FM switch on a VHF power amplifier? [BACK](#)

- 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 segment of the band
- D. Reduce the received signal noise

T7A10: What device increases the transmitted output power from a transceiver? [BACK](#)

- A. A voltage divider
- B. An RF power amplifier**
- C. An impedance network
- D. All these choices are correct

T7A11: Where is an RF preamplifier installed? [BACK](#)

- 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

T7B01: What can you do if you are told your FM handheld or mobile transceiver is overdeviating? [BACK](#)

- 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**

T7B02: What would cause a broadcast AM or FM radio to receive an amateur radio transmission unintentionally? [BACK](#)

- 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

T7B03: Which of the following can cause radio frequency interference? [BACK](#)

- A. Fundamental overload
- B. Harmonics
- C. Spurious emissions
- D. All these choices are correct**

T7B04: Which of the following could you use to cure distorted audio caused by RF current on the shield of a microphone cable? [BACK](#)

- A. Band-pass filter
- B. Low-pass filter
- C. Preamplifier
- D. Ferrite choke**

T7B05: How can fundamental overload of a non-amateur radio or TV receiver by an amateur signal be reduced or eliminated? [BACK](#)

- 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

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? [BACK](#)

- 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

T7B07: Which of the following can reduce overload of a VHF transceiver by a nearby commercial FM station? [BACK](#)

- 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

T7B08: What should you do if something in a neighbor's home is causing harmful interference to your amateur station? [BACK](#)

- 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

T7B09: What should be the first step to resolve non-fiber optic cable TV interference caused by your amateur radio transmission? [BACK](#)

- 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

T7B10: What might be a problem if you receive a report that your audio signal through an FM repeater is distorted or unintelligible? [BACK](#)

- A. Your transmitter is slightly off frequency
- B. Your batteries are running low
- C. You are in a bad location
- D. All these choices are correct

T7B11: What is a symptom of RF feedback in a transmitter or transceiver? [BACK](#)

- 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

T7C01: What is the primary purpose of a dummy load? [BACK](#)
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

T7C02: Which of the following is used to determine if an antenna is resonant at the desired operating frequency? [BACK](#)
A. A VTVM
B. An antenna analyzer
C. A Q meter
D. A frequency counter

T7C03: What does a dummy load consist of? [BACK](#)
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

T7C04: What reading on an SWR meter indicates a perfect impedance match between the antenna and the feed line? [BACK](#)
A. 50:50
B. Zero
C. 1:1
D. Full Scale

T7C05: Why do most solid-state transmitters reduce output power as SWR increases beyond a certain level? [BACK](#)
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

T7C06: What does an SWR reading of 4:1 indicate? [BACK](#)
A. Loss of -4 dB
B. Good impedance match
C. Gain of +4 dB
D. Impedance mismatch

T7C07: What happens to power lost in a feed line? [BACK](#)
A. It increases the SWR
B. It is radiated as harmonics
C. It is converted into heat
D. It distorts the signal

T7C08: Which instrument can be used to determine SWR? [BACK](#)
A. Voltmeter
B. Ohmmeter
C. Iambic pentameter
D. Directional wattmeter

T7C09: Which of the following causes failure of coaxial cables? [BACK](#)

- A. Moisture contamination
- B. Solder flux contamination
- C. Rapid fluctuation in transmitter output power
- D. Operation at 100% duty cycle for an extended period

T7C10: Why should the outer jacket of coaxial cable be resistant to ultraviolet light? [BACK](#)

- 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

T7C11: What is a disadvantage of air core coaxial cable when compared to foam or solid dielectric types? [BACK](#)

- 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

T7D01: Which instrument would you use to measure electric potential? [BACK](#)

- A. An ammeter
- B. A voltmeter
- C. A wavemeter
- D. An ohmmeter

T7D02: How is a voltmeter connected to a component to measure applied voltage? [BACK](#)

- A. In series
- B. In parallel
- C. In quadrature
- D. In phase

T7D03: When configured to measure current, how is a multimeter connected to a component? [BACK](#)

- A. In series
- B. In parallel
- C. In quadrature
- D. In phase

T7D04: Which instrument is used to measure electric current? [BACK](#)

- A. An ohmmeter
- B. An electrometer
- C. A voltmeter
- D. An ammeter

T7D06: Which of the following can damage a multimeter? [BACK](#)

- 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

T7D07: Which of the following measurements are made using a multimeter? [BACK](#)

- A. Signal strength and noise
- B. Impedance and reactance
- C. Voltage and resistance
- D. All these choices are correct

T7D08: Which of the following types of solder should not be used for radio and electronic applications? [BACK](#)

- A. Acid-core solder
- B. Lead-tin solder
- C. Rosin-core solder
- D. Tin-copper solder

T7D09: What is the characteristic appearance of a cold tin-lead solder joint? [BACK](#)

- A. Dark black spots
- B. A bright or shiny surface
- C. A rough or lumpy surface
- D. Excessive solder

T7D10: What reading indicates that an ohmmeter is connected across a large, discharged capacitor? [BACK](#)

- A. Increasing resistance with time
- B. Decreasing resistance with time
- C. Steady full-scale reading
- D. Alternating between open and short circuit

T7D11: Which of the following precautions should be taken when measuring in-circuit resistance with an ohmmeter? [BACK](#)

- 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

T8B02: What is the impact of using excessive effective radiated power on a satellite uplink? [BACK](#)

- 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

NOTE: If you're scrolling through the questions & answers, don't use the [BACK](#) buttons below. Just keep scrolling forward.

T8: SIGNALS AND EMISSIONS

T8A01: Which of the following is a form of amplitude modulation? [BACK](#)

- A. Spread spectrum
- B. Packet radio
- C. Single sideband**
- D. Phase shift keying (PSK)

T8A02: What type of modulation is commonly used for VHF packet radio transmissions? [BACK](#)

- A. FM or PM**
- B. SSB
- C. AM
- D. PSK

T8A03: Which type of voice mode is often used for long-distance (weak signal) contacts on the VHF and UHF bands? [BACK](#)

- A. FM
- B. DRM
- C. SSB**
- D. PM

T8A04: Which type of modulation is commonly used for VHF and UHF voice repeaters? [BACK](#)

- A. AM
- B. SSB
- C. PSK
- D. FM or PM**

T8A05: Which of the following types of signal has the narrowest bandwidth? [BACK](#)

- A. FM voice
- B. SSB voice
- C. CW**
- D. Slow-scan TV

T8A06: Which sideband is normally used for 10 meter HF, VHF, and UHF single-sideband communications? [BACK](#)

- A. Upper sideband**
- B. Lower sideband
- C. Suppressed sideband
- D. Inverted sideband

T8A07: What is a characteristic of single sideband (SSB) compared to FM? [BACK](#)

- 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

T8A08: What is the approximate bandwidth of a typical single sideband (SSB) voice signal? [BACK](#)

- A. 1 kHz
- B. 3 kHz**
- C. 6 kHz
- D. 15 kHz

T8A09: What is the approximate bandwidth of a VHF repeater FM voice signal? [BACK](#)

- A. Less than 500 Hz
- B. About 150 kHz
- C. Between 10 and 15 kHz**
- D. Between 50 and 125 kHz

T8A10: What is the approximate bandwidth of AM fast-scan TV transmissions? [BACK](#)

- A. More than 10 MHz
- B. About 6 MHz**
- C. About 3 MHz
- D. About 1 MHz

T8A11: What is the approximate bandwidth required to transmit a CW signal? [BACK](#)

- A. 2.4 kHz
- B. 150 Hz**
- C. 1000 Hz
- D. 15 kHz

T8A12: Which of the following is a disadvantage of FM compared with single sideband? [BACK](#)

- 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

T8B01: What telemetry information is typically transmitted by satellite beacons? [BACK](#)

- A. The signal strength of received signals
- B. Time of day accurate to plus or minus 1/10 second
- C. Health and status of the satellite**
- D. All these choices are correct

T8B03: Which of the following are provided by satellite tracking programs? [BACK](#)

- A. Maps showing the real-time position of the satellite track over Earth
- B. The time, azimuth, and elevation of the start, maximum altitude, and end of a pass
- C. The apparent frequency of the satellite transmission, including effects of Doppler shift
- D. All these choices are correct**

T8B04: What mode of transmission is commonly used by amateur radio satellites? [BACK](#)

- A. SSB
- B. FM
- C. CW/data
- D. All these choices are correct**

T8B05: What is a satellite beacon? [BACK](#)

- 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

T8B06: Which of the following are inputs to a satellite tracking program? [BACK](#)

- A. The satellite transmitted power
- B. The Keplerian elements
- C. The last observed time of zero Doppler shift
- D. All these choices are correct

T8B07: What is Doppler shift in reference to satellite communications? [BACK](#)

- 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

T8B08: What is meant by the statement that a satellite is operating in U/V mode? [BACK](#)

- 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

T8B09: What causes spin fading of satellite signals? [BACK](#)

- 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

T8B10: What is a LEO satellite? [BACK](#)

- 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

T8B11: Who may receive telemetry from a space station? [BACK](#)

- 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

T8B12: Which of the following is a way to determine whether your satellite uplink power is neither too low nor too high? [BACK](#)

- 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 these choices are correct

T8C01: Which of the following methods is used to locate sources of noise interference or jamming? [BACK](#)

- A. Echolocation
- B. Doppler radar
- C. Radio direction finding
- D. Phase locking

T8C02: Which of these items would be useful for a hidden transmitter hunt? [BACK](#)

- A. Calibrated SWR meter
- B. A directional antenna
- C. A calibrated noise bridge
- D. All these choices are correct

T8C03: What operating activity involves contacting as many stations as possible during a specified period? [BACK](#)

- A. Simulated emergency exercises
- B. Net operations
- C. Public service events
- D. Contesting

T8C04: Which of the following is good procedure when contacting another station in a contest? [BACK](#)

- A. Sign only the last two letters of your call if there are many other stations calling
- B. Contact the station twice to be sure that you are in his log
- C. Send only the minimum information needed for proper identification and the contest exchange
- D. All these choices are correct

T8C05: What is a grid locator? [BACK](#)

- 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

T8C06: How is over the air access to IRLP nodes accomplished? [BACK](#)

- 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

T8C07: What is Voice Over Internet Protocol (VoIP)? [BACK](#)

- 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

T8C08: What is the Internet Radio Linking Project (IRLP)? [BACK](#)

- 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

T8C09: Which of the following protocols enables an amateur station to transmit through a repeater without using a radio to initiate the transmission? [BACK](#)

- A. IRLP
- B. D-STAR
- C. DMR
- D. EchoLink

T8C10: What is required before using the EchoLink system? [BACK](#)

- 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

T8C11: What is an amateur radio station that connects other amateur stations to the internet? [BACK](#)

- A. A gateway
- B. A repeater
- C. A digipeater
- D. A beacon

T8D01: Which of the following is a digital communications mode? [BACK](#)

- A. Packet radio
- B. IEEE 802.11
- C. FT8
- D. All these choices are correct

T8D02: What is a Talkgroup on a DMR repeater? [BACK](#)

- 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

T8D03: What kind of data can be transmitted by APRS? [BACK](#)

- A. GPS position data
- B. Text messages
- C. Weather data
- D. All these choices are correct

T8D04: What type of transmission is indicated by the term "NTSC?" [BACK](#)

- 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

T8D05: Which of the following is an application of APRS? [BACK](#)

- 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

T8D06: What does the abbreviation "PSK" mean? [BACK](#)

- A. Pulse Shift Keying
- B. Phase Shift Keying**
- C. Packet Short Keying
- D. Phased Slide Keying

T8D07: Which of the following describes DMR? [BACK](#)

- 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

T8D08: Which of the following is included in packet radio transmissions? [BACK](#)

- 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 these choices are correct**

T8D09: What is CW? [BACK](#)

- 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**

T8D10: Which of the following operating activities is supported by digital mode software in the WSJT-X software suite? [BACK](#)

- A. Earth-Moon-Earth
- B. Weak signal propagation beacons
- C. Meteor scatter
- D. All these choices are correct**

T8D11: What is an ARQ transmission system? [BACK](#)

- 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

T8D12: Which of the following best describes an amateur radio mesh network? [BACK](#)

- A. An amateur-radio based data network using commercial Wi-Fi equipment with modified firmware**
- B. A wide-bandwidth digital voice mode employing DMR protocols
- C. A satellite communications network using modified commercial satellite TV hardware
- D. An internet linking protocol used to network repeaters

T8D13: What is FT8? [BACK](#)

- 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

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T9: ANTENNAS AND FEED LINES

T9A01: What is a beam antenna? [BACK](#)

- 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

T9A02: Which of the following describes a type of antenna loading? [BACK](#)

- 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

T9A03: Which of the following describes a simple dipole oriented parallel to Earth's surface? [BACK](#)

- A. A ground-wave antenna
- B. A horizontally polarized antenna**
- C. A travelling-wave antenna
- D. A vertically polarized antenna

T9A04: What is a disadvantage of the short, flexible antenna supplied with most handheld radio transceivers, compared to a full-sized quarter-wave antenna? [BACK](#)

- A. It has low efficiency**
- B. It transmits only circularly polarized signals
- C. It is mechanically fragile
- D. All these choices are correct

T9A05: Which of the following increases the resonant frequency of a dipole antenna? [BACK](#)

- 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

T9A06: Which of the following types of antenna offers the greatest gain? [BACK](#)

- A. 5/8 wave vertical
- B. Isotropic
- C. J pole
- D. Yagi**

T9A07: What is a disadvantage of using a handheld VHF transceiver with a flexible antenna inside a vehicle? [BACK](#)

- 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

T9A08: What is the approximate length, in inches, of a quarter-wavelength vertical antenna for 146 MHz? [BACK](#)

- A. 112
- B. 50
- C. 19
- D. 12

T9A09: What is the approximate length, in inches, of a half-wavelength 6 meter dipole antenna? [BACK](#)

- A. 6
- B. 50
- C. 112
- D. 236

T9A10: In which direction does a half-wave dipole antenna radiate the strongest signal? [BACK](#)

- 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

T9A11: What is antenna gain? [BACK](#)

- 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

T9A12: What is an advantage of a 5/8 wavelength whip antenna for VHF or UHF mobile service? [BACK](#)

- 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

T9B01: What is a benefit of low SWR? [BACK](#)

- A. Reduced television interference
- B. Reduced signal loss
- C. Less antenna wear
- D. All these choices are correct

T9B02: What is the most common impedance of coaxial cables used in amateur radio? [BACK](#)

- A. 8 ohms
- B. 50 ohms
- C. 600 ohms
- D. 12 ohms

T9B03: Why is coaxial cable the most common feed line for amateur radio antenna systems? [BACK](#)

- 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

T9B04: What is the major function of an antenna tuner (antenna coupler)? [BACK](#)

- 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

T9B05: What happens as the frequency of a signal in coaxial cable is increased? [BACK](#)

- A. The characteristic impedance decreases
- B. The loss decreases
- C. The characteristic impedance increases
- D. The loss increases

T9B06: Which of the following RF connector types is most suitable for frequencies above 400 MHz? [BACK](#)

- A. UHF (PL-259/SO-239)
- B. Type N
- C. RS-213
- D. DB-25

T9B07: Which of the following is true of PL-259 type coax connectors? [BACK](#)

- 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

T9B08: Which of the following is a source of loss in coaxial feed line? [BACK](#)

- A. Water intrusion into coaxial connectors
- B. High SWR
- C. Multiple connectors in the line
- D. All these choices are correct

T9B09: What can cause erratic changes in SWR? [BACK](#)

- A. Local thunderstorm
- B. Loose connection in the antenna or feed line
- C. Over-modulation
- D. Overload from a strong local station

T9B10: What is the electrical difference between RG-58 and RG-213 coaxial cable? [BACK](#)

- 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

T9B11: Which of the following types of feed line has the lowest loss at VHF and UHF? [BACK](#)

- A. 50-ohm flexible coax
- B. Multi-conductor unbalanced cable
- C. Air-insulated hardline
- D. 75-ohm flexible coax

T9B12: What is standing wave ratio (SWR)? [BACK](#)

- A. A measure of how well a load is matched to a transmission line
- B. The ratio of amplifier power output to input
- C. The transmitter efficiency ratio
- D. An indication of the quality of your station's ground connection

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T0: SAFETY

T0A01: Which of the following is a safety hazard of a 12-volt storage battery? [BACK](#)

- A. Touching both terminals with the hands can cause electrical shock
- B. Shorting the terminals can cause burns, fire, or an explosion**
- C. RF emissions from a nearby transmitter can cause the electrolyte to emit poison gas
- D. All these choices are correct

T0A02: What health hazard is presented by electrical current flowing through the body? [BACK](#)

- A. It may cause injury by heating tissue
- B. It may disrupt the electrical functions of cells
- C. It may cause involuntary muscle contractions
- D. All these choices are correct**

T0A03: In the United States, what circuit does black wire insulation indicate in a three-wire 120 V cable? [BACK](#)

- A. Neutral
- B. Hot**
- C. Equipment ground
- D. Black insulation is never used

T0A04: What is the purpose of a fuse in an electrical circuit? [BACK](#)

- A. To prevent power supply ripple from damaging a component
- B. To remove power in case of overload**
- C. To limit current to prevent shocks
- D. All these choices are correct

T0A05: Why should a 5-ampere fuse never be replaced with a 20-ampere fuse? [BACK](#)

- A. The larger fuse would be likely to blow because it is rated for higher current
- B. The power supply ripple would greatly increase
- C. Excessive current could cause a fire**
- D. All these choices are correct

T0A06: What is a good way to guard against electrical shock at your station? [BACK](#)

- A. Use three-wire cords and plugs for all AC powered equipment
- B. Connect all AC powered station equipment to a common safety ground
- C. Install mechanical interlocks in high-voltage circuits
- D. All these choices are correct**

T0A07: Where should a lightning arrester be installed in a coaxial feed line? [BACK](#)

- 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**

T0A08: Where should a fuse or circuit breaker be installed in a 120V AC power circuit? [BACK](#)

- 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

T0A09: What should be done to all external ground rods or earth connections? [BACK](#)

- 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

T0A10: What hazard is caused by charging or discharging a battery too quickly? [BACK](#)

- A. Overheating or out-gassing
- B. Excess output ripple
- C. Half-wave rectification
- D. Inverse memory effect

T0A11: What hazard exists in a power supply immediately after turning it off? [BACK](#)

- 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

T0A12: Which of the following precautions should be taken when measuring high voltages with a voltmeter? [BACK](#)

- 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

T0B01: Which of the following is good practice when installing ground wires on a tower for lightning protection? [BACK](#)

- 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

T0B02: What is required when climbing an antenna tower? [BACK](#)

- 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

T0B03: Under what circumstances is it safe to climb a tower without a helper or observer? [BACK](#)

- 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

T0B04: Which of the following is an important safety precaution to observe when putting up an antenna tower? [BACK](#)

- A. Wear a ground strap connected to your wrist at all times
- B. Insulate the base of the tower to avoid lightning strikes
- C. Look for and stay clear of any overhead electrical wires
- D. All these choices are correct

T0B05: What is the purpose of a safety wire through a turnbuckle used to tension guy lines? [BACK](#)

- 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

T0B06: What is the minimum safe distance from a power line to allow when installing an antenna? [BACK](#)

- 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

T0B07: Which of the following is an important safety rule to remember when using a crank-up tower? [BACK](#)

- A. This type of tower must never be painted
- B. This type of tower must never be grounded
- C. This type of tower must not be climbed unless it is retracted, or mechanical safety locking devices have been installed
- D. All these choices are correct

T0B08: Which is a proper grounding method for a tower? [BACK](#)

- A. A single four-foot ground rod, driven into the ground no more than 12 inches from the base
- B. A ferrite-core RF choke connected between the tower and ground
- C. A connection between the tower base and a cold water pipe
- D. Separate eight-foot ground rods for each tower leg, bonded to the tower and each Other

T0B09: Why should you avoid attaching an antenna to a utility pole? [BACK](#)

- 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 these choices are correct

T0B10: Which of the following is true when installing grounding conductors used for lightning protection? [BACK](#)

- 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

T0B11: Which of the following establishes grounding requirements for an amateur radio tower or antenna? [BACK](#)

- A. FCC Part 97 rules
- B. Local electrical codes
- C. FAA tower lighting regulations
- D. UL recommended practices

T0C01: What type of radiation are radio signals? [BACK](#)

- A. Gamma radiation
- B. Ionizing radiation
- C. Alpha radiation
- D. Non-ionizing radiation

T0C02: At which of the following frequencies does maximum permissible exposure have the lowest value? [BACK](#)

- A. 3.5 MHz
- B. 50 MHz
- C. 440 MHz
- D. 1296 MHz

T0C03: How does the allowable power density for RF safety change if duty cycle changes from 100 percent to 50 percent? [BACK](#)

- 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

T0C04: What factors affect the RF exposure of people near an amateur station antenna? [BACK](#)

- A. Frequency and power level of the RF field
- B. Distance from the antenna to a person
- C. Radiation pattern of the antenna
- D. All these choices are correct

T0C05: Why do exposure limits vary with frequency? [BACK](#)

- 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

T0C06: Which of the following is an acceptable method to determine whether your station complies with FCC RF exposure regulations? [BACK](#)

- A. By calculation based on FCC OET Bulletin 65
- B. By calculation based on computer modeling
- C. By measurement of field strength using calibrated equipment
- D. All these choices are correct

T0C07: What hazard is created by touching an antenna during a transmission? [BACK](#)

- A. Electrocutation
- B. RF burn to skin
- C. Radiation poisoning
- D. All these choices are correct

T0C08: Which of the following actions can reduce exposure to RF radiation? [BACK](#)

- A. Relocate antennas
- B. Relocate the transmitter
- C. Increase the duty cycle
- D. All these choices are correct

TOC09: How can you make sure your station stays in compliance with RF safety regulations? [BACK](#)

- A. By informing the FCC of any changes made in your station
- B. By re-evaluating the station whenever an item in the transmitter or antenna system is changed
- C. By making sure your antennas have low SWR
- D. All these choices are correct

TOC10: Why is duty cycle one of the factors used to determine safe RF radiation exposure levels? [BACK](#)

- 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

TOC11: What is the definition of duty cycle during the averaging time for RF exposure? [BACK](#)

- 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

TOC12: How does RF radiation differ from ionizing radiation (radioactivity)? [BACK](#)

- A. RF radiation does not have sufficient energy to cause chemical 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

TOC13: Who is responsible for ensuring that no person is exposed to RF energy above the FCC exposure limits? [BACK](#)

- A. The FCC
- B. The station licensee
- C. Anyone who is near an antenna
- D. The local zoning board

END OF QUESTIONS!

[TOC](#)

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