Amateur Radio

LEVEL 1 TECHNICIAN LICENSE SYLLABUS

For the 2018 to 2022 Question Pool

© Jack Tiley April 28, 2018

Rev. 2.0

Author
Jack Tiley AD7FO
Spokane Valley, WA
e-mail **Ad7fo@arrl.org**
Web site **www.ad7fo.com**

Technician License Class Syllabus

Written by Jack Tiley AD7FO

All questions are shown exactly as they will appear in the test with only the correct answer shown **(in green bold text)**. Question numbers have been included so you can go to the ARRL General Class License Manual, or the question pool itself at http://www.ncvec.org/page.php?id=369, to see the additional choices in the exam for each question.

This material is based on the published 2018 Technician Class License question pool, effective July 1, 2018, with additional information added by the author ***(in italicized blue text).***

Many of the illustrations used in this syllabus were copied from the ARRL Handbook CD-ROM, scanned from the license manual with permission from the copyright owner, ARRL, as well as other public sites on the web. This document has been written to assist students and instructors and may be distributed freely as long as no charge for the material is made (except for reproduction costs associated with delivering paper copies or electronic copies on CD-ROM's) and this note of copyright permission is not removed. This syllabus is copyrighted by the Author

The electronic file of this syllabus may be too large to be e-mailed so an alternate form of distribution such as color printed copies, CD-ROM, conversion to PDF or web posting will be required (it is recommended if this is posted to a web site that you link that site to the authors web site www.ad7fo.com which will always have the latest revision).

Additional information and resources to help you study for the Technician Class License can be found on the ARRL web site (www.arrl.org). The ARRL web site has articles, resources and reference materials on all aspects of the exam questions and Amateur Radio in general.

Syllabus Overview

This Syllabus is copyrighted by the author.

The Syllabus is intended either for classroom study or for self-study in pursuit of the Amateur Radio Technician License and to assist instructors in teaching a class. It may be distributed freely if no charge for the material is made. Reproduction costs associated with delivering paper or electronic copies on CD-ROM's may be charged and **the note of copyright permission on page 2 is not removed.**

Any modified copies must contain a note that the original material by the author has been modified and contain the name contact information of the person making the changes -an MS Word version is available from the Author ad7fo@arrl.org for those who want to customize this material for their class.

Question numbers are shown in bold text this, **T1A03** so you can go to the ARRL Technician Class License Manual, or the question pool itself, to see the actual questions and other answer choices that will be in the exam. If there is an FCC (Federal Communications Commission) Part 97 rule relating to the answer it is shown following the question number. The FCC regulation reference number like this, **T1A07 [97.3(a)(45)]**

All questions are shown with only the correct answer **in bold green text**, which in the authors view makes it easier when you see the other choices in your exam to identify the correct answer.

Additional information has been added by the author ***(in italicized blue text)*** for some of the questions to explain the answer or show calculations. In addition, some graphics have also been added for additional clarification.

You do not need a copy of the ARRL Technician Class License Manual. Everything you need to study for your license exam is in this syllabus. The author recommends if you want more technical background that you acquire a copy of the ARRL Handbook. The Handbook will cover your technical needs for all three licenses and will be a great reference after you are licensed. And at a cost of approximately $50 ($15 to $20 if you find a used one at a Hamfest). This will cost less than the total cost of purchasing all three license manuals from ARRL and provides a lot more technical information about amateur radio and Electronics.

While every effort was made to insure the accuracy of the material herein, this material was prepared by an ordinary human being (we all know "engineers can't spell"), and it is likely that a few typographical or other errors remain. Author welcomes corrections and can be contacted at ad7fo@arrl.net

Go to the authors web site www.ad7fo.com to be sure you have the latest revision of the syllabus.

A word document version is available for instructors who want to customize the material for their own use. Contact the Author at ad7fo@arrl.net .

About the Author

Education:
Electrical Engineering, Penn State University

Work Experience:
Hewlett Packard: Thirty-four years filling various positions (retired in 2004)

- RF Products Division in Spokane WA – 1981 to 2004 - Regional Sales Support, Application Engineering, World Wide Sales Management, Systems Development and Product Management
- Valley Forge PA - from 1969 until 1981 - Engineering Technical Support, Technical Customer Training and Field Sales Engineer

American Electronics Laboratories:

- Nine years working in and managing a Metrology (Calibration Standards) Laboratory in Colmar Pennsylvania. Responsible for managing a Metrology lab and team of Technicians that maintained a wide range of test instruments and their calibration traceability to the National Bureau of Standards (***NBS)*** [now the National Institute of Standards and Technology **(NIST**)].

Jerrold Electronics:

- Two years as a Technician at the Jerrold Electronics R&D Laboratory in Hatboro PA working on RF test equipment.

Hobbies:

- Amateur Radio
- Test Equipment
- Electronics in general.

Amateur Radio Activities:

- Teaching and mentoring.
  - Developing and teaching Technician, General and Extra License Classes
  - Developed and teach ARRL EMCOMM class with a power point presentation I have developed.
  - Wrote and presented greater than twenty, one-hour or less technical talks for local ham radio clubs (Available from the Authors web page www.ad7fo.com).
- Provide a radio and general-purpose test table every year at the Spokane Hamfest for folks to test their radios and other electronic Hamfest treasures.
- Attending as many Pacific Northwest Hamfest's as I can

ARRL Appointments:

- ARRL VE (Volunteer Examiner)
- ARRL Technical Specialist for Spokane area
- ARRL Technical Coordinator for Eastern Washington
- ARRL Registered Instructor
- ARRL Certified EMCOMM instructor

Other:

- Member of the Inland Empire VHF Club
- Member of the Spokane County ARES-RACES
- Member of Greater Spokane County COAD (Community Organizations Active in Disasters)

Class Requirements for Students

1. You will need a printed or down loaded copy of this syllabus to study from prior to the class. The Class will be taught directly from a power point version of the syllabus. The syllabus can be down loaded from the authors web site www.ad7fo.com. A printed, and bound copy of this syllabus can be purchased from The UPS Store located at 2910 East 57th Avenue #5, Spokane, WA 99223 Phone (509) 448-6368 (ask for Richard- KE7DQC) for around $15. These can be picked up at the store or can be ordered and shipped to a student. All the possible questions in the exam are covered in this syllabus.

2. A copy of Part 97 of the FCC rules is recommended and can be downloaded for free from the ARRL website at http://www.arrl.org/part-97-amateur-radio or purchased in printed form from amateur radio stores or Amazon. The FCC rules require that you to have access to a copy of the part 97 rules (printed copy or on line from your computer) after you receive your license.

3 You will need a basic scientific calculator that they are familiar with operating that is capable of normal math functions, square roots, trigonometry and Base 10 Log functions (all basic scientific calculators have these functions). Scientific calculators like the Texas Instruments TI30 are available from office supply stores for around $20 or less from office supply stores if you do not already have one. It is recommended you do not purchase a programmable calculator as it will not be allowed in the test session. Cell phone calculators are never allowed in test sessions.

4. A desire to learn and to ask questions. If you do not understand something that is being taught be sure you ask the instructor.

5. You must take and pass the Technician Class written exam (element 2)

- There are 35 questions on the exam. All questions are multiple choice (4 choices).
- Questions only come from the published Question Pool (all possible questions are covered in this syllabus).
- The number of possible questions for each topic area is fixed and shown for each question group in the test.
- You must have 26 correct answers to pass the exam (no more than 9 incorrect answers).
- There are online practice sites with the real test questions previously listed where you can take practice exams. Listed below are a few sites where you can find practice exams:
  http://aa9pw.com/radio/
  http://www.arrl.org/exam-practice
  http://www.eham.net/exams
  http://www.hamradionation.com
  http://www.qrz.com/hamtest
  http://www.hamexam.org
  http://www.hamstudy.org
  http://www.hamradiolicenseexam.com

6. You should read through this syllabus before the class. you are not expected to learn and understand everything you read but by being familiar with what will be covered you can identify those areas where you need to focus on and/or bring up questions during the class. Do not be intimidated. The material will be made easy to understand by your instructor(s). You can check for ham radio clubs in your area for a local Ham (known as Elmer's) that can help you or the go to the ARRL web site to find a local Technical Specialist.

7. You do not need a copy of the current ARRL Technician Class License Manual. Everything you need to study for your license exam is in this syllabus.

ELECTRICAL AND ELECTRONIC BASICS

(Background for the technical portion of the exam)

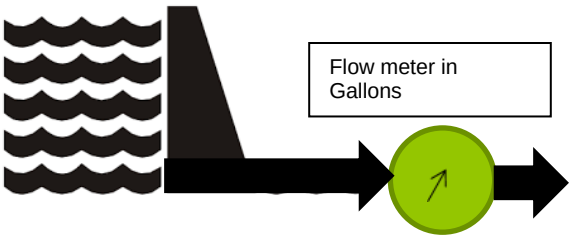
Metric system Basics for Ham Radio

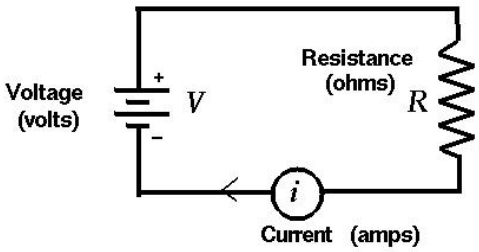
Giga XXXX = 1,000,000,000 (one thousand million) XXXX
Kilo XXXX = 1,000,000 (one million) times XXXX
Mega XXXX = 1/1,000,000 (one millionth) XXXX
Kilo XXXX = 1,000 (one Thousand) XXXX
Mili XXXX = 1/1,000 (one thousandth) XXXX
Nano XXXX = 1/1,000,000,000 (one thousandth of a Micro) XXXX
Pico XXXX = 1/1,000,000,000,000 (One millionth of a millionth) XXXX

Example: XXXX is the value you are expressing such as Volts, Amperes, Ohms, Watts, etc. One Kilovolt would be 1,000 Volts, one megaohms would be 1,000,000 ohms

Voltage, Resistance and Current Flow:

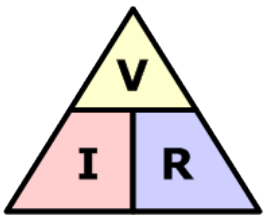
Everything we use in our amateur station requires a power source that delivers a specific **Voltage** and **Current**. ***Voltage*** is commonly referred to as ***Electro Motive Force*** *(EMF)* instead of volts is like the water pressure in a dam. Current, the flow of electricity, is measured in ***amperes*** and is commonly represented by the letter **I.** This is like the flow of water in a pipe at the bottom of the dam. The amount of water flowing would be limited by the diameter of the pipe and the pressure exerted by the height of the water in the dam. In an electronic circuit the current flow would be limited by the EMF (***voltage)*** and the resistance to current flow **(resistor)** measured in ohms.





If we know the voltage and the resistance in a circuit, we can calculate the current that would be flowing using the following expression:

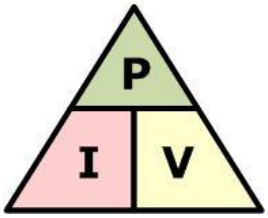
Current in amperes (I) is equal to the EMF in volts (E) divided by the resistance in ohms (R).
I (amperes) = E (voltage) ÷ R (resistance)



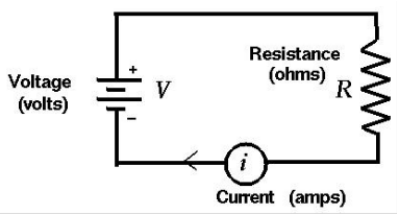
For example: if you have a 12-volt battery connected across a 6-ohm resistor the current flowing would be 2 amperes.

Current = 12 volts ÷ 6 Ohms or Current = 2 amperes

Power:



Power is work done by electricity and is defined as the voltage across a circuit multiplied by the current flowing through the circuit.



Examples:

A circuit connected to 120-volt power outlet that draws 10 amperes would be consuming 120 watts of power.

Power = voltage time the current or Power = 120 x 10 or 120 watts

A circuit powered by a 12-volt battery that draws 200 milliamperes (ma) would consume 2.4 watts.

Power = voltage time the current or Power = 12 x 0.20 or 2.4 watts

In the electronic world we have two kinds of commonly encountered sources of electric power:

Direct Current:

Direct Current (DC) is a voltage that has two terminals, one positive and one negative. Typically, DC power is available from Batteries, accessory jacks in vehicles, and plug in power supplies

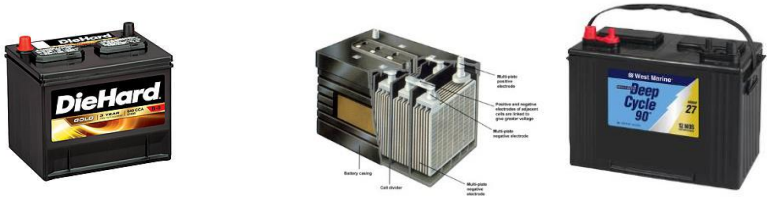
Commonly used batteries for amateur radio applications include the following:

- Alkaline and Zinc Carbon cells that produce 1.5 V - available in AAA, AA, C and D cells. **These batteries are not rechargeable**.

- Lithium batteries that produce1.5 or 3 volts. A typical example would be AAA, AA and coin cells. **These batteries are not rechargeable**.

- Nickel Cadmium (NICAD) and Nickel Metal Hydride (NIMH) that produce 1.2 volts, and are available in AAA, AA, C, D cells, and custom shapes. **These batteries are rechargeable**.

- Flooded Lead Acid batteries that produce 12 volts. Examples are automotive batteries and deep cycle marine batteries. These contain a liquid electrolyte and cannot be used tipped over, laid on their side or upside down. **These batteries are rechargeable**. These batteries release Hydrogen gas while charging so ventilation is required.

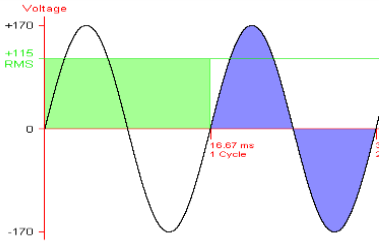


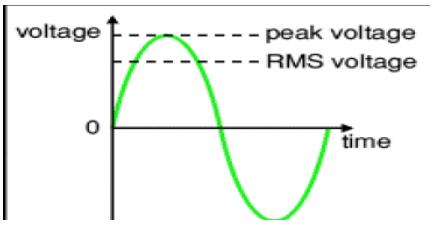
- Sealed Lead Acid batteries – Gel Cells and AGM (Absorbed Glass Mat) batteries that are available in 6-volt and 12-volt versions. They are sealed and use a "gelled" electrolyte and they can be operated in any position. They have high current ratings ranging from smaller ones with a 1 ampere hour rating up to 80 ampere hours and more. **These batteries are rechargeable**

Alternating Current

Alternating current is a voltage that alternates between equal positive and negative values. This is what is available from the 120 VAC wall outlet at home.

The 120 Volts we normally associate with the outlets in our home is the equivalent to a DC value that would provide the same heating effect (or work) of a 120-volt DC voltage and is known as the RMS value of the AC voltage. The heating effect of AC is less than the peak value because the voltage is continuously changing over the time for each cycle. The peak value of an AC voltage is **1.414 times the RMS value**. Therefore the peak voltage for a 120 Volt RMS coming from the outlet in our homes would be 1.414 times 120 volts or **169.68 volts Peak** or **339.36 volts peak to peak (**measured from the positive peak to the negative peak) .





For a pure sine wave the equivalent RMS value is 0.707 times the peak value. Conversely the peak voltage can be calculated as 1.414 times the RMS Value.

Examples:

The peak voltage present in standard 120V RMS AC line voltage is 1.414 x 120V or approx. 170 volts peak. The peak to peak (maximum negative to maximum positive peaks) would be two times the peak voltage or approx. 340 V Peak to Peak.

PP = 2x Peak or PP =2 x (120 x 1.414) or PP = 2 x 169.7 or PP = 339.4 Volts

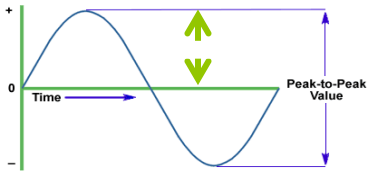
An AC voltage that reads 65 volts on an RMS meter will have a peak to peak voltage of 184 Volts.

Peak to peak Voltage = 2 x RMS x 1.414 or PP = 2 x 65 x 1.414 or PP = 183.8 V PP

FREQUENCY:

If we start at the first positive peak to the next positive peak of one cycle of our sine wave you will observe that it crosses through Zero twice in the cycle.
The time it takes for one cycle of a sine wave is the period of the sine wave. A 100 Hz sine wave has a period of .01 Seconds (or 10 milliseconds).

Frequency is the number of times per second that an event happens in one second of time. Shown below is a single cycle of a sine wave, as it would be displayed on an oscilloscope. To determine its frequency, you would divide the time in seconds for one cycle into 1.00.



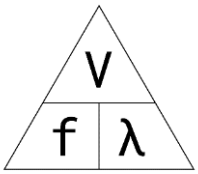
Examples:
What is the frequency of a sine wave with a 10 ms (millisecond) period for one cycle?
F=1÷ time or F = 1÷ .010 or F=100Hz
What is the frequency of a sine wave with a 1 µs (microsecond) period for one cycle?
F=1 ÷ time or F = 1 ÷ .000001 or F= 1,000,000 Hz or 1 MHz
What is the frequency of a sine wave with a 15 µs period for one cycle?
F=1 ÷ time or F = 1 ÷ .000015 or F=66,666 Hz or 66.666 KHz
What is the frequency of a sine wave with a 16.666 millisecond period for one cycle?
F=1 ÷ time or F = 1 ÷.016.666 or F=60.000 Hz
For a pure sine wave the equivalent RMS value is 0.707 times the peak value. Conversely the peak voltage can be calculated as 1.414 times the RMS Value. RMS from the peak voltages you can find the multiplier for RMS to peak by dividing 0.707 into 1.
1 ÷ 0.707 = 1.414

Wavelength:

Wave length is the distance a wave will travel during one cycle usually expressed in meters. Light travels and approximately 300 million meters per second ***(actual speed of light is 299 792 458 meters every second)*** in free space. Wavelength is important in amateur radio when designing and building antennas.

We frequently refer to the frequency bands in amateur radio by their wavelength in meters. For instance, 146 Megahertz (MHz) would be the 2-meter band. Wavelength is easily calculated as using the following equation:

Wavelength = speed of light divided by the frequency. For the 146 MHz example above this would be **300,000,000 divided by 146,000,000** or since both values are in millions simply **300/146 or 2.054 meters**



This is an important relationship to remember since there are questions in the exam relating to wave length for a specific frequency or the frequency for a given wavelength. ***Wavelength in meters can also be calculated as wavelength = 300 ÷ Frequency (in megahertz)***

In amateur radio we frequently refer to our frequencies in terms of approximate wavelength. Since we frequently operating in the megahertz rand we can simplify our conversion to wavelength by dividing the frequency in megahertz (MHz) into 300. For example:

A 146 MHz signal would be in the 2-meter band --- **300÷ 146 = 2.054-meters**
A 4.0 MHz signal would be in the 75-meter band --- ***300 ÷ 4 = 75-meters***

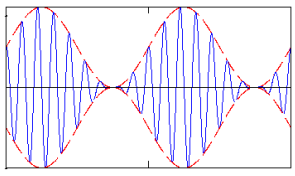
A frequency of 1 Megahertz (1,000,000 Hertz) which is in the middle of the AM broadcast band will travel 300 meters in one complete cycle.

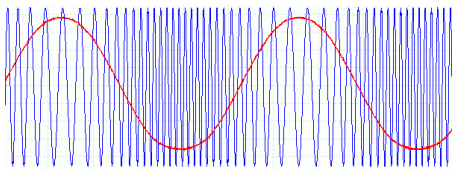
300,000,000 ÷ 1,000,000 or 300 ÷ 1 or 300 meters

RF Signals and Modulation

Radio frequencies are simply sine waves like we see coming out of the outlet at home except at a much higher frequency (rate). Radio signals in the AM Broadcast band are operating from 500,000 hertz to 1,700,000 Hertz. This frequency range can be expressed in kilohertz (thousands of hertz as 500 KHz to 1,700 KHz), or in megahertz (millions of hertz) as .500 MHz to 1.700 MHz

The frequency of a signal is just the carrier frequency, that is the frequency with no information applied. When we add voice or data to the carrier we are "modulating" or adding information. Simple modulation can be accomplished by varying the frequency of the carrier (Frequency Modulation or FM) or varying the amplitude of the carrier amplitude (AM)


Amplitude Modulation (AM)


Frequency Modulation (FM)

Question Pool Overview

SUBELEMENT T1 – FCC Rules, descriptions and definitions for the amateur radio service, operator and station license responsibilities

[6 exam Questions, one from each of 6 groups]

- T1A- Amateur Radio Service: purpose and permissible use of the Amateur Radio Service; operator/primary station license grant; where FCC rules are codified; basis and purpose of FCC rules; meanings of basic terms used in FCC rules; interference; spectrum management
- T1B - Authorized frequencies: frequency allocations; ITU; emission modes; restricted sub-bands; spectrum sharing; transmissions near band edges; contacting the International Space Station; power output
- T1C - Operator licensing: operator classes; sequential and vanity call sign systems; international communications; reciprocal operation; places where the Amateur Radio Service is regulated by the FCC; name and address on FCC license database; license term; renewal; grace period
- T1D - Authorized and prohibited transmission: communications with other countries; music; exchange of information with other services; indecent language; compensation for use of station; retransmission of other amateur signals; codes and ciphers; sale of equipment; unidentified transmissions; one-way transmission
- T1E - Control operator and control types: control operator required; eligibility; designation of control operator; privileges and duties; control point; local, automatic and remote control; location of control operator
- T1F - Station identification; repeaters; third-party communications; club stations; FCC inspection

SUBELEMENT T2 - Operating Procedures

[3 Exam Questions- one from each of 3 Groups]

- T2A - Station operation: choosing an operating frequency; calling another station; test transmissions; procedural signs; use of minimum power; choosing an operating frequency; band plans; calling frequencies; repeater offsets
- T2B – VHF/UHF operating practices: SSB phone; FM repeater; simplex; splits and shifts; CTCSS; DTMF; tone squelch; carrier squelch; phonetics; operational problem resolution; Q signals
- T2C – Public service: emergency and non-emergency operations; applicability of FCC rules; RACES and ARES; net and traffic procedures; operating restrictions during emergencies

SUBELEMENT T3 – Radio wave characteristics: properties of radio waves; propagation modes

[3 Exam Questions - one from each of 3 Groups]

- T3A - Radio wave characteristics: how a radio signal travels; fading; multipath; polarization; wavelength vs absorption; antenna orientation
- T3B - Radio and electromagnetic wave properties: the electromagnetic spectrum; wavelength vs frequency; nature and velocity of electromagnetic waves; definition of UHF, VHF, HF bands; calculating wavelength
- T3C - Propagation modes: line of sight; sporadic E; meteor and auroral scatter and reflections; tropospheric ducting; F layer skip; radio horizon

SUBELEMENT T4 - Amateur radio practices and station set-up

[2 Exam Questions - one from each of 2 Groups]

- T4A – Station setup: connecting microphones; reducing unwanted emissions; power source; connecting a computer; RF grounding; connecting digital equipment; connecting an SWR meter
- T4B - Operating controls: tuning; use of filters; squelch function; AGC; repeater offset; memory channels

SUBELEMENT T5 – Electrical principles: math for electronics; electronic principles; Ohm's Law

[4 Exam Questions - one from each of 4 Groups]

- T5A - Electrical principles, units, and terms: current and voltage; conductors and insulators; alternating and direct current; series and parallel circuits
- T5B - Math for electronics: conversion of electrical units; decibels; the metric system
- T5C - Electronic principles: capacitance; inductance; current flow in circuits; alternating current; definition of RF; definition of polarity; DC power calculations; impedance
- T5D – Ohm's Law: formulas and usage; components in series and parallel

SUBELEMENT T6 – Electrical components; circuit diagrams; component functions

[4 Exam Questions - one from each of 4 Groups]

- T6A - Electrical components: fixed and variable resistors; capacitors and inductors; fuses; switches; batteries
- T6B – Semiconductors: basic principles and applications of solid state devices; diodes and transistors
- T6C- Circuit diagrams; schematic symbols
  T6D - Component functions: rectification; switches; indicators; power supply components; resonant circuit; shielding; power transformers; integrated circuits

SUBELEMENT T7 – Station equipment: common transmitter and receiver problems; antenna measurements; troubleshooting; basic repair and testing

[4 Exam Questions - one from each of 4 Groups]

- T7A – Station equipment: receivers; transmitters; transceivers; modulation; transverters; transmit and receive amplifiers

- T7B – Common transmitter and receiver problems: symptoms of overload and overdrive; distortion; causes of interference; interference and consumer electronics; part 15 devices; over-modulation; RF feedback; off frequency signals
- T7C – Antenna measurements and troubleshooting: measuring SWR; dummy loads; coaxial cables; causes of feed line failures
- T7D – Basic repair and testing: soldering; using basic test instruments; connecting a voltmeter, ammeter, or ohmmeter

SUBELEMENT T8 – Modulation modes: amateur satellite operation; operating activities; non-voice and digital communications

[4 Exam Questions - one from each of 4 Groups]

- T8A – Modulation modes: bandwidth of various signals; choice of emission type
- T8B - Amateur satellite operation; Doppler shift; basic orbits; operating protocols; transmitter power considerations; telemetry and telecommand; satellite tracking
- T8C – Operating activities: radio direction finding; radio control; contests; linking over the internet; grid locators
- T8D – Non-voice and digital communications: image signals; digital modes; CW; packet radio; PSK31; APRS; error detection and correction; NTSC; amateur radio networking; Digital Mobile/Migration Radio

SUBELEMENT T9 – Antennas and feed lines

[2 Exam Questions - one from each of 2 Groups]

- T9A – Antennas: vertical and horizontal polarization; concept of gain; common portable and mobile antennas; relationships between resonant length and frequency; concept of dipole antennas
- T9B – Feed lines: types, attenuation vs frequency, selecting; SWR concepts; Antenna tuners (couplers); RF Connectors:

SUBELEMENT T0 – Electrical safety: AC and DC power circuits; antenna installation; RF hazards

[3 Exam Questions - one from each of 3 Groups]

- T0A – Power circuits and hazards: hazardous voltages; fuses and circuit breakers; grounding; lightning protection; battery safety; electrical code compliance
- T0B – Antenna safety: tower safety and grounding; erecting an antenna support; safely installing an antenna
- T0C - RF hazards: radiation exposure; proximity to antennas; recognized safe power levels; exposure to others; radiation types; duty cycle


So lets
Get
started

US Amateur Radio Bands

US AMATEUR POWER LIMITS

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

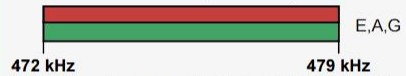
Effective Date for 2,200 and 630 Meters to be announced

ARRL The national association for AMATEUR RADIO®

On March 28, 2017, the Federal Communications Commission adopted rules that will allow Amateur Radio access to 472-479 kHz (630 meters) and to 135.7-137.8 kHz (2,200 meters). However, amateurs cannot use these frequencies until 30 days after the Report and Order is published in the Federal Register and the final procedures for registering stations with the Utilities Telecoms Council (UTC) have been approved and announced. At the time this chart was created, the Report and Order had not been published and the UTC online registration site is not yet available. Follow ARRL news for further information. New charts will be published at www.arrl.org/graphical-frequency-allocations when the bands are fully available for use.

2,200 Meters (135 kHz)

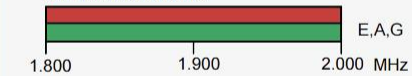
630 Meters (472 kHz)



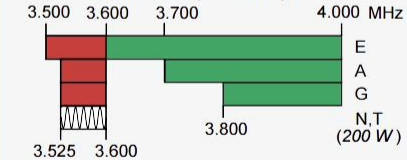
5 W EIRP maximum, except in Alaska within 496 miles of Russia where the power limit is 1 W EIRP.

160 Meters (1.8 MHz)

Avoid interference to radiolocation operations from 1.900 to 2.000 MHz



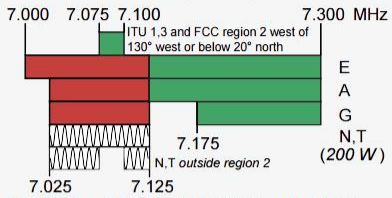
80 Meters (3.5 MHz)



60 Meters (5.3 MHz)

General, Advanced, and Amateur Extra licensees may operate on these five channels on a secondary basis with a maximum effective radiated power (ERP) of 100 W PEP relative to a half-wave dipole. Permitted operating modes include upper sideband voice (USB), CW, RTTY, PSK31 and other digital modes such as PACTOR III. Only one signal at a time is permitted on any channel.

40 Meters (7 MHz)

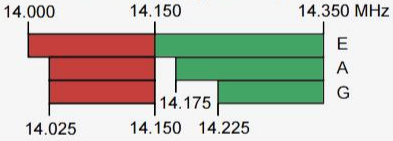


See Sections 97.305(c), 97.307(f)(11) and 97.301(e). These exemptions do not apply to stations in the continental US.

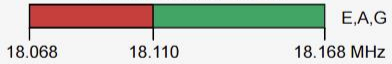
30 Meters (10.1 MHz)

Avoid interference to fixed services outside the US.

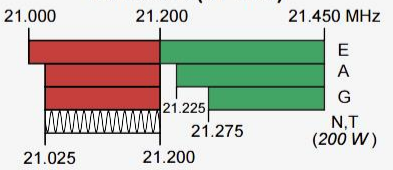
20 Meters (14 MHz)



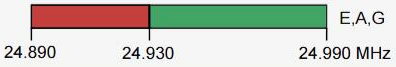
17 Meters (18 MHz)



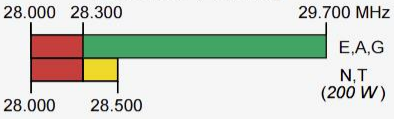
15 Meters (21 MHz)



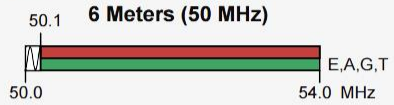
12 Meters (24 MHz)



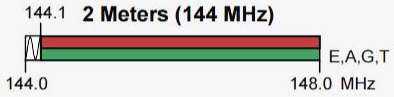
10 Meters (28 MHz)



6 Meters (50 MHz)



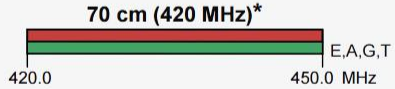
2 Meters (144 MHz)



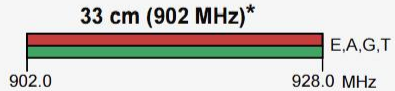
1.25 Meters (222 MHz)

*Geographical and power restrictions may apply to all bands above 420 MHz. See *The ARRL Operating Manual* for information about your area.

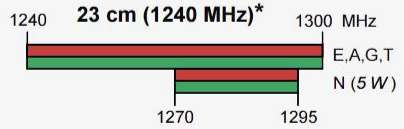
70 cm (420 MHz)*



33 cm (902 MHz)*



23 cm (1240 MHz)*



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

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

‡ No pulse emissions

KEY

Note:
CW operation is permitted throughout all amateur bands.

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

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

- = RTTY and data
- = phone and image
- = CW *only*
- = SSB phone
- = USB phone, CW, RTTY, and data
- = Fixed digital message forwarding systems *only*

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

See *ARRLWeb at www.arrl.org* for detailed band plans.

ARRL
We're At Your Service

ARRL Headquarters:
860-594-0200 (Fax 860-594-0259)
email: hq@arrl.org

Publication Orders:
www.arrl.org/shop
Toll-Free 1-888-277-5289 (860-594-0355)
email: orders@arrl.org

Membership/Circulation Desk:
www.arrl.org/membership
Toll-Free 1-888-277-5289 (860-594-0338)
email: membership@arrl.org

Getting Started in Amateur Radio:
Toll-Free 1-800-326-3942 (860-594-0355)
email: newham@arrl.org

Exams: 860-594-0300 email: vec@arrl.org

Copyright © ARRL 2017 **rev. 4/25/2017**

SUBELEMENT T1 – FCC Rules, descriptions, and definitions for the Amateur Radio Service, operator and station license responsibilities

[6 Exam Questions - 6 Groups]

T1A - Amateur Radio Service: purpose and permissible use of the Amateur Radio Service, operator/primary station license grant; Meanings of basic terms used in FCC rules; Interference; RACES rules; Phonetics; Frequency Coordinator

T1A01 [97.1]
Which of the following is a purpose of the Amateur Radio Service as stated in the FCC rules and regulations? **Advancing skills in the technical and communication phases of the radio art**

T1A02 [97.1]
Which agency regulates and enforces the rules for the Amateur Radio Service in the United States? **The FCC**

T1A03 [97.119(b) (2)]
What are the FCC rules regarding the use of a phonetic alphabet for station identification in the Amateur Radio Service? **It is encouraged**

T1A04 (A) [97.5(b)(1)]
How many operator/primary station license grants may be held by any one person? **One**

T1A05 [97.7]
What is proof of possession of an FCC-issued operator/primary license grant? **The control operator's operator/primary station license must appear in the FCC ULS consolidated licensee database**

T1A06 [97.3(a)(9)]
What is the FCC Part 97 definition of a "beacon"? **An amateur station transmitting communications for the purposes of observing propagation or related experimental activities**

T1A07 [97.3(a) (41)]
What is the FCC Part 97 definition of a "space station"? **An amateur station located more than 50 km *(31 Miles)* above the Earth's surface**

T1A08 [97.3(a) (22)]
Which of the following entities recommends transmit/receive channels and other parameters for auxiliary and repeater stations? **Volunteer Frequency Coordinator recognized by local amateurs**

T1A09 [97.3(a) (22)]
Who selects a Frequency Coordinator? **Amateur operators in a local or regional area whose stations are eligible to be repeater or auxiliary stations**

T1A10 [97.3(a) (38), 97.407]
Which of the following describes the Radio Amateur Civil Emergency Service (RACES)?

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

T1A11 [97.101 (d)]
When is willful interference to other amateur radio stations permitted? **At no time**

T1B - Authorized frequencies: frequency allocations; ITU; emission modes; restricted sub-bands; spectrum sharing; transmissions near band edges; contacting the International Space Station; power output

T1B01
What is the International Telecommunications Union (ITU)? **A United Nations agency for information and communication technology issues**

ITU is the United Nations specialized agency for information and communication technologies – ICTs.

The ITU allocates global radio spectrum and satellite orbits, develop the technical standards that ensure networks and technologies seamlessly interconnect, and strive to improve access to ICTs to underserved communities worldwide.

ITU is committed to connecting all the world's people – wherever they live and whatever their means. Through our work, we protect and support everyone's fundamental right to communicate.

T1B02 [97.301, 97.207(c)]
Which amateur radio stations may make contact with an amateur radio station on the International Space Station (ISS) using 2 meter and 70 cm band frequencies? **Any amateur holding a Technician or higher-class license**

T1B03 [97.301(a)]
Which frequency is within the 6-meter amateur band? **52.525 MHz**
Frequency = 300 ÷ Wavelength or 300 ÷ 6 or 50 MHz

T1B04 [97.301(a)]
Which amateur band are you using when your station is transmitting on 146.52 MHz? **2-meter band**
Wave Length = 300÷frequencyin MHz or 300÷146.52 or 2.047 meters

T1B05 [97.305(c)]
What is the limitation for emissions on the frequencies between 219 and 220 MHz? **Fixed digital message forwarding systems only**
See ARRL band plan on page 17

T1B06 [97.301(e), 97.305]
On which HF bands does a Technician class operator have phone privileges? **10 meters only**
See ARRL band plan on page 17

T1B07 [97.305(a), (c)]
Which of the following VHF/UHF frequencies ranges are limited to CW only? **50.0 MHz to 50.1 MHz and 144.0 MHz to 144.1 MHz**
***See ARRL band plan* on page 17**

T1B08 [97.303]
Which of the following is a result of the fact that the Amateur Radio Service is secondary in all or portions of some amateur bands (such as portions of the 70 cm band)? **U.S. amateurs may find non-amateur stations in those portions, and must avoid interfering with them**

T1B09 [97.101(a), 97.301(a-e)]
Why should you not set your transmit frequency to be exactly at the edge of an amateur band or sub-band?

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

T1B10 [97.301(e), 97.305(c)]
Which of the following HF bands have frequencies available to the Technician class operator for RTTY and data transmissions? **10 meters only**
See ARRL band plan on page 17

T1B11 [97.313]
What is the maximum peak envelope power output for Technician class operators using their assigned portions of the HF bands? **200 watts**
See ARRL band plan on page 17

T1B12 [97.313(b)]
Except for some specific restrictions, what is the maximum peak envelope power output for Technician class operators using frequencies above 30 MHz? **1500 watts**
See ARRL band plan on page 17

T1C - Operator licensing: operator classes; sequential and vanity call sign systems; international communications; reciprocal operation; places where the Amateur Radio Service is regulated by the FCC; name and address on FCC license database; license term; renewal; grace period

T1C01 [97.9(a), 97.17(a)]
For which license classes are ***new*** licenses currently available from the FCC? **Technician, General, Amateur Extra**

T1C02 [97.19]
Who may select a desired call sign under the vanity call sign rules? **Any licensed amateur**
Immediately after receiving your new technician license you can apply for a vanity call sign.

T1C03 [97.117]
What types of international communications is an FCC-licensed amateur radio station permitted to make? **Communications incidental to the purposes of the Amateur Radio Service and remarks of a personal character**

T1C04 [97.107]
When are you allowed to operate your amateur station in a foreign country? **When the foreign country authorizes it**

T1C05
Which of the following is a valid call sign for a Technician class amateur radio station?

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

Amateur radio Extra call signs are 1 by 2 (W1AW), 2 by 1 (AD7P) and 2 by 2 (AF6CA)
Technician and General call signs are 1 by 3 (W3JIN) or 2 by 3 (KE7HIV)
Temporary special event stations call signs are 1 by 1 (A5D)

T1C06 [97.5(a)(2)]
From which of the following locations may an FCC-licensed amateur station transmit**?** **From any vessel or craft located in international waters and documented or registered in the United States**

T1C07 [97.23]
What may result when correspondence from the FCC is returned as undeliverable because the grantee failed to provide and maintain a correct mailing address with the FCC? **Revocation of the station license or suspension of the operator license**

T1C08 [97.25]
What is the normal term for an FCC-issued primary station/operator amateur radio license grant? **Ten years**

T1C09 [97.21(a)(b)]
What is the grace period following the expiration of an amateur license within which the license may be renewed? **Two years**

After 2 years you must retake the element 2 (Technician)exam to reinstate your license

T1C10 [97.5a]
How soon after passing the examination for your first amateur radio license may you operate a transmitter on an Amateur Radio Service frequency? **As soon as your operator/station license grant appears in the FCC's license database**

T1C11 [97.21(b)]
If your license has expired and is still within the allowable grace period, may you continue to operate a transmitter on Amateur Radio Service frequencies? **No, transmitting is not allowed until the FCC license database shows that the license has been renewed**

T1D - Authorized and prohibited transmission: communications with other countries; music; exchange of information with other services; indecent language; compensation for use of station; retransmission of other amateur signals; codes and ciphers; sale of equipment; unidentified transmissions; one-way transmission

T1D01 [97.111(a)(1)]
With which countries are FCC-licensed amateur radio stations prohibited from exchanging communications? **Any country whose administration has notified the International Telecommunications Union (ITU) that it objects to such communications**
Two countries that currently do not allow ham radio operation by its citizens are Yemen and North Korea.

T1D02 [97.113(b),97.111(b)]
Under which of the following circumstances may an amateur radio station make one-way transmissions? **When transmitting code practice, information bulletins, or transmissions necessary to provide emergency communications**

T1D03 [97.211(b), 97.215(b), 97.114(a)(4)]
When is it permissible to transmit messages encoded to hide their meaning? **Only when transmitting control commands to space stations or radio control craft**

T1D04 [97.113(a)(4), 97.113(c)]
Under what conditions is an amateur station authorized to transmit music using a phone emission? **When incidental to an authorized retransmission of manned spacecraft communications**

T1D05 [97.113(a)(3)(ii)]
When may amateur radio operators use their stations to notify other amateurs of the availability of equipment for sale or trade? **When the equipment is normally used in an amateur station and such activity is not conducted on a regular basis**

T1D06 [97.113(a)(4)]
What, if any, are the restrictions concerning transmission of language that may be considered indecent or obscene? **Any such language is prohibited**

T1D07 [97.113(d)]
What types of amateur stations can automatically retransmit the signals of other amateur stations? **Repeater, auxiliary, or space stations**
When an amateur station, such as a repeater, is remotely controlled over a radio link, there is another station involved--the station doing the controlling. This "control" station is, under the FCC rules, called an auxiliary station

T1D08 [97.113(a)(3)(iii)]
In which of the following circumstances may the control operator of an amateur station receive compensation for operating that station**?** **When the communication is incidental to classroom instruction at an educational institution**

T1D09 [97.113(5)(b)]
Under which of the following circumstances are amateur stations authorized to transmit signals related to broadcasting, program production, or news gathering, assuming no other means is available? **Only where such communications directly relate to the immediate safety of human life or protection of property**

T1D10 [97.3(a)(10)]
What is the meaning of the term “broadcasting” in the FCC rules for the Amateur Radio Service? **Transmissions intended for reception by the general public**

T1D11 [97.119(a)]
When may an amateur station transmit without on-the-air identification? **When transmitting signals to control model craft**

T1E - Control operator and control types: control operator required; eligibility; designation of control operator; privileges and duties; control point; local, automatic and remote control; location of control operator

T1E01 [97.7(a)]
When is an amateur station permitted to transmit without a control operator? **Never**

T1E02 [97.301, 97.207(c)]
Who may be the control operator of a station communicating through an amateur satellite or space station? **Any amateur whose license privileges allow them to transmit on the satellite uplink frequency**

T1E03 [97.103(b)]
Who must designate the station control operator? **The station licensee**

T1E04 [97.103(b)]
What determines the transmitting privileges of an amateur station? **The class of operator license held by the control operator**

T1E05 [97.3(a)(14)]
What is an amateur station control point? **The location at which the control operator function is performed**

T1E06 [97.301]
When, under normal circumstances, may a Technician class licensee be the control operator of a station operating in an exclusive Amateur Extra class operator segment of the amateur bands? **At no time**

T1E07 [97.103(a)]
When the control operator is not the station licensee, who is responsible for the proper operation of the station? **The control operator and the station licensee are equally responsible**

T1E08 [97.3(a)(6), 97.205(d)]
Which of the following is an example of automatic control? **Repeater operation**

T1E09 [97.109(c)]
Which of the following is true of remote control operation?

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

T1E10 [97.3(a)(39)]
Which of the following is an example of remote control as defined in Part 97? **Operating the station over the internet**

T1E11 [97.103(a)]
Who does the FCC presume to be the control operator of an amateur station, unless documentation to the contrary is in the station records? **The station licensee**

T1F - Station identification; repeaters; third-party communications; club stations; FCC inspection

T1F01 [97.103(c)]
When must the station licensee make the station and its records available for FCC inspection? **At any time upon request by an FCC representative**

T1F02 [97.119 (a)]
When using tactical identifiers such as “Race Headquarters” during a community service net operation, how often must your station transmit the station’s FCC-assigned call sign? **At the end of each communication and every ten minutes during a communication**

T1F03 [97.119(a)]
When is an amateur station required to transmit its assigned call sign? **At least every 10 minutes during and at the end of a communication**

T1F04 [97.119(b)(2)]
Which of the following is an acceptable language to use for station identification when operating in a phone sub-band**?** **The English language**

T1F05 [97.119(b)(2)]
What method of call sign identification is required for a station transmitting phone signals?
Send the call sign using a CW or phone emission

T1F06 [97.119(c)]
Which of the following formats of a self-assigned indicator is acceptable when identifying using a phone transmission?

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

T1F07 [97.115(a)(2)]
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 Technician class control operator? **The foreign station must be one with which the U.S. has a third-party agreement**

T1F08 [97.3(a)(47)]
What is meant by the term "Third Party Communications"? **A message from a control operator to another amateur station control operator on behalf of another person**

T1F09 [97.3(a)(40)]
What type of amateur station simultaneously retransmits the signal of another amateur station on a different channel or channels? **Repeater station**

T1F10 [97.205(g)]
Who is accountable should a repeater inadvertently retransmit communications that violate the FCC rules? **The control operator of the originating station**

T1F11 [97.5(b)(2)]
Which of the following is a requirement for the issuance of a club station license grant?
The club must have at least four members

SUBELEMENT T2 - Operating Procedures

[3 Exam Questions - 3 Groups]

T2A - Station operation: choosing an operating frequency; calling another station; test transmissions; procedural signs; use of minimum power; choosing an operating frequency; band plans; calling frequencies; repeater offsets

T2A01
Which of the following is a common repeater frequency offset in the 2-meter band?
Plus, or minus 600 kHz

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

T2A03
What is a common repeater frequency offset in the 70 cm band? **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? **Say the station's call sign, then identify with your call sign**

T2A05
How should you respond to a station calling CQ? **Transmit the other station's call sign followed by your call sign**
CQ was adopted by the Marconi company in 1904 for use in wireless (spark) telegraphy and was adopted internationally at the 1912 London International Radiotelegraph Convention and is still used and means you are calling any station.

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

T2A07
What is meant by "repeater offset?" **The difference between a repeater's transmit frequency and its receive frequency**

T2A08
What is the meaning of the procedural signal "CQ"? **Calling any station**

T2A09
What brief statement indicates that you are listening on a repeater and looking for a contact?
Your call sign

T2A10
What is a band plan, beyond the privileges established by the FCC? **A voluntary guideline for using different modes or activities within an amateur band**
See ARRL Band plan on page 19 of this syllabus

T2A11
What kind of communication is taking place when an amateur station is transmitting and receiving on the same frequency? **Simplex**

T2A12
Which of the following is a guideline when choosing an operating frequency for calling CQ?

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

T2B – VHF/UHF operating practices: SSB phone; FM repeater; simplex; splits and shifts; CTCSS; DTMF; tone squelch; carrier squelch; phonetics; operational problem resolution; Q signals

T2B01
What is the most common use of the "reverse split" function of a VHF/UHF transceiver?
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? **CTCSS**
CTCSS is an abbreviation for "Continuous Tone Coded Squelch System"

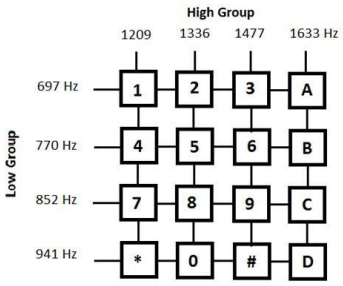
T2B03
If a station is not strong enough to keep a repeater's receiver squelch open, which of the following might allow you to receive the station's signal? ***Listen on the repeater input frequency***

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

A. Improper transceiver offset
B. The repeater may require a proper CTCSS tone from your transceiver
C. The repeater may require a proper DCS tone from your transceiver
D. All of these choices are correct

T2B05
What might be the problem if a repeater user says your transmissions are breaking up on voice peaks? **You are talking too loudly**

T2B06
What type of tones are used to control repeaters linked by the Internet Relay Linking Project (IRLP) protocol? **DTMF**
DTMF is an abbreviation for "Dual Tone Multi Frequency" telephone keypad tones



DTMF Frequencies vs Key

T2B07
How can you join a digital repeater's "talk group"? **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? **Common courtesy should prevail, but no one has absolute right to an amateur frequency**

T2B09
What is a "talk group" on a DMR digital repeater? **A way for groups of users to share a channel at different times without being heard by other users on the channel**
DMR is the Motorola Digital Mobile Radio format

T2B10
Which Q signal indicates that you are receiving interference from other stations? **QRM**
QRM --- Are you being interfered with? You are being interfered with
A list of common "Q signals" is in the appendix on page 83

T2B11
Which Q signal indicates that you are changing frequency? **QSY**
QSY -- Shall I change to another frequency? I am changing to another frequency
A list of common "Q signals" is in the appendix on page 83

T2B12
Why are simplex channels designated in the VHF/UHF band plans? **So that stations within mutual communications range can communicate without tying up a repeater**

T2B13
Where may SSB phone be used in amateur bands above 50 MHz? **In at least some portion of all these bands**

T2B14
Which of the following describes a linked repeater network? **A network of repeaters where signals received by one repeater are repeated by all the repeaters**
In Washington state there is a network of repeaters called the Evergreen Intertie that covers western Montana to Seattle WA and from Vancouver BC to northwestern Oregon.

T2C – Public service: emergency and non-emergency operations; applicability of FCC rules; RACES and ARES; net and traffic procedures; operating restrictions during emergencies

T2C01 [97.103(a)]
When do the FCC rules NOT apply to the operation of an amateur station? **Never, FCC rules always apply**

T2C02
What is meant by the term "NCS" used in net operation? **Net Control Station**

T2C03
What should be done when using voice modes to ensure that voice messages containing unusual words are received correctly? **Spell the words using a standard phonetic alphabet**
A copy of the standard Phonetic Alphabet is included in the appendix on page 84

T2C04
What do RACES and ARES have in common? **Both organizations may provide communications during emergencies**

T2C05
What does the term “traffic” refer to in net operation? **Formal messages exchanged by net stations**

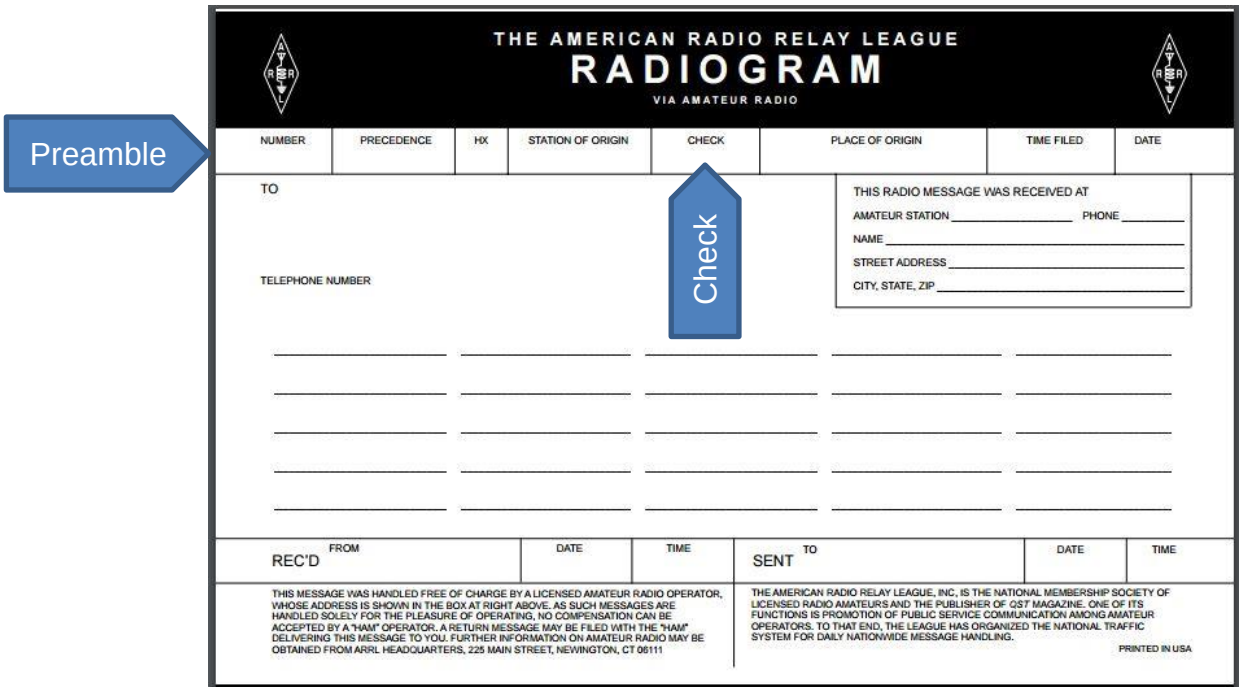
T2C06
Which of the following is an accepted practice to get the immediate attention of a net control station when reporting an emergency? **Begin your transmission by saying "Priority" or "Emergency" followed by your call sign**

T2C07
Which of the following is an accepted practice for an amateur operator who has checked into a net? **Remain on frequency without transmitting until asked to do so by the net control station**

T2C08
Which of the following is a characteristic of good traffic handling? **Passing messages exactly as received**

T2C09
Are amateur station control operators ever permitted to operate outside the frequency privileges of their license class? **Yes, but only if necessary 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? **The information needed to track the message**



T2C11
What is meant by the term "check," in reference to a formal traffic message? **The number of words or word equivalents in the text portion of the message**

T2C12
What is the Amateur Radio Emergency Service (ARES)**?** **Licensed amateurs who have voluntarily registered their qualifications and equipment for communications duty in the public service**

SUBELEMENT T3 – Radio wave characteristics: properties of radio waves; propagation modes

[3 Exam Questions - 3 Groups]

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

T3A01
What should you do if another operator reports that your station's 2-meter signals were strong just a moment ago, but now they are weak or distorted? **Try moving a few feet or changing the direction of your antenna if possible, as reflections may be causing multi-path distortion**

T3A02
Why might the range of VHF and UHF signals be greater in the winter? **Less absorption by vegetation**

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

T3A04
What can happen if the antennas at opposite ends of a VHF or UHF line of sight radio link are not using the same polarization? **Signals could be significantly weaker**
Stations with a 90° polarization experiance a signal loss of up to 20dB (100 times) or more

T3A05
When using a directional antenna, how might your station be able to access a distant repeater if buildings or obstructions are blocking the direct line of sight path? **Try to find a path that reflects signals to the repeater**

T3A06
What term is commonly used to describe the rapid fluttering sound sometimes heard from mobile stations that are moving while transmitting? **Picket fencing**
Picket fencing is when portions of speech are stripped from the conversation, as if the listener was walking by a picket fence, and hearing a conversation on the other side that changes audibly depending on the position of the pickets relative to the listener.

T3A07
What type of wave carries radio signals between transmitting and receiving stations?
Electromagnetic

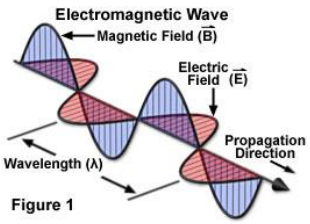
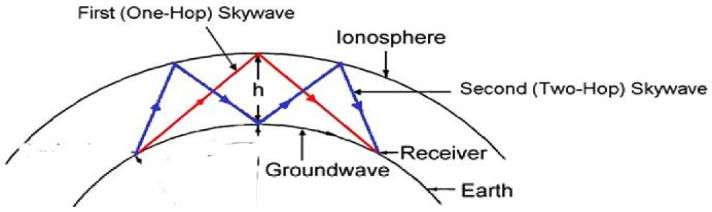


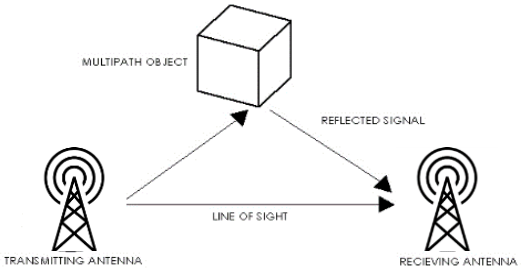
Figure 1

T3A08
Which of the following is a likely cause of irregular fading of signals received by ionospheric reflection? **Random combining of signals arriving via different paths**

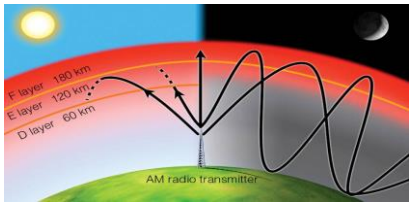


T3A09
Which of the following results from the fact that skip signals refracted from the ionosphere are elliptically polarized? **Either vertically or horizontally polarized antennas may be used for transmission or reception**

T3A10
What may occur if data signals arrive via multiple paths? **Error rates are likely to increase**
Different arrival times cause errors when the signals from the two paths are combined at the receiver antenna



T3A11
Which part of the atmosphere enables the propagation of radio signals around the world?
The ionosphere



T3A12
How might fog and light rain affect radio range on 10 meters and 6 meters? **Fog and light rain will have little effect on these bands**

T3A13
What weather condition would decrease range at microwave frequencies? **Precipitation**

T3B - Radio and electromagnetic wave properties: the electromagnetic spectrum; wavelength vs frequency; nature and velocity of electromagnetic waves; definition of UHF, VHF, HF bands; calculating wavelength

T3B01
What is the name for the distance a radio wave travels during one complete cycle? **Wavelength**

T3B02
What property of a radio wave is used to describe its polarization? **The orientation of the electric field**

T3B03
What are the two components of a radio wave? **Electric and magnetic fields**

T3B04
How fast does a radio wave travel through free space? **At the speed of light**
Approximately 300,000,000 meters per second. [actually 299,792,458 meters per second]

T3B05
How does the wavelength of a radio wave relate to its frequency? **The wavelength gets shorter as the frequency increases**

T3B06
What is the formula for converting frequency to approximate wavelength in meters?
Wavelength in meters equals 300 divided by frequency in megahertz
Example for 150 MHZ the wavelength would be 300/150 or 2 meters

T3B07
What property of radio waves is often used to identify the different frequency bands?
The approximate wavelength

T3B08
What are the frequency limits of the VHF spectrum? **30 to 300 MHz**
30 MHz < VHF Spectrum >300 MHz

T3B09
What are the frequency limits of the UHF spectrum? **300 to 3000 MHz**
300 MHz < UHF Spectrum > 3,000 MHz

T3B10
What frequency range is referred to as HF? **3 to 30 MHz**
3MHz< HF Spectrum > 30MHz

T3B11
What is the approximate velocity of a radio wave as it travels through free space?
300,000,000 meters per second
The speed of light

T3C - Propagation modes: line of sight; sporadic E; meteor and auroral scatter and reflections; tropospheric ducting; F layer skip; radio horizon

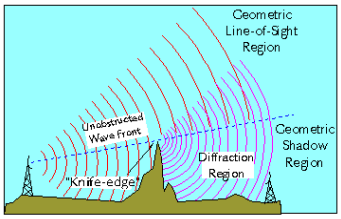
T3C01
Why are direct (not via a repeater) UHF signals rarely heard from stations outside your local coverage area? **UHF signals are usually not reflected by the ionosphere**

T3C02
Which of the following is an advantage of HF vs VHF and higher frequencies? **Long distance ionospheric propagation is far more common on HF**

T3C03
What is a characteristic of VHF signals received via auroral reflection? **The signals exhibit rapid fluctuations of strength and often sound distorted**

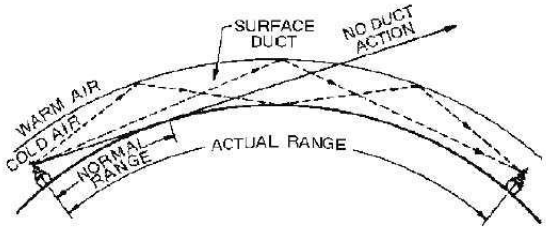
T3C04
Which of the following propagation types is most commonly associated with occasional strong over-the-horizon signals on the 10, 6, and 2-meter bands? **Sporadic E**
Sporadic means- "occurring at irregular intervals or only in a few places; scattered or isolated"

T3C05
Which of the following effects might cause radio signals to be heard despite obstructions between the transmitting and receiving stations? **Knife-edge diffraction**

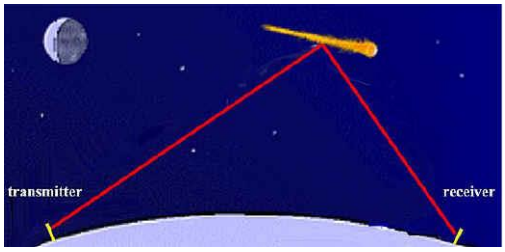


knife-edge effect

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



T3C07
What band is best suited for communicating via meteor scatter? **6 meters**



T3C08
What causes tropospheric ducting? **Temperature inversions in the atmosphere**
The troposphere is the lowest layer of the atmosphere with water vapor, vertical winds and temperatures that decrease as the altitude increases.

T3C09
What is generally the best time for long-distance 10-meter band propagation via the F layer?
From dawn to shortly after sunset during periods of high sunspot activity

T3C10
Which of the following bands may provide long distance communications during the peak of the sunspot cycle? **Six or ten meters**

T3C11
Why do VHF and UHF radio signals usually travel somewhat farther than the visual line of sight distance between two stations? **The Earth seems less curved to radio waves than to light**

SUBELEMENT T4 - Amateur radio practices and station set-up

[2 Exam Questions - 2 Groups]

T4A – Station setup: connecting microphones; reducing unwanted emissions; power source; connecting a computer; RF grounding; connecting digital equipment; connecting an SWR meter

T4A01

What must be considered to determine the minimum current capacity needed for a transceiver's power supply? **Power supply regulation and heat dissipation**

A linear power supply must throw away some of the input energy as heat to provide the regulated output voltage. Using heat sink or fans or both can prevent overheating.

T4A02

How might a computer be used as part of an amateur radio station?

A. For logging contacts and contact information
B. For sending and/or receiving CW
C. For generating and decoding digital signals
D. All of these choices are correct

T4A03

Why should wiring between the power source and radio be heavy-gauge wire and kept as short as possible? **To avoid voltage falling below that needed for proper operation**

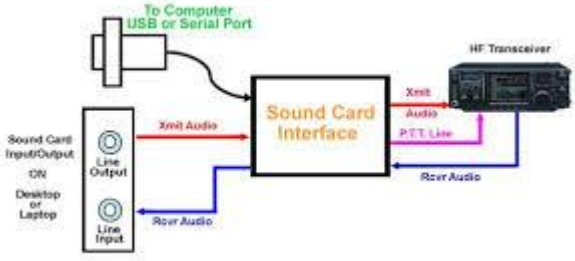
A 20-ft. run of 14-gauge wire from the radio to the battery or power source (Total of 40ft. of wire for both positive and negative leads) would have a resistance of .05 ohms. With a current of 20 amperes for a mobile HF Rig this would amount to a 2.02-volt voltage drop. With a 12-volt power source the radio would only see 9.98 volts from the 12-volt source.

Resistance of 14-gauge copper wire is 2.525 ohms per 1000ft. (.00253 ohms per foot). The 40-ft. length would therefore have a resistance of .101 ohms. The voltage drop for a .101-ohm resistor with 20 amperes of current would be Voltage = .101 ohms x 20 Amperes or 2.02 Volts

For 12-gauge wire at .00159 ohms per foot the voltage drop would be 1.3 Volts
For 10-gauge wire at .00100 ohms per foot the voltage drop would be 0.8 Volts

T4A04

Which computer sound card port is connected to a transceiver's headphone or speaker output for operating digital modes? **Microphone or line input**

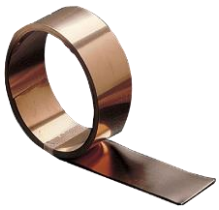


T4A05
What is the proper location for an external SWR meter? **In series with the feed line, between the transmitter and antenna**

T4A06
Which of the following connections might be used between a voice transceiver and a computer for digital operation? **Receive audio, transmit audio, and push-to-talk (PTT)**

T4A07
How is a computer's sound card used when conducting digital communications? **The sound card provides audio to the radio's microphone input and converts received audio to digital form**

T4A08
Which of the following conductors provides the lowest impedance to RF signals? **Flat strap**



T4A09
Which of the following could you use to cure distorted audio caused by RF current on the shield of a microphone cable? **Ferrite choke**

T4A10
What is the source of a high-pitched whine that varies with engine speed in a mobile transceivers receive audio? **The alternator**

T4A11
Where should the negative return connection of a mobile transceiver's power cable be connected? **At the battery or engine block ground strap**

T4B - Operating controls: tuning; use of filters; squelch function; AGC; repeater offset; memory channels

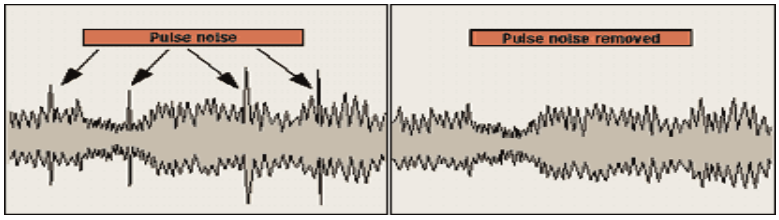
T4B01
What may happen if a transmitter is operated with the microphone gain set too high?
The output signal might become distorted
This can cause excessive modulation

T4B02
Which of the following can be used to enter the operating frequency on a modern transceiver?
The keypad or VFO knob

T4B03
What is the purpose of the squelch control on a transceiver? **To mute receiver output noise when no signal is being received**

T4B04
What is a way to enable quick access to a favorite frequency on your transceiver?
Store the frequency in a memory channel

T4B05
Which of the following would reduce ignition interference to a receiver?
Turn on the noise blanker



T4B06
Which of the following controls could be used if the voice pitch of a single-sideband signal seems too high or low? **The receiver RIT or clarifier**
Think of RIT as a fine frequency tuning control

T4B07
What does the term "RIT" mean? **Receiver Incremental Tuning**

T4B08
What is the advantage of having multiple receive bandwidth choices on a multimode transceiver? **Permits noise or interference reduction by selecting a bandwidth matching the mode**

CW – 150 Hz
SSB – 2,800 Hz
AM – 6,000 Hz
FM – 5,000 KHz to !5, 000 KHz

T4B09
Which of the following is an appropriate receive filter bandwidth for minimizing noise and interference for SSB reception? **2400 Hz**

T4B10
Which of the following is an appropriate receive filter bandwidth for minimizing noise and interference for CW reception? **500 Hz**

T4B11
What is the common meaning of the term "repeater offset"? **The difference between the repeaters transmit and receive frequencies**
This is usually +/- 600 kHz for the 2-meter band and +/- 5 MHz for the 70 cm band

T4B12
What is the function of automatic gain control, or AGC? **To keep received audio relatively constant**

T4B13
Which of the following could be used to remove power line noise or ignition noise?
Noise blanker

T4B14
Which of the following is a use for the scanning function of an FM transceiver?
To scan through a range of frequencies to check for activity

SUBELEMENT T5 – Electrical principles: math for electronics; electronic principles; Ohm's Law

[4 Exam Questions - 4 Groups]

T5A - Electrical principles, units, and terms: current and voltage; conductors and insulators; alternating and direct current; series and parallel circuits

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

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

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

T5A04
What is the name for a current that flows only in one direction? **Direct current**

T5A05
What is the electrical term for the electromotive force (EMF) that causes electron flow?
Voltage

T5A06
How much voltage does a mobile transceiver typically require? **About 12 volts**
Usually the transceiver specified performance is at 13.8 volts, the voltage in a vehicle with the engine running.

T5A07
Which of the following is a good electrical conductor? **Copper**

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

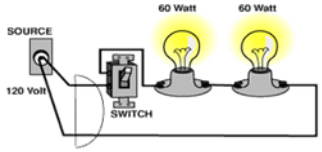
T5A09
What is the name for a current that reverses direction on a regular basis? **Alternating current**

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

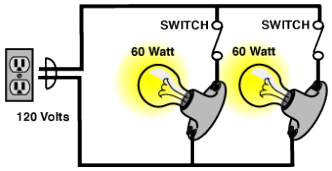
T5A11
What is the unit of electromotive force? **The volt**

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

T5A13
In which type of circuit is current the same through all components? **Series**



T5A14
In which type of circuit is voltage the same across all components? **Parallel**



T5B - Math for electronics: conversion of electrical units; decibels; the metric system

T5B01
How many milliamperes is 1.5 amperes? **1500 milliamperes**

T5B02
What is another way to specify a radio signal frequency of 1,500,000 hertz? **1,500 kHz**

T5B03
How many volts are equal to one kilovolt? **One thousand volts**

T5B04
How many volts are equal to one microvolt? **One one-millionth of a volt**
Note: Typical VHF and UHF transceivers can receive signals a small as 0 .15 microvolt's

T5B05
Which of the following is equal to 500 milliwatts? **0.5 watts**

T5B06
If an ammeter calibrated in amperes is used to measure a 3000-milliampere current, what reading would it show? **3 amperes**

T5B07
If a frequency display calibrated in megahertz shows a reading of 3.525 MHz, what would it show if it were calibrated in kilohertz? **3,525 kHz**

T5B08
How many microfarads are equal to 1,000,000 picofarads? **1 microfarad**

T5B09

What is the approximate amount of change, measured in decibels (dB), of a power increase from 5 watts to 10 watts? **3 dB**

By Calculation:

dB = 10 (log(P1÷P2)) or dB= 10(log (10÷5)) or dB= 10(log (2)) or dB= 10 (.3010) or dB= 3.01

By using the table

+	dB	-
2 x	3	.5 x
10 x	10	.1 x

T5B10

What is the approximate amount of change, measured in decibels (dB), of a power decrease from 12 watts to 3 watts? **-6 dB**

By Calculation:

dB = 10 (log(P1÷P2)) or dB= 10(log (12÷3)) or dB= 10(log (4)) or dB= 10 (-.6020) or dB= -6.02

Using the table in T5B09, ½ of 12 watts would be 6 watts for a loss of -3dB. Then ½ of 6 watts would be 3 watts for an additional -3dB loss or a total of -6dB loss

T5B11

What is the amount of change, measured in decibels (dB), of a power increase from 20 watts to 200 watts? **10 dB**

By Calculation:

dB = 10 (log(P1÷P2)) or dB= 10(log (200÷20)) or dB= 10(log 10)) or dB= 10 (1) or dB= 10

Using the table in T5B09, 200 watts is 10 times the 20-watt input. A ten times increase would be + 10dB

T5B12

Which of the following frequencies is equal to 28,400 kHz? **28.400 MHz**

T5B13

If a frequency display shows a reading of 2425 MHz, what frequency is that in GHz? **2.425 GHz**

T5C - Electronic principles: capacitance; inductance; current flow in circuits; alternating current; definition of RF; definition of polarity; DC power calculations; impedance

T5C01

What is the ability to store energy in an electric field called? **Capacitance**

T5C02

What is the basic unit of capacitance? **The farad**

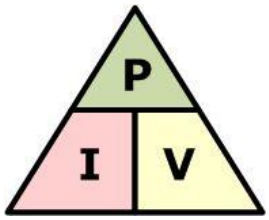
T5C03
What is the ability to store energy in a magnetic field called? **Inductance**

T5C04
What is the basic unit of inductance? **The henry**
T5C05
What is the unit of frequency? **Hertz**

T5C06
What does the abbreviation "RF" refer to? **Radio frequency signals of all types**

T5C07
A radio wave is made up of what type of energy? **Electromagnetic**

T5C08
What is the formula used to calculate electrical power in a DC circuit?
Power (P) equals voltage (E) multiplied by current (I)



T5C09
How much power is being used in a circuit when the applied voltage is 13.8 volts DC and the current is 10 amperes? **138 watts**
Power= current x voltage or P= 10 x 13.8 or P=138 watts

T5C10
How much power is being used in a circuit when the applied voltage is 12 volts DC and the current is 2.5 amperes? **30 watts**
Power= current x voltage or P= 2.5 x 12 or P=30 watts

T5C11
How many amperes are flowing in a circuit when the applied voltage is 12 volts DC and the load is 120 watts? **10 amperes**
Current = power ÷ voltage or Current = 120 ÷ 12 or current = 10 Amperes

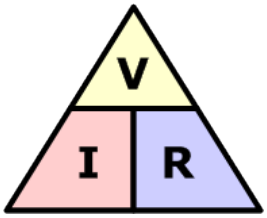
T5C12
What is impedance? **A measure of the opposition to AC current flow in a circuit**
If a circuit containing inductance or capacitance with the resistive component the impedance will change as the frequency is changed.

T5C13
What are the units of impedance? **Ohms**

T5C14
What is the proper abbreviation for megahertz? **MHz**

T5D – Ohm's Law: formulas and usage; components in series and parallel

T5D01
What formula is used to calculate current in a circuit? **Current (I) equals voltage (E) divided by resistance (R)**



T5D02
What formula is used to calculate voltage in a circuit? **Voltage (E) equals current (I) multiplied by resistance (R)**

T5D03
What formula is used to calculate resistance in a circuit? **Resistance (R) equals voltage (E) divided by current (I)**

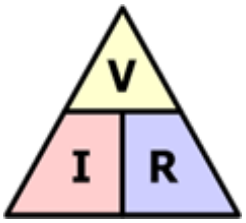
T5D04
What is the resistance of a circuit in which a current of 3 amperes flows through a resistor connected to 90 volts? **30 ohms**
Resistance = voltage ÷ current or 90 ÷ 3 or 30 ohms

T5D05
What is the resistance in a circuit for which the applied voltage is 12 volts and the current flow is 1.5 amperes? **8 ohms**
Resistance = voltage ÷ current or Resistance=12 ÷ 1.5 or resistance= 8 ohms

T5D06
What is the resistance of a circuit that draws 4 amperes from a 12-volt source? **3 ohms**
Resistance = voltage ÷ Current or Resistance = 12 ÷ 4 or resistance = 3 ohms

T5D07
What is the current in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms? **1.5 amperes**
Current= voltage ÷ Resistance or Current =120 ÷ 80 or Current = 1.5 amperes

T5D08
What is the current through a 100-ohm resistor connected across 200 volts? **2 amperes**
Current= voltage ÷ Resistance or Current =200 ÷ 100 or Current = 2 amperes



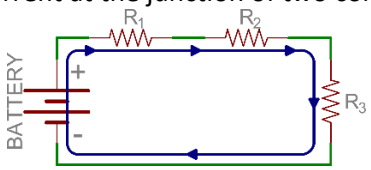
T5D09
What is the current through a 24-ohm resistor connected across 240 volts? **10 amperes**
Current= voltage ÷ Resistance or Current =240 ÷ 24 or Current = 10 amperes

T5D10
What is the voltage across a 2-ohm resistor if a current of 0.5 amperes flows through it? **1 volt**
Voltage = current x Resistance or Voltage =.5 x 2 or Voltage = 1 Volt

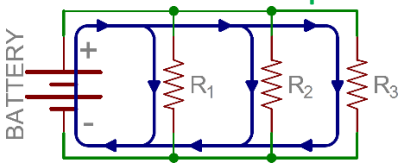
T5D11
What is the voltage across a 10-ohm resistor if a current of 1 ampere flows through it? **10 volts**
Voltage = Current x Resistance or Voltage =1 x 10 or Voltage = 10 Volts

T5D12
What is the voltage across a 10-ohm resistor if a current of 2 amperes flows through it? **20 volts**
Voltage = Current x Resistance or Voltage = 2 x 10 or Voltage = 20 Volts

T5D13
What happens to current at the junction of two components in series? **It is unchanged**



T5D14
What happens to current at the junction of two components in parallel? **It divides between them dependent on the value of the components**



T5D15
What is the voltage across each of two components in series with a voltage source? **It is determined by the type and value of the components**

T5D16
What is the voltage across each of two components in parallel with a voltage source?
The same voltage as the source

SUBELEMENT T6 – Electrical components; circuit diagrams; component functions

[4 Exam Questions - 4 Groups]

T6A - Electrical components: fixed and variable resistors; capacitors and inductors; fuses; switches; batteries

T6A01

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

T6A 02

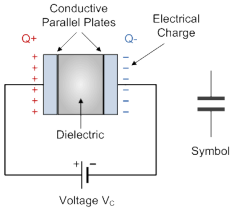
What type of component is often used as an adjustable volume control? **Potentiometer**

T6A03

What electrical parameter is controlled by a potentiometer? **Resistance**

T6A04

What electrical component stores energy in an electric field? **Capacitor**



T6A05

What type of electrical component consists of two or more conductive surfaces separated by an insulator? **Capacitor**

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

T6A07
What electrical component usually takes the form of a coil of wire? **Inductor**

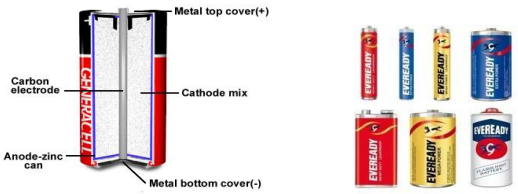
T6A08
What electrical component is used to connect or disconnect electrical circuits? **Switch**

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

T6A10
Which of the following battery types is rechargeable?

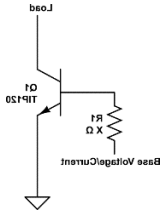
A. Nickel-metal hydride
B. Lithium-ion
C. Lead-acid gel-cell
D. All of these choices are correct

T6A11
Which of the following battery types is not rechargeable? **Carbon-zinc**



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

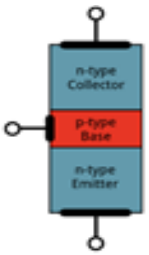
T6B01
What class of electronic components uses a voltage or current signal to control current flow?
Transistors



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

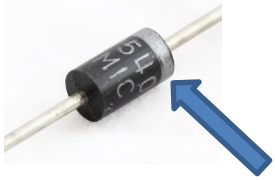
T6B03
Which of these components can be used as an electronic switch or amplifier? **Transistor**

T6B04
Which of the following components can consist of three layers of semiconductor material?
Transistor

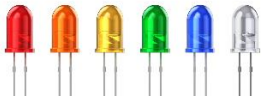


T6B05
Which of the following electronic components can amplify signals? **Transistor**

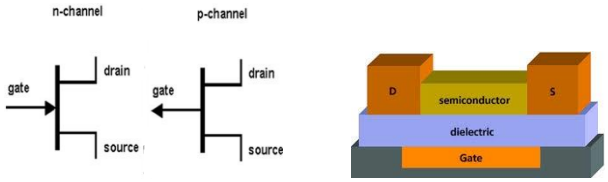
T6B06
How is the cathode lead of a semiconductor diode often marked on the package?
With a stripe



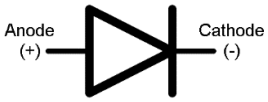
T6B07
What does the abbreviation LED stand for? **Light Emitting Diode**



T6B08
What does the abbreviation FET stand for? **Field Effect Transistor**



T6B09
What are the names of the two electrodes of a diode? **Anode and cathode**



T6B10
Which of the following could be the primary gain-producing component in an RF power amplifier? **Transistor**

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

T6C - Circuit diagrams; schematic symbols

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

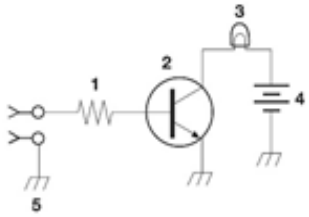


Figure T-1

T6C02
What is component 1 in figure T1? **Resistor**

T6C03
What is component 2 in figure T1? **Transistor**

T6C04
What is component 3 in figure T1? **Lamp**

T6C05
What is component 4 in figure T1? **Battery**

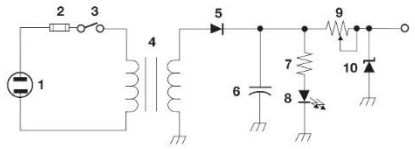


Figure T-2

T6C06
What is component 6 in figure T2? **Capacitor**

T6C07
What is component 8 in figure T2? **Light emitting diode**

T6C08
What is component 9 in figure T2? **Variable resistor**

T6C09
What is component 4 in figure T2? **Transformer**

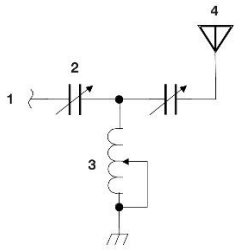


Figure T-3

T6C10
What is component 3 in figure T3? **Variable inductor**

T6C11
What is component 4 in figure T3? **Antenna**

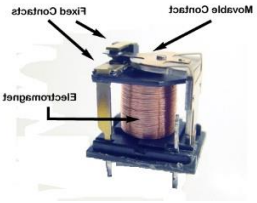
T6C12
What do the symbols on an electrical schematic represent? **Electrical components**

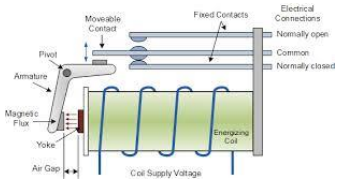
T6C13
Which of the following is accurately represented in electrical schematics? **The way components are interconnected**

T6D - Component functions: rectification; switches; indicators; power supply components; resonant circuit; shielding; power transformers; integrated circuits

T6D01
Which of the following devices or circuits changes an alternating current into a varying direct current signal? **Rectifier**
Rectifier is another name for a Diode

T6D02
What is a relay? **An electrically-controlled switch**





T6D03
What type of switch is represented by component 3 in figure T2? **Single-pole single-throw**

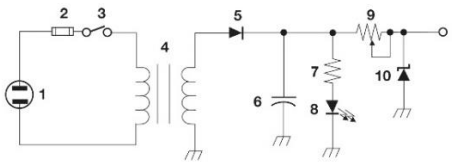
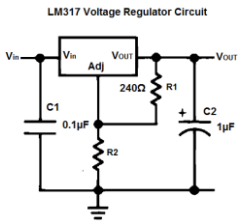


Figure T-2

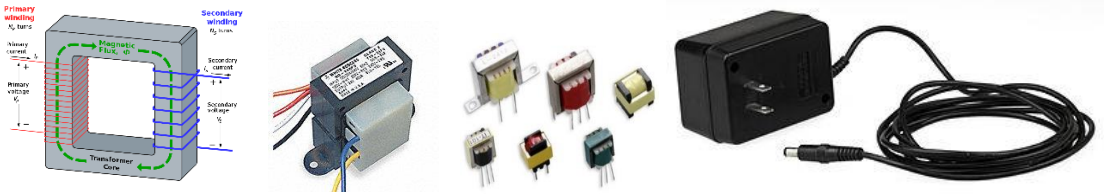
Pole and Throw Configurations

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

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

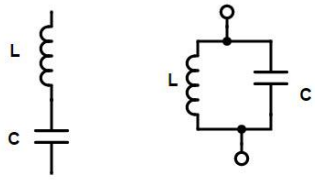


T6D06
What component is commonly used to change 120V AC house current to a lower AC voltage for other uses? **Transformer**



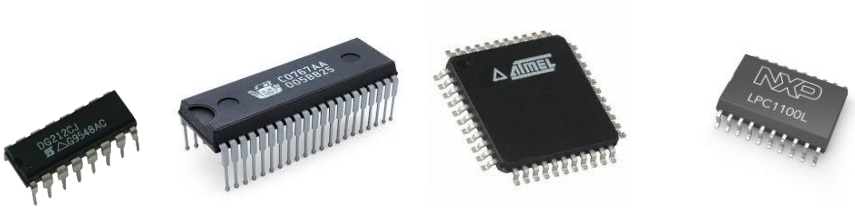
T6D07
Which of the following is commonly used as a visual indicator? **LED**

T6D08
Which of the following is combined with an inductor to make a tuned circuit? **Capacitor**



T6D09

What is the name of a device that combines several semiconductors and other components into one package? **Integrated circuit**



T6D10

What is the function of component 2 in Figure T1? **Control the flow of current**

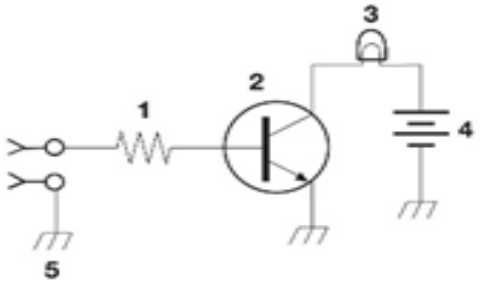
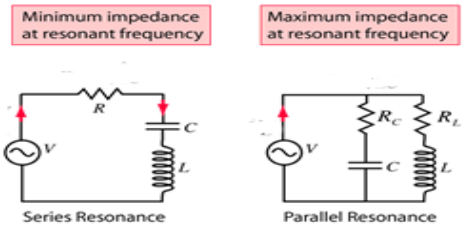


Figure T-1

T6D11

Which of the following is a resonant or tuned circuit? **An inductor and a capacitor connected in series or parallel to form a filter**



T6D12

Which of the following is a common reason to use shielded wire? **To prevent coupling of unwanted signals to or from the wire**

SUBELEMENT T7 – Station equipment: common transmitter and receiver problems; antenna measurements; troubleshooting; basic repair and testing

[4 Exam Questions - 4 Groups]

T7A – Station equipment: receivers; transmitters; transceivers; modulation; transverters; transmit and receive amplifiers

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

T7A02
What is a transceiver? **A unit combining the functions of a transmitter and a receiver**

T7A03
Which of the following is used to convert a radio signal from one frequency to another? **Mixer**
The output of a mixer circuit is two signals. One is the sum of the two input frequencies the second id the difference of the two signals.

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

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

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

T7A07
What is meant by "PTT"? **The push-to-talk function that switches between receive and transmit**

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

T7A09
What is the function of the SSB/CW-FM switch on a VHF power amplifier? **Set the amplifier for proper operation in the selected mode**

T7A10
What device increases the low-power output from a handheld transceiver? **An RF power amplifier**

T7A11
Where is an RF preamplifier installed? **Between the antenna and receiver**

T7B – Common transmitter and receiver problems: symptoms of overload and overdrive; distortion; causes of interference; interference and consumer electronics; part 15 devices; over-modulation; RF feedback; off frequency signals

T7B01
What can you do if you are told your FM handheld or mobile transceiver is over-deviating?
Talk farther away from the microphone

T7B02
What would cause a broadcast AM or FM radio to receive an amateur radio transmission unintentionally? **The receiver is unable to reject strong signals outside the AM or FM band**

T7B03
Which of the following can cause radio frequency interference?

A. Fundamental overload
B. Harmonics
C. Spurious emissions
D. All of these choices are correct

T7B04
Which of the following is a way to reduce or eliminate interference from an amateur transmitter to a nearby telephone? **Put an RF filter on the telephone**

T7B05
How can overload of a non-amateur radio or TV receiver by an amateur signal be reduced or eliminated? **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? **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 to a VHF transceiver from a nearby FM broadcast station? **Band-reject filter**

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

A. Work with your neighbor to identify the offending device
B. Politely inform your neighbor about the rules that prohibit the use of devices that cause interference
C. Check your station and make sure it meets the standards of good amateur practice
D. All of these choices are correct

T7B09
What is a Part 15 device? **An unlicensed device that may emit low-powered radio signals on frequencies used by a licensed service**

This device complies with part 15 of the FCC Rule. Operation is subject to the following two conditions; (1) this device may not cause harmful interference, and (2) this device must accept any interreference received including interference that may cause undesired operation

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

A. Your transmitter is slightly off frequency
B. Your batteries are running low
C. You are in a bad location
D. All of these choices are correct

T7B11
What is a symptom of RF feedback in a transmitter or transceiver? **Reports of garbled, distorted, or unintelligible voice transmissions**

T7B12
What should be the first step to resolve cable TV interference from your ham radio transmission? **Be sure all TV coaxial connectors are installed properly**
Properly includes making sure all coaxial connections are tight

T7C – Antenna measurements and troubleshooting: measuring SWR; dummy loads; coaxial cables; causes of feed line failures

T7C01
What is the primary purpose of a dummy load? **To prevent transmitting signals over the air when making tests**

T7C02
Which of the following instruments can be used to determine if an antenna is resonant at the desired operating frequency? **An antenna analyzer**


T7C03
What, in general terms, is standing wave ratio (SWR)? **A measure of how well a load is matched to a transmission line**

T7C04
What reading on an SWR meter indicates a perfect impedance match between the antenna and the feed line? **1 to 1**
The load (antenna) Impedance matches the source (transmitter) impedance
T7C05
Why do most solid-state amateur radio transmitters reduce output power as SWR increases?
To protect the output amplifier transistors

T7C06
What does an SWR reading of 4:1 indicate? **Impedance mismatch**
In a 50-ohm system the load is 200 ohms or 12.5 ohms

T7C07
What happens to power lost in a feed line? **It is converted into heat**

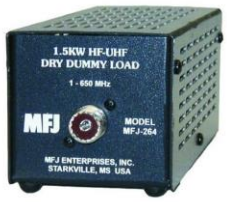
T7C08
What instrument other than an SWR meter could you use to determine if a feed line and antenna are properly matched? **Directional wattmeter**


T7C09
Which of the following is the most common cause for failure of coaxial cables? **Moisture contamination**

T7C10
Why should the outer jacket of coaxial cable be resistant to ultraviolet light? **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? **It requires special techniques to prevent water absorption**

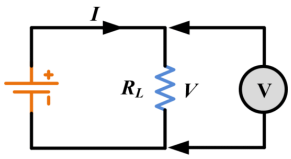
T7C12
What does a dummy load consist of? **A non-inductive resistor and a heat sink**



T7D – Basic repair and testing: soldering; using basic test instruments; connecting a voltmeter, ammeter, or ohmmeter

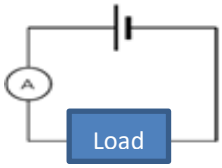
T7D01
Which instrument would you use to measure electric potential or electromotive force?
A voltmeter

T7D02
What is the correct way to connect a voltmeter to a circuit? **In parallel with the circuit**



T7D03

How is a simple ammeter connected to a circuit? **In series with the circuit**



T7D04

Which instrument is used to measure electric current? **An ammeter**

T7D05

What instrument is used to measure resistance? **An ohmmeter**

T7D06

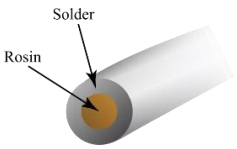
Which of the following might damage a multimeter? **Attempting to measure voltage when using the resistance setting**

T7D07

Which of the following measurements are commonly made using a multimeter?
Voltage and resistance

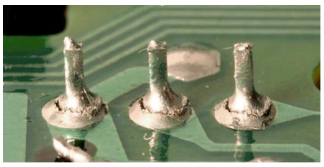
T7D08

Which of the following types of solder is best for radio and electronic use? **Rosin-core solder**



Using acid core solder will cause the connection to eventually corrode and fail

T7D09
What is the characteristic appearance of a cold solder joint? **A grainy or dull surface**



T7D10
What is probably happening when an ohmmeter, connected across an unpowered circuit, initially indicates a low resistance and then shows increasing resistance with time?
The circuit contains a large capacitor

T7D11
Which of the following precautions should be taken when measuring circuit resistance with an ohmmeter? **Ensure that the circuit is not powered**
You should also insure that any large capacitors in the circuit are discharged.

T7D12
Which of the following precautions should be taken when measuring high voltages with a voltmeter? **Ensure that the voltmeter and leads are rated for use at the voltages to be measured**

SUBELEMENT T8 – Modulation modes: amateur satellite operation; operating activities; non-voice and digital communications

[4 Exam Questions - 4 Groups]

T8A – Modulation modes: bandwidth of various signals; choice of emission type

T8A01
Which of the following is a form of amplitude modulation? **Single sideband**

T8A02
What type of modulation is most commonly used for VHF packet radio transmissions? **FM**

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

T8A04
Which type of modulation is most commonly used for VHF and UHF voice repeaters? **FM**

T8A05
Which of the following types of emission has the narrowest bandwidth? **CW**

T8A06
Which sideband is normally used for 10-meter HF, VHF, and UHF single-sideband communications? **Upper sideband**
By general agreement upper sideband is used for any frequency above 10 MHz and Lower sideband is used for frequencies below 10 MHz (except 60 meters which is Upper Sideband)

T8A07
What is an advantage of single sideband (SSB) over FM for voice transmissions?
SSB signals have narrower bandwidth

T8A08
What is the approximate bandwidth of a single sideband (SSB) voice signal? **3 kHz**

T8A09
What is the approximate bandwidth of a VHF repeater FM phone signal? **Between 10 and 15 kHz**

T8A10
What is the typical bandwidth of analog fast-scan TV transmissions on the 70-centimeter band?
About 6 MHz

T8A11
What is the approximate maximum bandwidth required to transmit a CW signal? **150 Hz**

T8B - Amateur satellite operation; Doppler shift; basic orbits; operating protocols; transmitter power considerations; telemetry and telecommand; satellite tracking

T8B01
What telemetry information is typically transmitted by satellite beacons? **Health and status of the satellite**

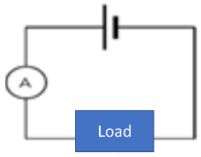
T8B02
What is the impact of using too much effective radiated power on a satellite uplink?
Blocking access by other users

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

A. Maps showing the real-time position of the satellite track over the 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 used for satellite beacons?

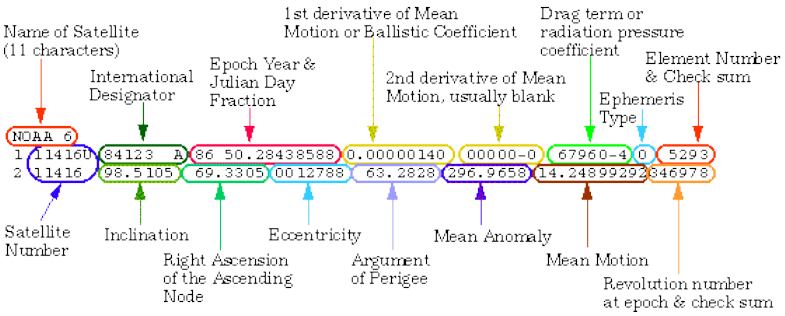
A. RTTY
B. CW
C. Packet
D. All Cof these choices are correct



T8B05
What is a satellite beacon? **A transmission from a satellite that contains status information**

T8B06

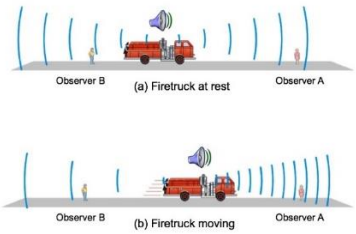
Which of the following are inputs to a satellite tracking program? **The Keplerian elements**



T8B07

With regard to satellite communications, what is Doppler shift? **An observed change in signal frequency caused by relative motion between the satellite and the earth station**

If you are standing in a fixed location and a fire truck with a siren is stationary the frequency of the siren will be the same whether it is in front or behind you. If the fire truck is moving towards you the siren frequency will be higher as it approaches you and lower as it moves away from you.



T8B08

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

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? **Rotation of the satellite and its antennas**

T8B10

What do the initials LEO tell you about an amateur satellite? **The satellite is in a Low Earth Orbit**

A low Earth orbit (LEO) is an orbit around Earth with an altitude of 2,000 kilometers (1,200 mi) or less, and an orbital period of between about 84 and 127 minutes. Objects below approximately 160 kilometers (99 mi) will experience very rapid orbital decay and altitude loss due to atmospheric drag.

T8B11

Who may receive telemetry from a space station? **Anyone who can receive the telemetry signal**

T8B12

Which of the following is a good way to judge whether your uplink power is neither too low nor too high? **Your signal strength on the downlink should be about the same as the beacon**

T8C – Operating activities: radio direction finding; radio control; contests; linking over the internet; grid locators

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

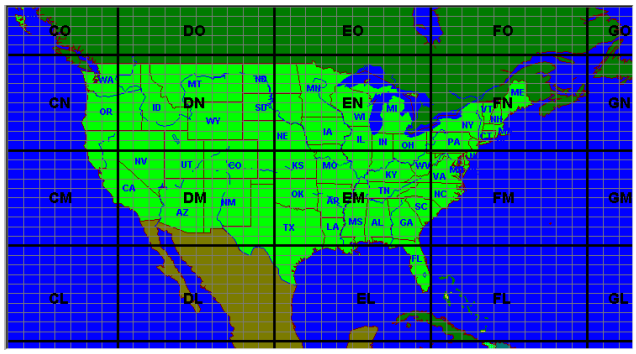
T8C02
Which of these items would be useful for a hidden transmitter hunt? **A directional antenna**

T8C03
What operating activity involves contacting as many stations as possible during a specified period? **Contesting**

T8C04
Which of the following is good procedure when contacting another station in a radio contest?
Send only the minimum information needed for proper identification and the contest exchange

T8C05
What is a grid locator? **A letter-number designator assigned to a geographic location**

For VHF and higher frequencies in contests you send your Grid Square letter and number as your location. Spokane WA is in grid square DN17



T8C06
How is access to some IRLP nodes accomplished? **By using DTMF signals**

T8C07
What is meant by Voice Over Internet Protocol (VoIP) as used in amateur radio?
A method of delivering voice communications over the internet using digital techniques

T8C08
What is the Internet Radio Linking Project (IRLP)? **A technique to connect amateur radio systems, such as repeaters, via the internet using Voice Over Internet Protocol (VOIP)**

T8C09
How might you obtain a list of active nodes that use VoIP?

A. By subscribing to an on-line service
B. From on line repeater lists maintained by the local repeater frequency coordinator
C. From a repeater directory
D. All of these choices are correct

T8C10
What must be done before you may use the Echolink system to communicate using a repeater?
You must register your call sign and provide proof of license

T8C11
What name is given to an amateur radio station that is used to connect other amateur stations to the internet? **A gateway**

T8D – Non-voice and digital communications: image signals; digital modes; CW; packet radio; PSK31; APRS; error detection and correction; NTSC; amateur radio networking; Digital Mobile/Migration Radio

T8D01
Which of the following is a digital communications mode?

A. Packet radio
B. IEEE 802.11
C. JT65
D. All of these choices are correct

T8D02
What does the term “APRS” mean? **Automatic Packet Reporting System**

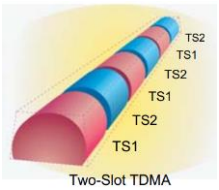
T8D03
Which of the following devices is used to provide data to the transmitter when sending automatic position reports from a mobile amateur radio station?
A Global Positioning System receiver

T8D04
What type of transmission is indicated by the term "NTSC?" **An analog fast scan color TV signal**
NTSC is National Television standards Committee (the old analog TV format before we went Digital transmission)

T8D05
Which of the following is an application of APRS (Automatic Packet Reporting System)?
Providing real-time tactical digital communications in conjunction with a map showing the locations of stations

T8D06
What does the abbreviation "PSK" mean? **Phase Shift Keying**

T8D07
Which of the following best describes DMR (Digital Mobile Radio or Digital Migration Radio)?
A technique for time-multiplexing two digital voice signals on a single 12.5 kHz repeater channel.
DMR is a modulation format that digitizes your voice. The digital signal is then transmitted with another channel, using time division multiplexing.



Two-Slot TDMA

T8D08
Which of the following may be included in packet transmissions?

A. A check sum that permits error detection
B. A header that contains the call sign of the station to which the information is being sent
C. Automatic repeat request in case of error
D. All of these choices are correct

T8D09
What code is used when sending CW in the amateur bands? **International Morse**

T8D10
Which of the following operating activities is supported by digital mode software in the WSJT suite?

A. Moonbounce or Earth-Moon-Earth
B. Weak-signal propagation beacons
C. Meteor scatter
D. All of these choices are correct

T8D11
What is an ARQ transmission system? **A digital scheme whereby the receiving station detects errors and sends a request to the sending station to retransmit the information**

T8D12
Which of the following best describes Broadband-Hamnet(TM), also referred to as a high-speed multi-media network? **An amateur-radio-based data network using commercial Wi-Fi gear with modified firmware**

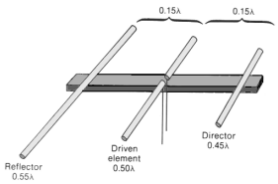
T8D13
What is FT8? **A digital mode capable of operating in low signal-to-noise conditions that transmits on 15-second intervals**

T8D14
What is an electronic keyer? **A device that assists in manual sending of Morse code**

SUBELEMENT T9 – Antennas and feed lines
[2 Exam Questions - 2 Groups]

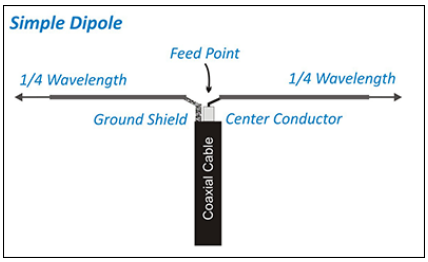
T9A – Antennas: vertical and horizontal polarization; concept of gain; common portable and mobile antennas; relationships between resonant length and frequency; concept of dipole antennas

T9A01
What is a beam antenna? **An antenna that concentrates signals in one direction**



T9A02
Which of the following describes a type of antenna loading? **Inserting an inductor in the radiating portion of the antenna to make it electrically longer**

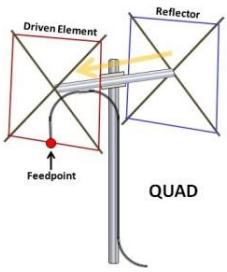
T9A03
Which of the following describes a simple dipole oriented parallel to the Earth's surface?
A horizontally polarized antenna



T9A04
What is a disadvantage of the “rubber duck” antenna supplied with most handheld radio transceivers when compared to a full-sized quarter-wave antenna?
It does not transmit or receive as effectively

T9A05
How would you change a dipole antenna to make it resonant on a higher frequency?
Shorten it

T9A06
What type of antennas are the quad, Yagi, and dish? **Directional antennas**



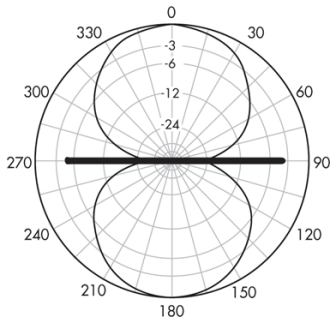
T9A07
What is a disadvantage of using a handheld VHF transceiver, with its integral antenna, inside a vehicle? **Signals might not propagate well due to the shielding effect of the vehicle**

T9A08
What is the approximate length, in inches, of a quarter-wavelength vertical antenna for 146 MHz? **19**

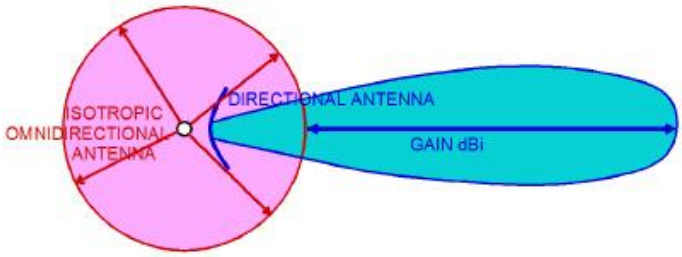
WL= ((300 ÷ 146) ÷ 4) or (2.05÷4) or .5134 meters or 51.34 cm
Divide cm by 2.54 to get inches or 51.34 ÷ 2.54 or 20.2 Inches, the closest answer is 19 inches
Directly in inches:
¼ WL= ((492 ÷ 146) ÷2) or 3.36÷2 or 1.684 FT or in inches 1.684 FT x 12 or 20.21 inches.
19 is the closest answer show in the choices.

T9A09
What is the approximate length, in inches, of a half-wavelength 6-meter dipole antenna? **112**
½ WL= (496 ÷ 50) or 9.920 FT or in inches 9.920 x 12 or 119 inches. 112 is the closest answer

T9A10
In which direction does a half-wave dipole antenna radiate the strongest signal? **Broadside to the antenna**



T9A11
What is the gain of an antenna? **The increase in signal strength in a specified direction compared to a reference antenna**



T9A12
What is an advantage of using a properly mounted 5/8 wavelength antenna for VHF or UHF mobile service? **It has a lower radiation angle and more gain than a 1/4 wavelength antenna**

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

T9B01
Why is it important to have low SWR when using coaxial cable feed line? **To reduce signal loss**

T9B02
What is the impedance of most coaxial cables used in amateur radio installations? **50 ohms**

T9B03
Why is coaxial cable the most common feed line selected for amateur radio antenna systems?
It is easy to use and requires few special installation considerations

T9B04
What is the major function of an antenna tuner (antenna coupler)?
It matches the antenna system impedance to the transceiver's output impedance

T9B05
In general, what happens as the frequency of a signal passing through coaxial cable is increased?
The loss increases

T9B06
Which of the following connectors is most suitable for frequencies above 400 MHz?
A Type N connector

T9B07
Which of the following is true of PL-259 type coax connectors? **They are commonly used at HF frequencies**

PL259

This is a SO239 that mates with the PL259

T9B08
Why should coax connectors exposed to the weather be sealed against water intrusion?
To prevent an increase in feed line loss

T9B09
What can cause erratic changes in SWR readings? **A loose connection in an antenna or a feed line**

T9B10
What is the electrical difference between RG-58 and RG-8 coaxial cable?
RG-8 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?
Air-insulated hard line

SUBELEMENT T0 – Electrical safety: AC and DC power circuits; antenna installation; RF hazards
[3 Exam Questions - 3 Groups]

T0A – Power circuits and hazards: hazardous voltages; fuses and circuit breakers; grounding; lightning protection; battery safety; electrical code compliance

T0A01
Which of the following is a safety hazard of a 12-volt storage battery?
Shorting the terminals can cause burns, fire, or an explosion

T0A02
What health hazard is presented by electrical current flowing through the body?
A. It may cause injury by heating tissue
B. It may disrupt the electrical functions of cells
C. It may cause involuntary muscle contractions
D. All of these choices are correct

T0A03
In the United States, what is connected to the green wire in a three-wire electrical AC plug?
Equipment ground

T0A04
What is the purpose of a fuse in an electrical circuit? **To interrupt power in case of overload**

T0A05
Why is it unwise to install a 20-ampere fuse in the place of a 5-ampere fuse?
Excessive current could cause a fire

T0A06
What is a good way to guard against electrical shock at your station?
A. Use three-wire cords and plugs for all AC powered equipment
B. Connect all AC powered station equipment to a common safety ground
C. Use a circuit protected by a ground-fault interrupter
D. All of these choices are correct

T0A07
Which of these precautions should be taken when installing devices for lightning protection in a coaxial cable feed line? **Mount all of the protectors on a metal plate that is in turn connected to an external ground rod**

T0A08
What safety equipment should always be included in home-built equipment that is powered from 120V AC power circuits? **A fuse or circuit breaker in series with the AC hot conductor**

T0A09
What should be done to all external ground rods or earth connections?
Bond them together with heavy wire or conductive strap

T0A10
What can happen if a lead-acid storage battery is charged or discharged too quickly?
The battery could overheat, give off flammable gas, or explode

T0A11
What kind of hazard might exist in a power supply when it is turned off and disconnected?
You might receive an electric shock from the charge stored in large capacitors

T0B – Antenna safety: tower safety and grounding; erecting an antenna support; safely installing an antenna

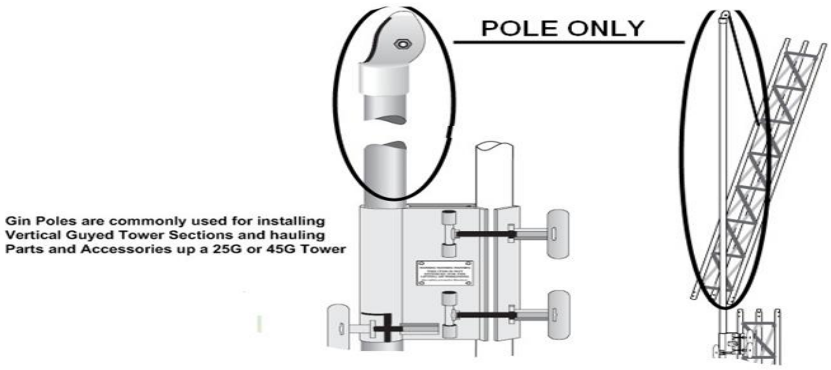
T0B01
When should members of a tower work team wear a hard hat and safety glasses?
At all times when any work is being done on the tower

T0B02
What is a good precaution to observe before climbing an antenna tower?
Put on a carefully inspected climbing harness (fall arrester) and safety glasses

T0B03
Under what circumstances is it safe to climb a tower without a helper or observer? **Never**

T0B04
Which of the following is an important safety precaution to observe when putting up an antenna tower? **Look for and stay clear of any overhead electrical wires**

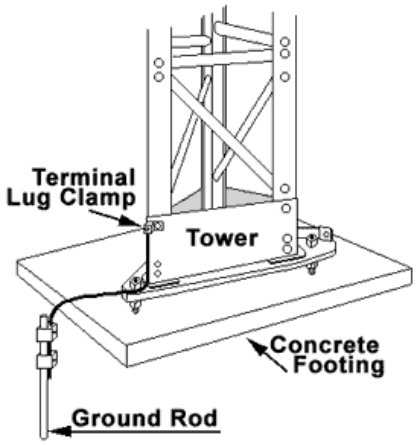
T0B05
What is the purpose of a gin pole? **To lift tower sections or antennas**



T0B06
What is the minimum safe distance from a power line to allow when installing an antenna?
Enough so that if the antenna falls unexpectedly, no part of it can come closer than 10 feet to the power wires

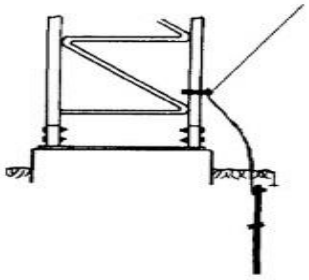
T0B07
Which of the following is an important safety rule to remember when using a crank-up tower?
This type of tower must not be climbed unless retracted or mechanical safety locking devices have been installed

T0B08
What is considered to be a proper grounding method for a tower?
Separate eight-foot long 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?
The antenna could contact high-voltage power lines
And in addition, it is illegal to attach an antenna to a utility pole. The utility company may come out and remove your antenna and send you a bill for the service.

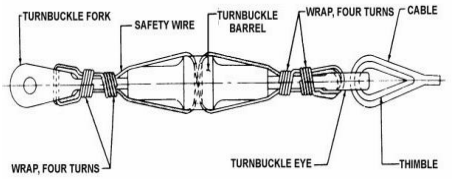
T0B10
Which of the following is true when installing grounding conductors used for lightning protection? **Sharp bends must be avoided**



T0B11
Which of the following establishes grounding requirements for an amateur radio tower or antenna? **Local electrical codes**

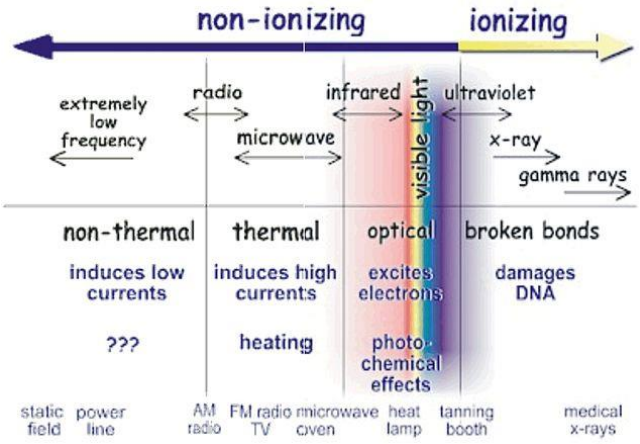
T0B12
Which of the following is good practice when installing ground wires on a tower for lightning protection? **Ensure that connections are short and direct**

T0B13
What is the purpose of a safety wire through a turnbuckle used to tension guy lines?
Prevent loosening of the guy line from vibration



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

T0C01
What type of radiation are VHF and UHF radio signals? **Non-ionizing radiation**



T0C02
Which of the following frequencies has the lowest value for Maximum Permissible Exposure limit? **50 MHz**
See table on page 78

T0C03
What is the maximum power level that an amateur radio station may use at VHF frequencies before an RF exposure evaluation is required? **50 watts PEP at the antenna**
See table on page 78

T0C04
What factors affect the RF exposure of people near an amateur station antenna?

A. Frequency and power level of the RF field
B. Distance from the antenna to a person
C. Radiation pattern of the antenna
D. All of these choices are correct

T0C05
Why do exposure limits vary with frequency?
The human body absorbs more RF energy at some frequencies than at others

T0C06
Which of the following is an acceptable method to determine that your station complies with FCC RF exposure regulations?

A. By calculation based on FCC OET Bulletin 65
B. By calculation based on computer modeling
C. By measurement of field strength using calibrated equipment
D. All of these choices are correct

T0C07
What could happen if a person accidentally touched your antenna while you were transmitting?
They might receive a painful RF burn

T0C08
Which of the following actions might amateur operators take to prevent exposure to RF radiation in excess of FCC-supplied limits? **Relocate antennas**

T0C09
How can you make sure your station stays in compliance with RF safety regulations?
By re-evaluating the station whenever an item of equipment is changed

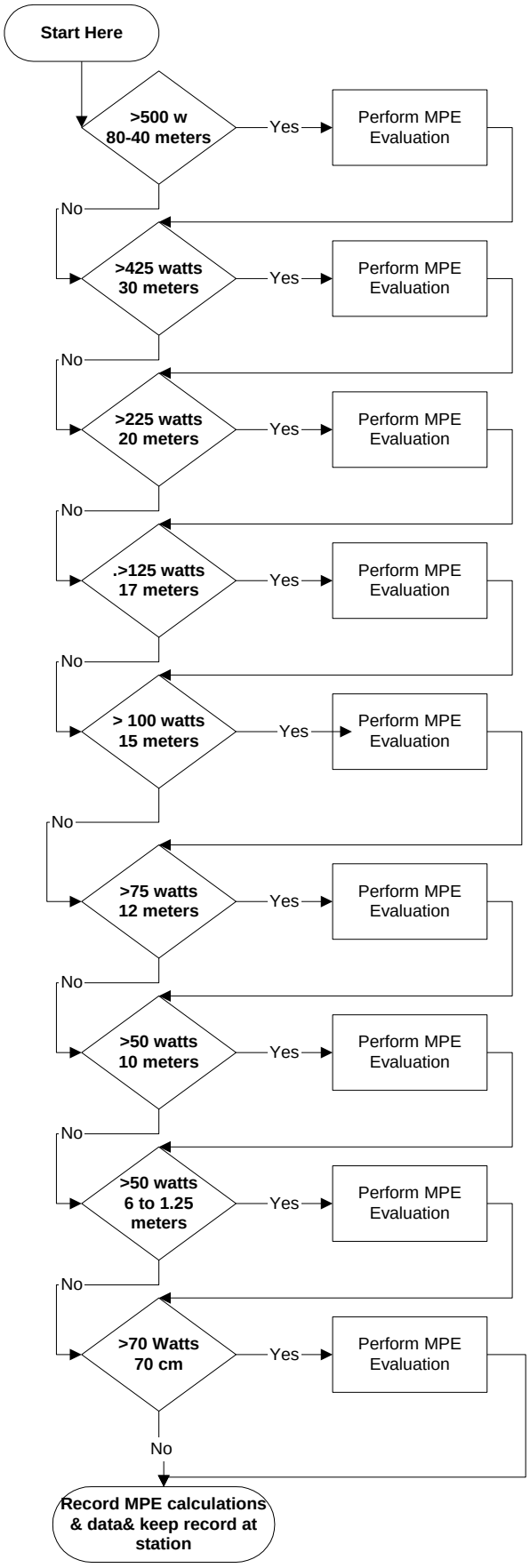
T0C10
Why is duty cycle one of the factors used to determine safe RF radiation exposure levels?
It affects the average exposure of people to radiation

T0C11
What is the definition of duty cycle during the averaging time for RF exposure?
The percentage of time that a transmitter is transmitting

T0C12
How does RF radiation differ from ionizing radiation (radioactivity)?
RF radiation does not have sufficient energy to cause genetic damage

T0C13
If the averaging time for exposure is 6 minutes, how much power density is permitted if the signal is present for 3 minutes and absent for 3 minutes rather than being present for the entire 6 minutes? **2 times as much**

MPE Exposure evaluation decision tree



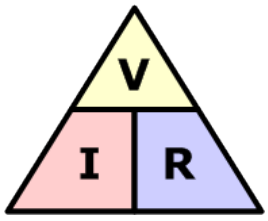
Note- Decision for running MPE at any specific frequency is determined by the ERP which is the transmiter output power plus antenna gain minus any feed line losses, filter or other losses

Example: The ERP for a 200 watt transmitter on 80 meters with an antenna gain of 9dB, feedline loss of 1.5 db and a band pass filter wit a loss of 1.5 dB would hava an ERP of 800 watts and would requires an MPE evaluation

MPE = 200 watts +9dB -1.5 dB -1.5 dB or 200 watts with + 6db of gain. #db would be 2 times the power and an additional 3db to make 6 db would be times 2 again for a total of times 4. Withe the 200 watt input the ERP would be 4 x 200 or 800 watts. An MPE evaluation would be required

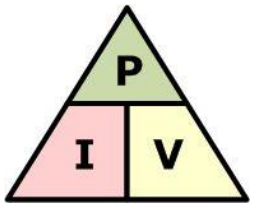
Appendix

Ohms Law Triangle



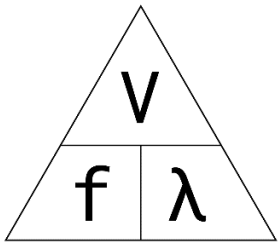
Ohms Law Triangle

V = Voltage in Volts
I = Current in Amperes
R= Resistance in Ohms



Power Law Triangle

V = Voltage in Volts
I = Current in Amperes
P = Power in Watts



Wavelength Triangle

V = Velocity of Light (300,000,000 meters per second)
f = Frequency in Hz
λ= Wavelength in Meters

To solve for a frequency in Mega Hertz (MHz) substitute 300 for the velocity of light. For example:

The wavelength for 146 MHz is 300 ÷ 146 or 2.055 Meter

Greek alphabet used in electronics

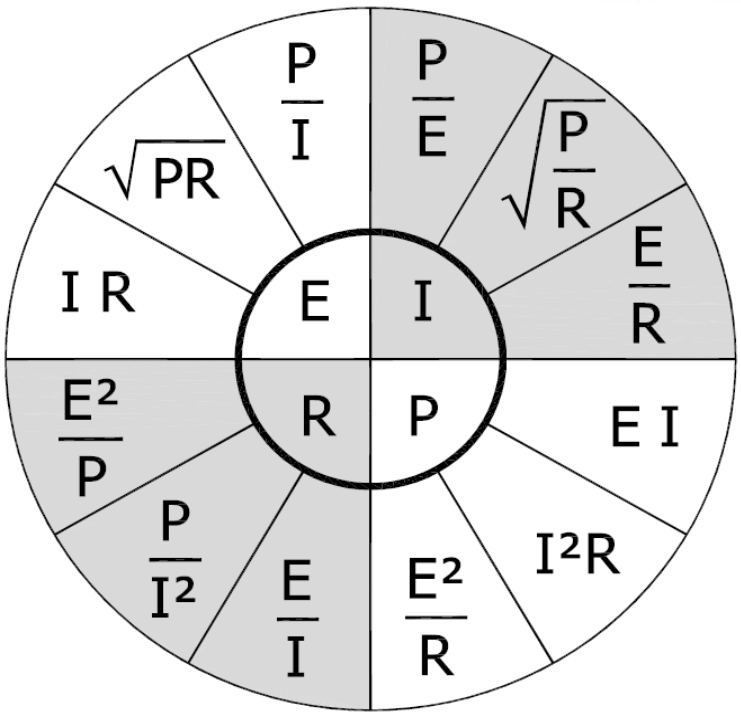
Α α	alpha	Ν ν	nu
Β β	beta	Ξ ξ	ksi
Γ γ	gamma	Ο ο	omicron
Δ δ	delta	Π π	pi
Ε ε	epsilon	Ρ ρ	rho
Ζ ζ	zeta	Σ σς	sigma
Η η	eta	Τ τ	tau
Θ θ	theta	Υ υ	upsilon
Ι ι	iota	Φ φ	phi
Κ κ	kappa	Χ χ	chi
Λ λ	lambda	Ψ ψ	psi
Μ μ	mu	Ω ω	omega

s

International System of Metric Units

Prefix	Symbol	————Multiplication Factor———	
exe	E	10+18	1,000,000 000,000,000,000
peta	P	10+15	1,000 000,000,000,000
tera	T	10+12	1,000,000,000,000
giga	G	10+9	1,000,000,000
mega	M	10+6	1,000,000
kilo	k	10+3	1,000
hecto	h	10+2	100
deca	da	10+1	10
(unit)		10+0	1
deci	d	10-1	0.1
centi	c	10-2	0.01
milli	m	10-3	0.001
micro	μ	10-6	0.000001
nano	n	10-9	0.000000001
pico	p	10-12	0.000000000001
femto	f	10-15	0.000000000000001
atto	a	10-18	0.000000000000000001

Ohms Law Circle



Units are E in Volts, R in Ohms, I in amperes, P in watts

Scientific Notation to component values

Milli	m= .001 or	1x 10^-3
Micro	µ = .000,001 or	1x 10^-6
Nano	n= .000,000,001 or	1 x 10^-9
Pico	p= .000,000,000,001 or	1 x 10^-12
Fempto	f= .000,000,000,000,001 or	1 x 10^-15

Series connected Resistors

$R = R1 + R2 + R3 + \ldots\ldots\ldots Rx$

Parallel connected Resistors

$$R = \frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \frac{1}{Rx}}$$

Series inductors

Total Inductance = $L1 + L2 + L3 + Lx$

Parallel inductors

Parallel Inductances

$$L_{total} = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \ldots \frac{1}{L_n}}$$

Capacitors in parallel

$C = C1 + C2 + C3 + \ldots\ldots\ldots\ldots Cx$

Capacitors in series

Series Capacitances

$$C_{total} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \ldots \frac{1}{C_n}}$$

Effective Radiated Power

Let's take an example with the following characteristics:

Power output from radio = **50 watts**
Feed line loss = **- 4 dB**
Duplexer loss = **-2 dB**
Circulator loss = **- 1 dB**
Antenna Gain = **+ 4 dB**

We calculate the overall ERP as follows:

ERP=Transmitter Power Out = +((-4) +(-2) +(- 1) +(+4)) or 50 - 3 dB or 25 watts

Transmitter Power Measurements

The PEP power output for a transmitter with an observed 30-volt peak envelope voltage (as seen on an oscilloscope) would be 9 watts. To determent the PEP power we take the peak voltage and multiply it by .707 to get the Peak RMS voltage then using the Peak RMS voltage we calculate power using the equation $P_{(watts)} = V_{(RMS)}^2 / R_{(load)}$

PEP (watts) = [$V_{(peak)}$ x .707] ² / Load Resistance

PEP (watts) = [$V_{(peak)}$ x .707] ² / 50 = $(21.2)^2$/ 50 = 449 / 50 = 9

Amplifier efficiency
Amplifier efficiency is the ratio of power divided by power input times 100%.

Efficiency = $P_{(out)}$ / $P_{(input)}$ x 100

A typical 1500-Watt PEP class B amplifier will require 2500 watts of DC input power (assume 60% efficiency). A typical class A amplifier will be typically 25 to 35% efficient.

$P_{(input)} = P_{(output)}$ / Efficiently = 1500 Watts/.60 = 2500Watts

Common Q signals

QRB	***How far are you from my station?***
QRK	***What is the readability of my signal?***
QRL	***Are you busy? / Is this frequency in use?***
QRM	***Are you being interfered with?***
QRP	***Shall I decrease power?***
QRV	***Are you ready?***
QTH	***What is your location?***
QTR	***What is the correct time?***
QSK	***Full break in telegraphy***
QRQ	***Send Faster***
QRS	***Send slower***
QRV	***I am ready to receive***
QRZ	***Who is calling me?***
QSL	***Can you acknowledge receipt?***
QSY	***Shall I change to another frequency?***

A complete list of Q signals can be found at
http://bclingan.org/mainpage_000012.htm

The Phonetic Alphabet