

Amateur Radio Technician Class License Study Guide

(For use July 1, 2022 to June 30, 2026)

Compliments of:

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Study Guide is based upon the FCC Exam Element 2 Question Pool for Technician Class, effective 7/01/2022-6/30/2026 with added and revised material.

Foreword

This document is based upon the publicly available question pool. Specific references to Part 97 are retained throughout. The format intent is to retain as much of the original words from the question pool as possible to leverage familiarization in the learning and memory process. It is designed to pair with an aligned set of PowerPoint Presentations for course instruction.

The 30 most frequently used phrases and terms used in the text are:

amateur	current	radio service
amateur radio	electrical	radio wave
amateur stations	FCC	repeater
antenna	FCC rules	signals
band	feed line	signal strength
call sign	frequency	station
circuit	license	station license
communication	operator	station licensee
control	power	VHF UHF
control operator	radio	voltage

The author's hope is that this document might be useful as a resource in studying for the Element 2, Technician Class License Amateur Radio Exam.

In order to pass the exam, you must correctly answer 26 of 35 questions. While subject to change as the question pool is adjusted, the exam is constructed from the sections of the Question Pool in manner consistent with the following table:

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SUBELEMENT T1 - FCC RULES - [6 Exam Questions - 6 Groups]**T1A - Amateur Radio Service****Purpose and permissible use of the Amateur Radio Service**

- Advancing skills in the technical and communication phases of the radio art is a part of the Basis and Purpose of the Amateur Radio Service. [97.1]
- The FCC is the agency that regulates and enforces the rules for the Amateur Radio Service in the United States. [97.1]

Operator/primary station license grant

- One operator/primary station license grants may be held by any one person. [97.5(b)(1)]
- Proof that the FCC has issued an operator/primary license grant is the license appears in the FCC ULS database. [97.7]

Meanings of basic terms used in FCC rules

- The FCC Part 97 definition of a beacon is an amateur station transmitting communications for the purposes of observing propagation or related experimental activities. [97.3(a)(9)]
- The FCC Part 97 definition of a space station an amateur station located more than 50 km above Earth's surface. [97.3(a)(41)]

Radio Amateur Civil Emergency Service (RACES) rules

- The Radio Amateur Civil Emergency Service (RACES) is:
 - A radio service using amateur frequencies for emergency management or civil defense communications
 - A radio service using amateur stations for emergency management or civil defense communications
 - An emergency service using amateur operators certified by a civil defense organization as being enrolled in that organization(All these choices are correct)

Interference

- At no time is willful interference to other amateur radio stations permitted. [97.101 (d)]

Phonetics

- The FCC rules state the use of a phonetic alphabet for station identification in the Amateur Radio Service is encouraged. [97.119(b)(2)]

Frequency Coordinator

- Volunteer Frequency Coordinator recognized by local amateurs recommends transmit/receive channels and other parameters for auxiliary and repeater stations. [97.3(a) (22)]
- Amateur operators in a local or regional area whose stations are eligible to be repeater or auxiliary stations select a Frequency Coordinator. [97.3(a) (22)]

T1B - Frequency allocations

Frequency Allocations & Emission modes

- Technician class operator have phone privileges only on the 10-meter HF band. [97.301(e), 97.305]
- The frequency range, 28.300 MHz to 28.500 MHz, are available for phone operation by Technician licensees. [97.301 (e)]
- In at least some segment of all these bands SSB phone may be used in amateur bands above 50 MHz. [97.305(c)]
- The frequency, 52.525 MHz, is in the 6-meter amateur band. [97.301(a)]
- The two (2) meters band includes 146.52 MHz. [97.301(a)]
- Amateurs may only use fixed digital message forwarding systems on the 219 to 220 MHz segment of 1.25-meter band. [97.305(c)]
- The 50.0 MHz to 50.1 MHz and 144.0 MHz to 144.1 MHz VHF/UHF band segments are limited to CW only. [97.305(a), (c)]

Transmissions near band edges

- You should not set your transmit frequency to be exactly at the edge of an amateur band or sub-band:
 - To allow for calibration error in the transmitter frequency display
 - So that modulation sidebands do not extend beyond the band edge
 - To allow for transmitter frequency drift(All these choices are correct [97.101(a), 97.301(a-e)])

Spectrum sharing

- US amateurs are restricted in segments of bands where the Amateur Radio Service is secondary. U.S. amateurs may find non-amateur stations in those segments, and must avoid interfering with them. [97.303]

Contacting the International Space Station

- Any amateur holding a technician class or higher license may contact the International Space Station (ISS) on VHF bands. [97.301, 97.207(c)]

Power output

- The maximum peak envelope power output for Technician class operators in their HF band segments is 200 watts. [97.313]

- Except for some specific restrictions, the maximum peak envelope power output for Technician class operators using frequencies above 30 MHz is 1500 watts. [97.313(b)]

T1C - Licensing

License Classes

- New licenses currently available from the FCC are Technician, General, Amateur Extra. [97.9(a), 97.17(a)]

Sequential and vanity call sign systems

- Any licensed amateur may select a desired call sign under the vanity call sign rules. [97.19]
- KF1XXX is a valid Technician class call sign format.

Places where the Amateur Radio Service is regulated by the FCC

- An FCC-licensed amateur station may transmit from any vessel or craft located in international waters and documented or registered in the United States. [97.5(a) (2)]

Name and address on FCC license database / Maintaining mailing address

- If the FCC is unable to reach you by email, revocation of the station license or suspension of the operator license may be the result. [97.23]
- Failure to provide and maintain a correct email address with the FCC can result in revocation of the station license or suspension of the operator license. [97.23]

License Term, Renewal & Grace Period

- After passing the examination for your first amateur radio license you may transmit on the amateur radio bands as soon as your operator/station license grant appears in the FCC's license database. [97.5a]
- The normal term for an FCC-issued amateur radio license is Ten (10) years. [97.25]
- If your license has expired and is still within the allowable grace period, you may NOT continue to transmit on the amateur radio bands until the license has been renewed. [97.21(b)]
- If an amateur license expires, the grace period is two (2) years for renewal. [97.21(a) (b)]

International communications

- The types of international communications an FCC-licensed amateur radio station is permitted to make are communications incidental to the purposes of the Amateur Radio Service and remarks of a personal character. [97.117]

T1D - Authorized and prohibited transmissions

Communications with other countries

- FCC-licensed amateur radio stations are prohibited from exchanging communications with any country whose administration has notified the International Telecommunication Union (ITU) that it objects to such communications. [97.111(a)(1)]

Music

- An amateur station is authorized to transmit music using a phone emission only when incidental to an authorized retransmission of manned spacecraft communications. [97.113(a)(4), 97.113(c)]

Exchange of information with other services

- Only when such communications are directly related to the immediate safety of human life or protection of property, amateur stations may transmit information in support of broadcasting, program production, or news gathering, assuming no other means is available. [97.113(5)(b)]

Indecent language

- Transmission of language that may be considered indecent or obscene is prohibited. [97.113(a)(4)]

Compensation for operating

- The control operator of an amateur station may receive compensation for operating that station when the communication is incidental to classroom instruction at an educational institution. [97.113(a)(3)(iii)]

Retransmission of other amateur signals

- Repeater, auxiliary, or space stations are types of amateur stations that can automatically retransmit the signals of other amateur stations. [97.113(d)]

Encryption

- It is permissible to transmit messages encoded to obscure their meaning only when transmitting control commands to space stations or radio control craft. [97.211(b), 97.215(b), 97.113(a)(4)]

Sale of equipment

- Amateur radio operators may use their stations to notify other amateurs of the availability of equipment for sale or trade when selling amateur radio equipment is **not conducted on a regular basis**. [97.113(a)(3)(ii)]

Unidentified transmissions

- An amateur station may transmit without identifying on the air when transmitting signals to control model craft. [97.119(a)]

One-way transmission

- One-way transmissions by an amateur station are prohibited where it could be defined as Broadcasting. [97.113(b), 97.111(b)]
- The FCC defines 'broadcasting' for the Amateur Radio Service as transmissions intended for reception by the general public. [97.3(a)(10)]

T1E - Control operator

Privileges and Eligibility

- The class of operator license held by the control operator determines the transmitting frequency privileges of an amateur station. [97.103(b)]
- Any amateur allowed to transmit on the satellite uplink frequency may be the control operator of a station communicating through an amateur satellite or space station. [97.301, 97.207(c)]
- At no time may a Technician class licensee be the control operator of a station operating in an Amateur Extra Class band segment. [97.301]

Designating

- The station licensee must designate the station control operator. [97.103(b)]
- The FCC presumes the station licensee to be the control operator of an amateur station, unless documentation to the contrary is in the station records. [97.103(a)]

Duties

- When the control operator is not the station licensee, both the control operator and the station licensee are responsible for the proper operation of the station. [97.103(a)]

Control point location

- An amateur station's control point is the location at which the control operator function is performed. [97.3(a)(14)]

Required

- An amateur station may never transmit without a control operator. [97.7(a)]

Control types: automatic, remote

- Operating the station over the internet is an example of remote control, as defined in Part 97. [97.3(a)(39)]
- Repeater operation is an example of automatic control. [97.3(a)(6), 97.205(d)]
- The following are required for remote control operation:
 - The control operator must be at the control point
 - A control operator is required at all times
 - The control operator must indirectly manipulate the controls(All these choices are correct) [97.109(c)]

T1F - Station identification

- You are required to transmit your assigned call sign at least every 10 minutes during and at the end of a communication. [97.119(a)]
- The method of call sign identification required for a station transmitting phone signals is by sending the call sign using a CW or phone emission. [97.119(b)(2)]
- You may use the English language for identification when operating in a phone sub-band. [97.119(b)(2)]
- All of these self-assigned indicators are acceptable when using a phone transmission:
 - o KL7CC stroke W3
 - o KL7CC slant W3
 - o KL7CC slash W3(All these choices are correct) [97.119(c)]
- When using tactical call signs such as "Race Headquarters", you must identify with your FCC-assigned call sign at the end of each communication and every ten minutes during a communication. [97.119 (a)]

Club stations

- A requirement for the issuance of a club station license grant is the club must have at least four members. [97.5(b)(2)]

Repeaters

- A Repeater station is a type of amateur station that simultaneously retransmits the signal of another amateur station on a different channel or channels. [97.3(a)(40)]
- The control operator of the originating station is accountable if a repeater inadvertently retransmits communications that violate the FCC rules. [97.205(g)]

Third party communications

- Third party communication is a message from a control operator to another amateur station control operator on behalf of another person. [97.3(a)(47)]

- A non-licensed person is allowed to speak to a foreign station using a station under the control of a licensed amateur operator when the foreign station is a country with which the U.S. has a third-party agreement.
[97.115(a) (2)]

FCC inspection

- The station and its records must be available for FCC inspection at any time after written notification by the FCC of such inspection.
[97.103(c)]

SUBELEMENT T2 - OPERATING PROCEDURES - [3 Exam Questions - 3 Groups]

T2A - Station operation

Choosing an operating frequency / Band plans

- Beyond the privileges established by the FCC, a band plan is a voluntary guideline for using different modes or activities within an amateur band.

Calling frequencies

- The national calling frequency for FM simplex operations in the 2-meter band is 146.520 MHz.
- Simplex is a term that describes an amateur station that is transmitting and receiving on the same frequency.

Repeater offsets

- A "repeater offset" is the difference between a repeater's transmit and receive frequencies.
- A common repeater frequency offset in the 2-meter band is Plus or Minus 600 kHz.
- A common repeater frequency offset in the 70 cm band is Plus or Minus 5 MHz.

Calling another station

- An appropriate way to call another station on a repeater, if you know the other station's call sign is to say the station's call sign, then identify with your call sign.
- The station's call sign followed by the word "monitoring" indicates that a station is listening on a repeater and looking for a contact.
- The procedural signal "CQ" means "calling any station".
- You should respond to a station calling CQ by transmitting the other station's call sign followed by your call sign.
- Before calling CQ you should:
 - Listen first to be sure that no one else is using the frequency
 - Ask if the frequency is in use
 - Make sure you are authorized to use that frequency(All these choices are correct)

Test transmissions

- When making on-the-air test transmissions it is required that you identify the transmitting station.

T2B – VHF/UHF operating practices

FM repeater

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

Simplex

- Simplex channels are designated in the VHF/UHF band plans so stations within range of each other can communicate without tying up a repeater.

Reverse splits

- A VHF/UHF transceiver's "reverse" function is used to listen on a repeater's input frequency.

Access tones: CTCSS, DTMF

- CTCSS is a term that describes the use of a sub-audible tone transmitted along with normal voice audio to open the squelch of a receiver.
- DTMF is a type of signaling that uses pairs of audio tones.
- All of the following could be the reason you are unable to access a repeater whose output you can hear:
 - Improper transceiver offset
 - You are using the wrong CTCSS tone
 - You are using the wrong DCS code(All these choices are correct)

DMR operation

- To join a digital repeater's "talkgroup", program your radio with the group's ID or code.
- The purpose of the color code used on DMR repeater systems is to establish groups of users.

Resolving operational problems

- Talking too loudly would cause your FM transmission audio to be distorted on voice peaks.
- When two stations transmitting on the same frequency interfere with each other, the stations should negotiate continued use of the frequency.
- The purpose of a squelch function is to mute the receiver audio when a signal is not present.

Q signals

- QRM is the Q signal indicating that you are receiving interference from other stations.
- QSY is the Q signal indicating that you are changing frequency.

T2C - Public service / Emergency operations

Applicability of FCC rules

- FCC rules always apply to the operation of an amateur station.
[97.103(a)]

RACES

- Radio Amateur Civil Emergency Service (RACES) is an FCC part 97 amateur radio service for civil defense communications during national emergencies.

ARES

- The Amateur Radio Emergency Service (ARES) is a group of licensed amateurs who have voluntarily registered their qualifications and equipment for communications duty in the public service.

Net and traffic procedures

- The typical duties of a Net Control Station are to call the net to order and direct communications between stations checking in.
- The term "traffic" refers to messages exchanged by net stations in net operations.
- A standard practice when you participate in a net is unless you are reporting an emergency, transmit only when directed by the net control station.
- Information needed to track the message is contained in the preamble of a formal traffic message.
- The "check" in a radiogram header is the number of words or word equivalents in the text portion of the message.
- A characteristic of good traffic handling is passing messages exactly as received.

Operating restrictions during emergencies

- Amateur station control operators are permitted to operate outside the frequency privileges of their license class ***only in situations involving the immediate safety of human life or protection of property.***

Use of phonetics in message handling

- Spelling the words using a standard phonetic alphabet is a technique used to ensure that voice messages containing unusual words are received correctly.

SUBELEMENT T3 – RADIO WAVE PROPAGATION – [3 Exam Questions – 3 Groups]

T3A – Radio wave characteristics

How a radio signal travels

- If buildings or obstructions are blocking the direct line of sight path, when using a directional antenna, you might be able to communicate with a distant repeater by trying to find a path that reflects signals to the repeater.
- The ionosphere is a region of the atmosphere that can refract or bend HF and VHF radio waves.

Multipath & Fading

- A likely cause of irregular fading of signals propagated by the ionosphere is random combining of signals arriving via different paths.
- VHF signal strengths sometimes vary greatly when the antenna is moved only a few feet when Multipath propagation cancels or reinforces signals.
- Multi-path propagation effects data transmissions resulting in likely increase in error rates.
- The term “picket fencing” refers to a rapid flutter on mobile signals due to multipath propagation.

Polarization and Antenna orientation

- The fact that signals propagated by the ionosphere are elliptically polarized allows either vertically or horizontally polarized antennas to be used for transmission or reception.
- Horizontal antenna polarization is normally used for long-distance CW and SSB contacts on the VHF and UHF bands.
- When antennas at opposite ends of a VHF or UHF line of sight radio link are not using the same polarization the received signal strength is reduced.

Wavelength vs absorption

- Absorption is the effect of vegetation on UHF and microwave signals.
- Precipitation is a weather condition that might decrease range at microwave frequencies.
- There is little effect of fog and rain on signals in the 10 meter and 6-meter bands.

T3B – Electromagnetic wave properties

Nature of electromagnetic waves

- The two components of a radio wave are the electric and magnetic fields.
- The relationship between the electric and magnetic fields of an electromagnetic wave is they are at right angles to each other.

- The orientation of the electric field, is the property of a radio wave that defines its polarization.

Velocity of electromagnetic waves

- The velocity of a radio wave traveling through free space is the Speed of Light.
- The approximate velocity of a radio wave in free space is 300,000,000 meters per second.

Wavelength vs frequency

- In addition to frequency, the approximate wavelength in meters is used to identify amateur radio bands.

Relationship of wavelength and frequency

- The formula for converting frequency to approximate wavelength in meters is wavelength in meters equals 300 divided by frequency in megahertz.
- The relationship between wavelength and frequency is the wavelength gets shorter as frequency increases.

Electromagnetic spectrum definitions: UHF, VHF, HF

- The frequency range, 3 to 30 MHz, is referred to as HF.
- The frequency range, 30 MHz to 300 MHz, is referred to as VHF.
- The frequency range, 300 to 3000 MHz, is referred to as UHF.

T3C - Propagation modes

Sporadic E

- Sporadic E propagation is most commonly associated with occasional strong signals on the 10-, 6-, and 2-meter bands from beyond the radio horizon.

Meteor scatter

- The 6 meters band is best suited for communicating via meteor scatter.

Auroral propagation

- A characteristic of VHF signals received via auroral backscatter is distorted and signal strength varies considerably.

Tropospheric ducting

- Tropospheric ducting propagation is responsible for allowing over-the-horizon VHF and UHF communications to ranges of approximately 300 miles on a regular basis.
- Temperature inversions in the atmosphere causes tropospheric ducting.

F region skip

- Generally, the best time for long-distance 10-meter band propagation via the F region is from dawn to shortly after sunset during periods of high sunspot activity.
- The 6- and 10-meters bands may provide long-distance communications via the ionosphere's F region during the peak of the sunspot cycle.

Line of sight and radio horizon

- UHF signals are usually not propagated by the ionosphere and that's why simplex UHF signals are rarely heard beyond their radio horizon.
- A characteristic of HF communication compared with communications on VHF and higher frequencies is that long-distance ionospheric propagation is far more common on HF.
- The radio horizon for VHF and UHF signals is more distant than the visual horizon due to the atmosphere refracts radio waves slightly.

Knife-edge diffraction

- Knife-edge diffraction effects may allow radio signals to travel beyond obstructions between the transmitting and receiving stations.

SUBELEMENT T4 – AMATEUR RADIO PRACTICES – [2 Exam Questions – 2 Groups]

T4A – Station Setup & Connections

Power source

- A 13.8 volts at 12 amperes power supply rating is appropriate for a typical 50-watt output mobile FM transceiver.
- Short, heavy-gauge wires are used for a transceiver's DC power connection to minimize voltage drop when transmitting.
- You can determine the length of time that equipment can be powered from a battery by dividing the battery ampere-hour rating by the average current draw of the equipment.

Computer & Digital Equipment

- Computer "line in" to transceiver speaker connector connections are made between a computer and a transceiver to use computer software when operating digital modes.
- The transceiver audio input and output are connected to the audio input and output of a computer running WSJT-X software in a station configured to operate using FT8.
- Receive audio, transmit audio, and transmitter keying signals are used in a computer-radio interface for digital mode operation.
- The function performed with a transceiver and a digital mode hot spot is communication using digital voice or data systems via the internet.
- An electronic keyer is a device that assists in manual sending of Morse code.

SWR/Power meter

- The frequency and power level at which the measurements will be made should be considered when selecting an accessory SWR meter.
- An RF power meter should be installed in the feed line, between the transmitter and antenna.

Bonding

- Flat copper strap conductors are preferred for bonding at RF.

Mobile radio installation

- The negative power return of a mobile transceiver should be connected in a vehicle at the 12 volts battery chassis ground.

T4B – Operating controls

Frequency tuning

- The keypad or VFO knob can be used to enter a transceiver's operating frequency.

- The scanning function of an FM transceiver tunes through a range of frequencies to check for activity.
- Distortion of the signal's audio is the result of tuning an FM receiver above or below a signal's frequency.

Receiver incremental tuning (RIT)

- The RIT or Clarifier controls could be used if the voice pitch of a single-sideband signal returning your CQ call seems too high or low.

Use of filters

- The 2400 Hz receiver filter bandwidth provides the best signal-to-noise ratio for SSB reception.

Bandwidth selection

- The advantage of having multiple receive bandwidth choices on a multimode transceiver is it permits noise or interference reduction by selecting a bandwidth matching the mode.

Squelch function

- The squelch can be adjusted so that a weak FM signal can be heard by setting the squelch threshold so that receiver output audio is on all the time.

Memory channels

- To enable quick access to a favorite frequency or channel on your transceiver, store it in a memory channel.

Microphone gain

- Distorted transmitted audio is the effect of excessive microphone gain on SSB transmissions.

Digital transceiver configuration

- A DMR "code plug" contains access information for repeaters and talkgroups.
- A specific group of stations is selected on a digital voice transceiver by entering the group's identification code.
- Your call sign must be programmed into a D-STAR digital transceiver before transmitting.

SUBELEMENT T5 – ELECTRICAL PRINCIPLES – [4 Exam Questions – 4 Groups]

T5A – Current and voltage

Terminology and units

- Voltage is the electrical term for the force that causes electron flow.
- Current is the name for the flow of electrons in an electric circuit.
- Electrical current is measured in units of Amperes.
- Ohms is the unit of electrical resistance.
- Power is the term that describes the rate at which electrical energy is used.
- Electrical power is measured in units of Watts.
- Frequency is the number of times per second that an alternating current makes a complete cycle.
- Hertz is the unit of frequency.

Conductors and insulators

- Metals are generally good conductors of electricity because they have many free electrons.
- Glass is a good electrical insulator.

Alternating and direct current

- Alternating current that alternates between positive and negative directions.
- These types of current flow are opposed by resistance:
 - Direct current
 - Alternating current
 - RF current(All these choices are correct)

T5B – Math for electronics

Conversion of electrical units

- 1.5 amperes = 1500 **milliamperes**
- 3000 **milliamperes** = 3 amperes
- One **kilovolt** = One thousand volts
- One **microvolt** = One one-millionth of a volt
- 500 **milliwatts** = 0.5 watts
- 1,000,000 **pico**farads = 1 **micro**farad
- 28400 kHz = 28.400 MHz
- 1,500,000 hertz = 1500 kHz
- 3.525 MHz = 3525 kHz
- 2425 MHz = 2.425 GHz

Decibels

- A power increase from 5 watts to 10 watts is 3 dB.
- A power decrease from 12 watts to 3 watts is -6 dB.
- A power increase from 20 watts to 200 watts is 10 dB.

T5C -Terminology and units

Capacitance

- Capacitance is the ability to store energy in an electric field.
- The unit of capacitance is the farad.

Inductance

- Inductance is the ability to store energy in a magnetic field.
- The unit of inductance is the henry.

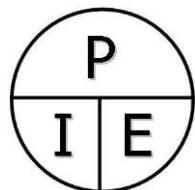
Radio frequency definition and units

- The abbreviation "RF" means radio frequency signals of all types.
- The abbreviation for megahertz is MHz.
- The abbreviation for kilohertz is kHz.

Impedance definition and units

- Impedance is the opposition to AC current flow.
- The unit of impedance is the ohm.

Calculating power



- The formula used to calculate electrical power (P) in a DC circuit is $P = E \times I$.

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

Answer: 138 watts

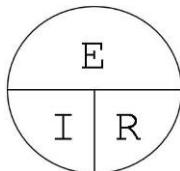
- How much power is delivered by a voltage of 12 volts DC and a current of 2.5 amperes?

Answer: 30 watts

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

Answer: 10 amperes

T5D – Ohm's Law



- The formula used to calculate voltage in a circuit is $E = I \times R$.**
- What is the voltage across a 2-ohm resistor if a current of 0.5 amperes flows through it?
Answer: 1 volt
- What is the voltage across a 10-ohm resistor if a current of 1 ampere flows through it?
Answer: 10 volts
- What is the voltage across a 10-ohm resistor if a current of 2 amperes flows through it?
Answer: 20 volts
- The formula used to calculate current in a circuit is $I = E / R$.**
- What is the current in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms?
Answer: 1.5 amperes
- What is the current through a 100-ohm resistor connected across 200 volts?
Answer: 2 amperes
- What is the current through a 24-ohm resistor connected across 240 volts?
Answer: 10 amperes
- The formula used to calculate resistance in a circuit is $R = E / I$.**
- What is the resistance of a circuit in which a current of 3 amperes flows when connected to 90 volts?
Answer: 30 ohms
- What is the resistance of a circuit for which the applied voltage is 12 volts and the current flow is 1.5 amperes?
Answer: 8 ohms
- What is the resistance of a circuit that draws 4 amperes from a 12-volt source?
Answer: 3 ohms

Series and parallel circuits

- In a Series circuit, DC current the same through all components.
- In a Parallel circuit, voltage is the same across all components.

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

T6A - Fixed and variable resistors

- A resistor opposes the flow of current in a DC circuit.
- Resistance is the electrical parameter controlled by a potentiometer.
- A Potentiometer is often used as an adjustable volume control.

Capacitors \rightarrow

- A capacitor stores energy in an electric field.
- A capacitor consists of conductive surfaces separated by an insulator.

Inductors

- An Inductor stores energy in a magnetic field.
- An Inductor is typically constructed as a coil of wire.

Fuses

A Fuse is used to protect other circuit components from current overloads.

Batteries

- Carbon-zinc battery chemistries is not rechargeable.
- The following battery chemistries are rechargeable:
 - Nickel-metal hydride
 - Lithium-ion
 - Lead-acid

(All these choices are correct)

Switches

What type of switch is represented by component 3 in figure T-2?
Answer: **Single-pole single-throw**

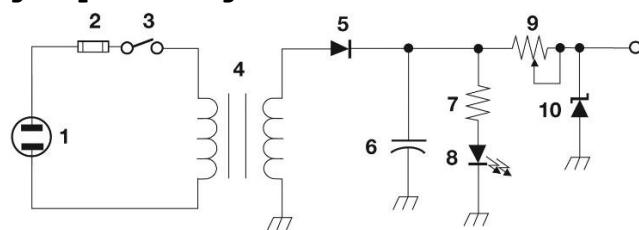


Figure T-2

- The function of a **Single Pole Double Throw (SPDT) switch** is a single circuit is switched between one of two other circuits.

T6B – Semiconductors

Basic principles and applications of solid-state devices

- Gain is the term that describes a device's ability to amplify a signal.

Diodes ➔

- A Diode allows current to flow in only one direction.
- The names for the electrodes of a diode are Anode and cathode.
- The cathode lead of a semiconductor diode is often marked on the package with a stripe.
- The forward voltage drop in a diode is lower in some diode types than in others.
- Forward DC current causes a light-emitting diode (LED) to emit light.

Transistors

- A Transistor can consist of three regions of semiconductor material.
- The names of the electrodes of a bipolar junction transistor are Emitter, base, collector.
- A Transistor can be used as an electronic switch.
- A Transistor can provide power gain.

Field Effect Transistor (FET)

- The abbreviation FET stands for Field Effect Transistor.
- A Field-effect transistor has a gate, drain, and source.

T6C – Circuit diagrams: use of schematics, basic structure

- The name of an electrical wiring diagram that uses standard component symbols is Schematic.
- Component connections are accurately represented in electrical schematics.

Schematic symbols of basic components

In Figure 1:

- Component 1: Resistor
- Component 2: Transistor
- Component 3: Lamp
- Component 4: Battery
- Component 5: Common or Chassis Ground

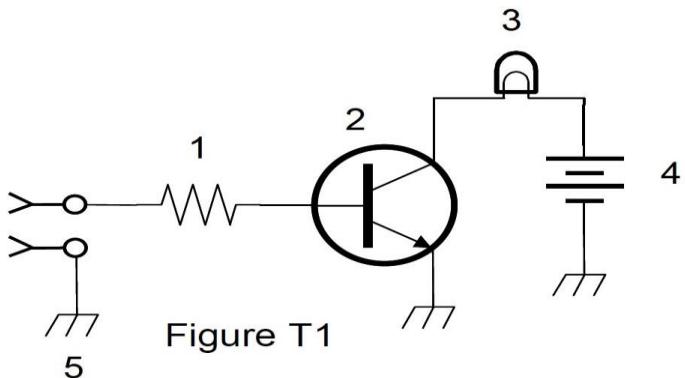


Figure T1

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

Answer: Control the flow of current

In figure 2:

- Component 1: AC Power Connector
- Component 2: Fuse
- Component 3: SPST Switch
- Component 4: Transformer
- Component 5: Diode Rectifier
- Component 6: Capacitor
- Component 7: Resistor
- Component 8: Light
- Emitting Diode (LED)
- Component 9: Variable Resistor
- Component 10: Zener Diode Voltage Regulator

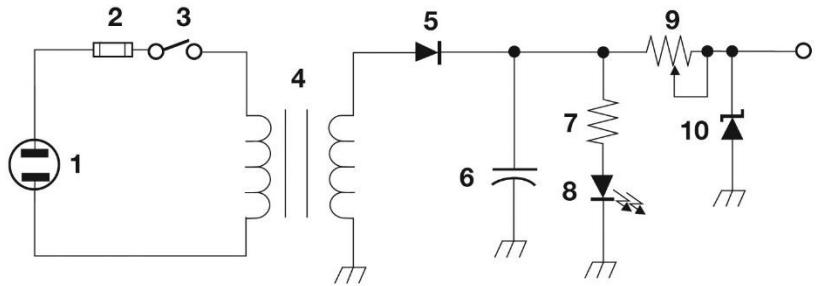


Figure T-2

In figure 3:

- Component 1: Input
- Component 2: Variable Capacitor
- Component 3: Variable Inductor
- Component 4: Antenna

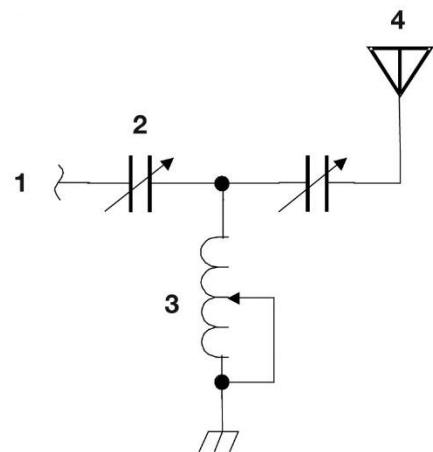


Figure T-3

T6D - Component functions

Rectifiers

- Rectifier devices or circuits change an alternating current into a varying direct current signal.

Relays

- A relay is an electrically-controlled switch.

Voltage regulators

- A regulator circuit controls the amount of voltage from a power supply.

Meters

- A Meter displays an electrical quantity as a numeric value.

Indicators

- An LED is commonly used as a visual indicator.

Integrated circuits

- An integrated circuit is the name of a device that combines several semiconductors and other components into one package.

Transformers

- A Transformer changes 120 V AC power to a lower AC voltage for other uses.

Resonant circuit

- A Capacitor is combined with an inductor to make a resonant circuit.
- An inductor and a capacitor in series or parallel forms a resonant or tuned circuit.

Shielding

- A reason to use shielded wire is to prevent coupling of unwanted signals to or from the wire.

SUBELEMENT T7 – PRACTICAL CIRCUITS – [4 Exam Questions – 4 Groups]

T7A – Station equipment

Receivers/Transceivers

- A Transceiver is a device that combines a receiver and transmitter.

Transmitter amplifiers

- An RF power amplifier device increases the transmitted output power from a transceiver.
- The function of the SSB/CW-FM switch on a VHF power amplifier is to set the amplifier for proper operation in the selected mode.

Receive amplifiers

- An RF preamplifier is installed between the antenna and receiver.

Transverters

- A Transverter device converts the RF input and output of a transceiver to another band.

Receiver Sensitivity

- Sensitivity is the term describing the ability of a receiver to detect the presence of a signal.

Receiver Selectivity

- Selectivity is the term describing the ability of a receiver to discriminate between multiple signals.

Mixers

- A Mixer is used to convert a signal from one frequency to another.

Oscillators

- An Oscillator circuit generates a signal at a specific frequency.

Push to Talk (PTT)

- A transceiver's PTT input switches transceiver from receive to transmit when grounded.

Modulation

- Modulation describes combining speech with an RF carrier signal.

T7B – Symptoms, causes, and cures of common transmitter and receiver problems

Overload and overdrive

- If you are told your FM handheld or mobile transceiver is over-deviating, talk farther away from the microphone.
- If the receiver is unable to reject strong signals outside the AM or FM band, it might cause a broadcast AM or FM radio to receive an amateur radio transmission unintentionally.
- Fundamental overload of a non-amateur radio or TV receiver by an amateur signal be reduced or eliminated by blocking the amateur signal with a filter at the antenna input of the affected receiver.
- Installing a band-reject filter can reduce overload of a VHF transceiver by a nearby commercial FM station.

Distortion

- You could use a Ferrite Choke to cure distorted audio caused by RF current on the shield of a microphone cable.
- What might be a problem if you receive a report that your audio signal through an FM repeater is distorted or unintelligible?
 - Your transmitter is slightly off frequency
 - Your batteries are running low
 - You are in a bad location(All these choices are correct)

Interference and consumer electronics

- The first step to resolve non-fiber optic cable TV interference caused by your amateur radio transmission should be ensure all TV feed line coaxial connectors are installed properly.
- 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.
- What should you do if something in a neighbor's home is causing harmful interference to your amateur station?
 - Work with your neighbor to identify the offending device
 - Politely inform your neighbor that FCC rules prohibit the use of devices that cause interference
 - Make sure your station meets the standards of good amateur practice(All these choices are correct)
- All of the following can cause radio frequency interference:
 - Fundamental overload
 - Harmonics
 - Spurious emissions(All these choices are correct)

RF feedback

- A symptom of RF feedback in a transmitter or transceiver is reports of garbled, distorted, or unintelligible voice transmissions.

T7C – Antenna and transmission line measurements and troubleshooting

Measuring SWR

- A Directional wattmeter can be used to determine SWR.
- An antenna analyzer is used to determine if an antenna is resonant at the desired operating frequency.
- A 1:1 reading on an SWR meter indicates a perfect impedance match between the antenna and the feed line.
- A SWR reading of 4:1 indicates Impedance mismatch.

Effects of high SWR

- Most solid-state transmitters reduce output power as SWR increases beyond a certain level to protect the output amplifier transistors.
- Power lost in a feed line is converted into heat.

Causes of feed line failures

- Moisture contamination causes failure of coaxial cables.
- The outer jacket of coaxial cable should be resistant to ultraviolet light because Ultraviolet light can damage the jacket and allow water to enter the cable.

Basic coaxial cable characteristics

- A disadvantage of air core coaxial cable when compared to foam or solid dielectric types is it requires special techniques to prevent moisture in the cable.

Use of dummy loads when testing

- The primary purpose of a dummy load is to prevent transmitting signals over the air when making tests.
- A dummy load consists of a non-inductive resistor mounted on a heat sink.

T7D – Using basic test instruments

Voltmeter

- You would use a voltmeter to measure electric potential.
- A voltmeter is connected in parallel to a component to measure applied voltage.
- Voltage and resistance measurements are made using a multimeter.
- Attempting to measure voltage when using the resistance setting can damage a multimeter.

Ammeter

- An ammeter is used to measure electric current.
- When configured to measure current, a multimeter is connected in series with a component.

Ohmmeter

- An ohmmeter is connected in parallel with a component to measure its resistance.
- When an ohmmeter is connected across a large, discharged capacitor, the reading indicates increasing resistance with time.
- Precautions should be taken when measuring in-circuit resistance with an ohmmeter. Ensure that the circuit is not powered.

Soldering

- Acid-core solder should not be used for radio and electronic applications.
- The characteristic appearance of a cold tin-lead solder joint is a rough or lumpy surface.

SUBELEMENT T8 - SIGNALS AND EMISSIONS - [4 Exam Questions - 4 Groups]

T8A - Basic characteristics of FM and SSB

Choice of emission type: selection of USB vs LSB, use of SSB for weak signal work, use of FM for VHF packet and repeaters

- Single sideband (SSB) is a form of amplitude modulation.
- SSB voice mode is often used for long-distance (weak signal) contacts on the VHF and UHF bands.
- Upper sideband is normally used for 10-meter HF, VHF, and UHF single-sideband communications.
- FM or PM type of modulation is commonly used for VHF packet radio transmissions.
- FM or PM type of modulation is commonly used for VHF and UHF voice repeaters.
- A disadvantage of FM compared with single sideband is only one signal can be received at a time.

Bandwidth of various modulation modes: CW, SSB, FM, fast-scan TV

- CW has the narrowest bandwidth.
- The approximate bandwidth required to transmit a CW signal is 150 Hz.
- The approximate bandwidth of a typical single sideband (SSB) voice signal is 3 kHz.
- Single sideband (SSB) signals have narrower bandwidth compared to FM.
- The approximate bandwidth of a VHF repeater FM voice signal is between 10 and 15 kHz.
- The approximate bandwidth of AM fast-scan TV transmissions is about 6 MHz.

T8B - Amateur satellite operation

Basic orbits / Definition of "LEO"

- A LEO satellite is a satellite in low earth orbit.

Doppler shift

- In reference to satellite communications, doppler shift is an observed change in signal frequency caused by relative motion between the satellite and Earth station.

Spin fading

- Rotation of the satellite and its antennas causes spin fading of satellite signals.

Modulation mode selection

- The following modes of transmission are commonly used by amateur radio satellites:
 - SSB
 - FM
 - CW/data(All these choices are correct)

Uplink and downlink mode definitions

- A satellite is operating in U/V mode when the satellite uplink is in the 70-centimeter band and the downlink is in the 2-meter band.

Transmitter power considerations

- The impact of using excessive effective radiated power on a satellite uplink is blocking access by other users.

Setting uplink power

- A way to determine whether your satellite uplink power is neither too low nor too high is your signal strength on the downlink should be about the same as the beacon.

Beacons

- A satellite beacon is a transmission from a satellite that contains status information.

Telemetry and telecommand

- Health and status of the satellite telemetry information is typically transmitted by satellite beacons.
- Anyone may receive telemetry from a space station.

Satellite tracking programs

- The Keplerian elements are inputs to a satellite tracking program.
- Satellite tracking programs provide:
 - Maps showing the real-time position of the satellite track over Earth
 - The time, azimuth, and elevation of the start, maximum altitude, and end of a pass
 - The apparent frequency of the satellite transmission, including effects of Doppler shift(All these choices are correct)

T8C – Operating activities

Radio direction finding

- Radio direction finding methods are used to locate sources of noise interference or jamming.
- A directional antenna would be useful for a hidden transmitter hunt.

Contests

- Contesting involves contacting as many stations as possible during a specified period.
- A good procedure when contacting another station in a contest is to send only the minimum information needed for proper identification and the contest exchange.

Linking over the internet

- A gateway is an amateur radio station that connects other amateur stations to the internet.
- Voice Over Internet Protocol (VoIP) is a method of delivering voice communications over the internet using digital techniques.
- The Internet Radio Linking Project (IRLP) is a technique to connect amateur radio systems, such as repeaters, via the internet using Voice Over Internet Protocol (VoIP).
- Over the air access to IRLP nodes is accomplished by using DTMF signals.

Echolink

- EchoLink enables an amateur station to transmit through a repeater without using a radio to initiate the transmission.
- Before using the EchoLink system you must register your call sign and provide proof of license.

Exchanging grid locators

- A grid locator is a letter-number designator assigned to a geographic location.

T8D – Non-voice and digital communications

- The following are digital communications modes:
 - Packet radio
 - IEEE 802.11
 - FT8(All these choices are correct)

Image signals and definition of NTSC

- An analog fast-scan color TV signal transmission is indicated by the term "NTSC".

CW

- CW is another name for a Morse code transmission.

Packet radio

- Packet radio transmissions may include:
 - A check sum that permits error detection
 - A header that contains the call sign of the station to which the information is being sent
 - Automatic repeat request in case of error(All these choices are correct)

PSK

- The abbreviation "PSK" means Phase Shift Keying.

Automatic Packet Reporting System (APRS)

- An application of APRS is providing real-time tactical digital communications in conjunction with a map showing the locations of stations.
- What kind of data can be transmitted by APRS?
 - GPS position data
 - Text messages
 - Weather data(All these choices are correct)

Error detection and correction

- ARQ transmission system is an error correction method in which the receiving station detects errors and sends a request for retransmission.

WSJT modes

- FT8 is a digital mode capable of low signal-to-noise operation.
- The following operating activities are supported by digital mode software in the WSJT-X software suite:
 - Earth-Moon-Earth
 - Weak signal propagation beacons
 - Meteor scatter(All these choices are correct)

Digital Mobile Radio (DMR)

- DMR is a technique for time-multiplexing two digital voice signals on a single 12.5 kHz repeater channel.
- A “talkgroup” on a digital repeater is a way for groups of users to share a channel at different times without hearing other users on the channel.

Amateur radio networking / Broadband-Hamnet

- An amateur radio mesh network is an amateur-radio based data network using commercial Wi-Fi equipment with modified firmware.

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

T9A – Antennas

Dipole pattern

- A half-wave dipole antenna radiates the strongest signal broadside to the antenna.

Vertical and horizontal polarization

- A simple dipole oriented parallel to Earth's surface is a horizontally polarized antenna.

Concept of antenna gain

- Antenna gain is the increase in signal strength in a specified direction compared to a reference antenna.
- An advantage of a 5/8 wavelength whip antenna for VHF or UHF mobile service is it has more gain than a $\frac{1}{4}$ -wavelength antenna.

Definition and types of beam antennas

- A beam antenna is an antenna that concentrates signals in one direction.
- A Yagi type of antenna offers the greatest gain.

Common portable and mobile antennas

- A disadvantage of the short, flexible antenna supplied with most handheld radio transceivers, compared to a full-sized quarter-wave antenna is it has low efficiency.
- A disadvantage of using a handheld VHF transceiver with a flexible antenna inside a vehicle is signal strength is reduced due to the shielding effect of the vehicle.

Relationships between resonant length and frequency

- Shortening a dipole antenna increases the resonant frequency.
- The approximate length, in inches, of a quarter-wavelength vertical antenna for 146 MHz is 19 inches.
- The approximate length, in inches, of a half-wavelength 6-meter dipole antenna is 112 inches.

Antenna loading

- Electrically lengthening by inserting inductors in radiating elements describes a type of antenna loading.

T9B – Feed lines

Types

- Coaxial cable is the most common feed line for amateur radio antenna systems because it is easy to use and requires few special installation considerations.
- The most common impedance of coaxial cables used in amateur radio is 50 ohms.

Attenuation vs frequency

- The loss increases as the frequency of a signal in coaxial cable is increased.

Selecting

- RG-213 cable has less loss at a given frequency than RG-58 coaxial cable.
- Air-insulated hardline feed line has the lowest loss at VHF and UHF.

SWR concepts

- Standing wave ratio (SWR) is a measure of how well a load is matched to a transmission line
- A benefit of low SWR is reduced signal loss.
- Loose connection in the antenna or feed line can cause erratic changes in SWR.
- The following are sources of loss in coaxial feed line:
 - Water intrusion into coaxial connectors
 - High SWR
 - Multiple connectors in the line(All these choices are correct)

Antenna tuners (couplers)

- The major function of an antenna tuner (antenna coupler) is it matches the antenna system impedance to the transceiver's output impedance.

RF Connectors: selecting, weather protection

- The Type N RF connector type is most suitable for frequencies above 400 MHz.
- PL-259 type coax connectors are commonly used at HF and VHF frequencies.

SUBELEMENT T0 – SAFETY – [3 Exam Questions – 3 Groups]

T0A – Power circuits and hazards

Hazardous voltages

- Charge stored in filter capacitors is a hazard that exists in a power supply immediately after turning it off.
- Ensure that the voltmeter and leads are rated for use at the voltages to be measured when measuring high voltages.
- Electrical current flowing through the body is a health hazard because:
 - It may cause injury by heating tissue
 - It may disrupt the electrical functions of cells
 - It may cause involuntary muscle contractions(All these choices are correct)

Fuses and circuit breakers

- The purpose of a fuse in an electrical circuit is to remove power in case of overload.
- A 5-ampere fuse should never be replaced with a 20-ampere fuse because excessive current could cause a fire.
- A fuse or circuit breaker should be installed in series with the hot conductor only in a 120V AC power circuit.

Grounding

- All external ground rods or earth connections should be bonded together with heavy wire or conductive strap.

Electrical code compliance

- In the United States, the Hot circuit is indicated by the black wire insulation in a three-wire 120 V cable.
- Good ways to guard against electrical shock at your station:
 - Use three-wire cords and plugs for all AC powered equipment
 - Connect all AC powered station equipment to a common safety ground
 - Install mechanical interlocks in high-voltage circuits(All these choices are correct)

Battery safety

- A safety hazard of a 12-volt storage battery is shorting the terminals can cause burns, fire, or an explosion.
- Overheating or out-gassing hazard is caused by charging or discharging a battery too quickly.

Lightning protection

- A lightning arrester should be installed in a coaxial feed line on a grounded panel near where feed lines enter the building.

T0B - Antenna safety

Tower safety

- It is never safe to climb a tower without a helper or observer.
- When putting up an antenna tower, look for and stay clear of any overhead electrical wires
- A crank-up tower must not be climbed unless it is retracted, or mechanical safety locking devices have been installed.
- Requirements when climbing an antenna tower:
 - Have sufficient training on safe tower climbing techniques
 - Use appropriate tie-off to the tower at all times
 - Always wear an approved climbing harness(All these choices are correct)

Tower Grounding

- When installing ground wires on a tower for lightning protection ensure that connections are short and direct.
- A proper grounding method for a tower is separate eight-foot ground rods for each tower leg, bonded to the tower and each other.
- When installing grounding conductors used for lightning protection, sharp bends must be avoided.
- Local electrical codes establish grounding requirements for an amateur radio tower or antenna.

Installing antennas

- The minimum safe distance from a power line to allow when installing an antenna is enough so that if the antenna falls, no part of it can come closer than 10 feet to the power wires.

Antenna supports

- The purpose of a safety wire through a turnbuckle used to tension guy lines is to prevent loosening of the turnbuckle from vibration.
- You should avoid attaching an antenna to a utility pole. The antenna could contact high-voltage power lines.

T0C - RF hazards

Radiation exposure / Recognized safe power levels

- Maximum permissible exposure limit has the lowest value at 50 MHz.

- The exposure limits vary with frequency because the human body absorbs more RF energy at some frequencies than at others.
- Acceptable methods to determine whether your station complies with FCC RF exposure regulations include:
 - By calculation based on FCC OET Bulletin 65
 - By calculation based on computer modeling
 - By measurement of field strength using calibrated equipment(All these choices are correct)
- You can make sure your station stays in compliance with RF safety regulations by re-evaluating the station whenever an item in the transmitter or antenna system is changed.
- The station licensee is responsible for ensuring that no person is exposed to RF energy above the FCC exposure limits.

Proximity to antennas

- These factors affect the RF exposure of people near an amateur station antenna:
 - Frequency and power level of the RF field
 - Distance from the antenna to a person
 - Radiation pattern of the antenna(All these choices are correct)
- Relocating antennas can reduce exposure to RF radiation.
- RF burn to skin hazard is created by touching an antenna during a transmission.

Radiation types

- Radio signals are non-ionizing radiation.
- RF radiation differs from ionizing radiation (radioactivity). RF radiation does not have sufficient energy to cause chemical changes in cells and damage DNA.

Duty cycle

- Duty cycle is one of the factors used to determine safe RF radiation exposure levels. It affects the average exposure to radiation.
- The definition of duty cycle during the averaging time for RF exposure is the percentage of time that a transmitter is transmitting.
- The allowable power density for RF safety changes if duty cycle changes from 100 percent to 50 percent is it increases by a factor of 2.

End of Guide