

# Amateur Radio No-Code Technician License Examination Study Guide and Workbook

For tests given after July 1, 2003

*Everything you need to know to pass the FCC test!*

*Compliments of:*

Keuka Lake Amateur Radio Association

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and

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## Introduction

The Federal Communications Commission (FCC) makes and enforces the rules for amateur radio (the amateur service) in the United States. Two reasons for amateur radio in the US are to increase the number of trained radio operators and electronics experts, and improve international goodwill. The FCC must grant you an amateur operator/primary station license before you can operate an amateur station in the US (or wherever the FCC is in charge). The FCC may inspect your station at any time.

The amateur operator licenses are: Technician, Technician with Morse code, General, and Amateur Extra.

A Volunteer Examiner (VE) is an accredited amateur who volunteers to administer amateur license exams.

There are 4 examination elements.

For a Technician amateur license, you must pass a single 35 question multiple-choice written exam, Element 2.

### **THE ANSWER TO EVERY QUESTION ON THE ELEMENT 2 EXAM IS IN THIS DOCUMENT! SIX YEAR OLD CHILDREN HAVE PASSED THIS TEST, AND YOU CAN TOO!**

Anyone except a representative of a foreign government can become an amateur licensee in the US, and there are no age limits. The questions on the Element 2 exam are taken from a pool of 510 questions. A score of 26 is passing.

Included in this study guide are 2 pages of graphics. These graphics are used in some of the questions. In this study guide I ask you to write things on your copy of the graphics. This will help you remember, and you can study it later. Unless you enjoy long division, you should have a calculator handy while studying. You're allowed to use a calculator while taking the exam.

After you pass element 2, you may transmit as soon as the FCC grants you a license and the data appears in the FCC's ULS database (available on-line). Licenses are good for 10 years. You may renew your license no more than 90 days before it expires. If your license expires, you may NOT continue to transmit, however you'll have a 2 year "grace period" in which to renew. A Technician class license is the only FCC certification required for amateur radio operators to build or modify their own transmitting equipment. FCC Part 97 contains a detailed list of your operating privileges.

To upgrade your license from Technician to Technician with Morse code, you'll need to pass the 5 word-per-minute Morse code exam, element 1. A deaf person can take this test using a flashing light or vibrating surface. When you pass the element 1 exam you'll receive a Certificate of Successful Completion of Examination proving that you passed, and that you are authorized to use certain amateur frequencies. This credit can be used for license upgrade purposes for 365 days.

The Table of Contents tells you how much time you should need for each section, and the questions from the question pool that are covered. You'll pass the exam if you learn enough to answer half the questions, and eliminate half the choices on the other questions.

If one of the choices on a question is "All of these...", that will be the correct answer 62% of the time.

The technical material is covered in the first half of this study guide. The second half is easier, so don't get discouraged!

Some of the topics in this study guide have been over-simplified to make it easy for you to pass the test.

Please send comments to: W8BBS@YAHOO.COM.

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# Basic Electronics

## Electricity

A current is a flow of electrons in an electric circuit. Currents flow through electrical conductors such as gold, silver, and aluminum. The basic unit of electric current is the ampere. Current is measured using an ammeter.

A direct current (DC) is a current that flows in one direction only.

An alternating current (AC) flows back and forth, first in one direction, then in the opposite direction.

To have a current, there must be an electromotive force to move the electrons.

The basic unit of electromotive force, or electric potential, is the volt (V). Voltage is measured with a voltmeter.

An automobile battery supplies about 12 volts.

Resistance limits the current that flows through a circuit for a particular applied DC Voltage. The basic unit of resistance is the ohm, measured with an ohmmeter. A resistor is an electronic component that has a specific resistance. If two resistors are connected in series, their total resistance is the sum of the two resistor values. The watt is the basic unit of electrical power.

Figure T8-9: Meter B is an ammeter. Label it "current". It's connected in series with the circuit (so all the current flows through it).

Meter A is a voltmeter. Label it "voltage". It's connected in parallel with the circuit under test, which means some of the current goes through it, but not all.

Write "Power = R x B squared". The power in a circuit is equal to the resistance times the current squared.

A **Multimeter** is a meter that combines an ohmmeter, an ammeter, and a voltmeter. It's used to measure voltage, current and resistance. Measuring voltage when using the ohms setting might damage a multimeter that uses a moving-needle meter. When you switch a voltmeter from a lower to a higher voltage range, inside the voltmeter resistance is added in series with the meter.

**Ohm's Law** is a formula that shows how voltage, current and resistance are related in an electric circuit.

$$\text{Volts} = \text{Amperes} \times \text{Ohms}$$

To answer the Ohm's Law problems, just try all the answers in the formula until you find the one that works.

A **Capacitor** is two sets of conducting plates facing each other separated by an insulator (a non-conducting material). In a variable capacitor, the plates can be moved, changing the surface area where the plates face each other. A capacitor blocks the flow of direct current while allowing alternating current to pass. A capacitor stores electrostatic voltage (and keeps the voltage constant). A high voltage capacitor can give you a shock from a residual stored charge even if it's not in an energized circuit. The basic unit of capacitance is the farad. If two capacitors are connected in parallel, their total capacitance is the sum of the two capacitors.

## Metric system prefixes & decibels

Kilo = thousand, Mega = million, Giga = billion. Milli = thousandth, micro = millionth, pico = millionth of a millionth.

If a hand-held transceiver has an output of 500 milliwatts, this is .5 watts.

If an ammeter marked in amperes is used to measure a 3000-milliampere current, it would show 3 amperes.

One microfarad is 1,000,000 picofarads.

To say something represents a 3 decibel (dB) increase means it doubled.

If you increase your transmitter output power from 5 watts to 10 watts that's a 3 dB increase.

## Fuses

A short circuit draws high current, which blows a fuse, which creates an open circuit. If you replace a transceiver's 5 amp fuse with a 30 amp fuse, the transceiver could use more than 5 amps (without blowing the fuse) and cause a fire.

When fuses are installed in 12-volt DC wiring, they should be placed at the voltage source. Fuses are always installed in series.

Home built equipment powered from 110 volt AC lines should always have a fuse or circuit breaker in series with the equipment.

## Other components

PNP transistors use low voltage, whereas vacuum tubes use high voltage.

A diode controls current to flow in one direction only.

ICs (integrated circuits) combine several functions into one package.

A signal generator produces a stable, low-level signal that can be set to a desired frequency.

A rectifier changes an alternating current signal into a varying direct current signal.

Figure T7-1: Label symbol 3 "fixed resistor", symbol 2 "variable resistor", symbol 1 "fixed capacitor", symbol 4 "NPN transistor", symbol 7 "antenna", symbol 13 "single-cell battery", symbol 6 "iron-core inductor". An Inductor (a wire coil) stores current electromagnetically (keeps the current constant). The basic unit of inductance is the henry.

Figure T7-2: Label symbol 3 "double-pole, single-throw". Label symbol 4 "single-pole, double-throw".

## Radio waves

### Frequency / Wavelength

The number of times per second that an alternating current (AC) flows back and forth is the frequency.

The standard unit of frequency is the hertz (Hz). 60 hertz (Hz) means 60 cycles per second.

There are 1000 hertz in a kilohertz (kHz), and 1,000,000 hertz in a megahertz (MHz).

If a radio wave makes 3,725,000 cycles in one second, this means its frequency is 3725 kilohertz, or 3.725 megahertz (MHz).

When an alternating current is fed to an antenna, radio waves are emitted from the antenna. Radio waves are waves of electric and magnetic energy that travel through space at the speed of light, about 300 million meters per second. The distance a signal (radio wave) travels during one complete cycle is its wavelength. Therefore, the speed of a wave is equal to its wavelength times its frequency. Radio waves travel at the speed of light, 300 million meters per second, so if we measure a radio wave's frequency in megahertz (MHz), and its wavelength in meters,

$$\text{Wavelength} \times \text{Frequency} = 300$$

You MUST know how to use this formula. Using this formula, we can find the wavelength if we know the frequency, or the frequency if we know the wavelength. To find the frequency, divide the wavelength into 300. To find the wavelength, divide the frequency into 300. Using your calculator, find the frequency of a 6 meter wave.  $300 / 6 = 50$  MHz. Find the wavelength of a 223 MHz signal.  $300 / 223 = 1.35$  meters. Note that as a signal's frequency increases, its wavelength gets shorter. Note also that the frequency of a 100 meter wave is 3 MHz, for 10 meters it's 30 MHz, for 1 meter it's 300 MHz. Remember, you always use 300 divided by something.

Frequencies from 20 Hz to 20,000 Hz are called audio frequencies because the human ear can sense sounds in this range.

Frequencies more than 20 kHz are radio frequency waves (RF).

Electrical energy at a frequency of 7125 kHz is in the radio frequency (RF) range.

Radio waves are classified as **HF**, **VHF**, or **UHF** according to their frequency and wavelength.

	Frequency	Wavelength
HF = high frequency	3 – 30 MHz	100 – 10 meters
VHF = very high frequency	30 – 300 MHz	10 -- 1 meters
UHF = ultra high frequency	300 – 3000 MHz	1 – .1 meter

### Modulation, bandwidth, and emission types

The basic principle of radio communications is: a radio wave (an RF carrier) is combined with an information signal and is transmitted; a receiver separates the two.

The information signal can be analog, which means continuous, or digital, which means it occurs in specific steps.

Modulation is the process of combining an information signal with a radio signal.

Modulation causes the radio signal to be spread over a range of frequencies. This range is the bandwidth.

Different types of modulation produce different emission types. Here are some emission types, in order of bandwidth:

Digital modes:

- **CW** (continuous wave) - Morse code. CW is transmitted by on/off keying an RF signal to form dots and dashes. Bandwidth is about 100 Hz.
- **RTTY** (radioteletype) - The RF carrier is modulated using a modem. Bandwidth is about 300 Hz.

Analog modes:

- **SSB** (single sideband) - When an RF carrier is modulated by an audio signal, it occupies a bandwidth. Most of this bandwidth is removed, so you only transmit one sideband of the signal (usually the upper sideband). Bandwidth is 2 to 3 kHz.
- **FM** (frequency-modulation) - FM voice is good because it has less static than AM. Bandwidth is between 10 and 20 kHz. .
- Amateur fast-scan television - A cable ready TV receiver will allow you to monitor Amateur Television (ATV). Bandwidth is about 6 MHz.

SSB and CW are considered to be weak-signal modes and have the greatest potential for **DX** (long distant) contacts.

The best emission mode for two-way EME (earth-moon-earth) contacts is CW.

The FCC calls voice emissions phone. It has nothing to do with telephones. "Phone transmissions" means AM, FM or SSB voice.

### Technician with Code HF Operating Privileges

	Band:	From:	To:	Emission types:	Frequency Space:
HF	80 meter	3.675 MHz	3.725 MHz	CW Only	.05 MHz
HF	40 meter	7.1 MHz	7.15 MHz	CW Only	.05 MHz
HF	10 meter	28.1 MHz	28.3 MHz		.4 MHz
HF	10 meter	28.3 MHz	28.5 MHz	CW, SSB phone	

### Technician VHF Operating Privileges

VHF	6 meter	50 MHz	54 MHz		4 MHz
VHF	2 meter	144 MHz	148 MHz		4 MHz
VHF	"special band"	219 MHz	220 MHz	Digital message forwarding only	
VHF	1.25 meter	222 MHz	225 MHz	All are allowed	3 MHz

### Technician UHF Operating Privileges

UHF	70 centimeters	420 MHz	450 MHz	All are allowed	30 MHz
UHF	70 centimeters	430 MHz	450 MHz	Frequency limits north of line A	
UHF	33 centimeters	902 MHz	928 MHz	All are allowed	26 MHz
UHF	23 centimeters	1240 MHz	1300 MHz	All are allowed	60 MHz
UHF	13 centimeters	2300 MHz	2310 MHz	All are allowed	70 MHz
UHF	13 centimeters	2390 MHz	2450 MHz	All are allowed	

#### How to study the frequency band chart

This chart lists some of the frequencies Technician and Technician with code licensees are allowed to use.

Don't memorize it, just look it over. I've given all the frequencies in MHz; some of the test questions use kHz, so convert to MHz.

Notice the different bands.

A Technician with code can operate with up to 200 watts on the HF bands.

There are 3 VHF bands, 6, 2, and 1.25 meters, and a Technician has full privileges on them.

Notice you can use 219-220 for digital message forwarding, this isn't really a band.

Next we have the 4 UHF bands, .70, .33, .23, and .13 meters.

Everything on this chart is in the question pool except the "frequency space".

If you know the "frequency space", you can figure out the answer to questions about the frequency limits for the different bands.

Use the formula  $\text{Wavelength} \times \text{Frequency} = 300$  to determine which band has a certain frequency.

For example, 28.400 MHz has a wavelength of 10.56 meters, so it's on the 10 meter band.

There is little frequency space for the longer wavelengths; for 40 and 80 meters it's only .05 MHz, for 10 meters it's .4 MHz.

Because there is so little space on the HF bands, you're only allowed to use modes that use little bandwidth.

CW uses little bandwidth and is allowed on every band. The second half of the 10 meter band (28.3 to 28.5) allows SSB phone.

The frequency space for the VHF bands is more than the HF bands, 4 MHz for 6 and 2 meters, 3 MHz for 1.25 meters.

For all bands 1.25 meters and shorter, all modes are allowed for Technicians.

The UHF bands are even wider than the VHF bands, 30 MHz for 70 centimeters, 26 MHz for 33 centimeters, 60 MHz for 23 centimeters, and 70 MHz for 13 centimeters. North of line A you can't use 420 MHz to 430 MHz. This is because in Canada these frequencies are allocated for another service. If you transmitted on these frequencies, you might interfere with communications on this other service. FCC rules strive to always minimize interference.

A band plan is a voluntary guideline for using different operating modes within an amateur band.

## Propagation

Line-of-sight propagation: When a signal travels in a straight line from one antenna to another.

Ground-wave propagation: When a signal travels along the surface of the Earth (following the earth's curvature).

Sky-wave propagation: When a signal is returned to Earth (bent) by the ionosphere (usually an HF signal).

Multi-hop propagation: When a signal bounces several times between the Earth and the ionosphere.

Sporadic-E propagation: Occurs on the 6 meter band in summertime, not on the shorter wavelengths.

Tropospheric ducting: A widespread temperature inversion can cause VHF radio waves to travel many miles over oceans through the troposphere. Path loss through the troposphere increases as frequency increases.

Maximum usable frequency: In relation to sky-waves, the highest frequency signal that will reach its intended destination. UHF is almost always above the maximum usable frequency.

VHF and UHF waves normally travel by line-of-sight; however they can be reflected by metal-framed buildings.

## Ionosphere

Ultraviolet solar radiation (sun-light) causes ionization in the outer atmosphere, forming the ionosphere.

Ionization is at a minimum just before sunrise. Sunspots increase ionization. Sunspot cycles are 11 years.

The ionosphere has several regions.

The D region is closest to the Earth; it absorbs MF/HF radio signals during the daytime.

In the F2 region, radio waves are bent back to earth (sky-waves), making DX (long distant) radio communications possible.

Sky-waves have much longer range than ground waves, making HF well suited for DX contacts.

Local amateur communications should use VHF and UHF instead of HF, to minimize interference on HF bands capable of DX.

Signals that take off vertically from the antenna and are higher in frequency than the critical frequency pass through the ionosphere, which is why many amateur satellites operate on the VHF/UHF bands.

## Amateur Radio Equipment

### Transceivers

Hand-held transceivers are portable devices, transceivers installed in cars are mobile devices, fixed devices are in homes.

The two most common bands used by "dual band" hand-held transceivers are 2 meters and 70 cm (VHF and UHF).

A power amplifier could boost the low-power output from your hand-held radio up to 100 watts.

If you are told your FM hand-held or mobile transceiver is over deviating you should talk farther away from the microphone.

Over deviation in an FM transmitter can cause out-of-channel emissions.

If your mobile transceiver does not power up, check the 12-volt fuses. To operate a mobile transceiver in your home, you could use a 12-volt car battery or a power supply. A power supply converts 120 V AC (house current) to 12 V DC. If you think the supply voltage to your 12-volt transceiver may be low when you transmit, you could connect a voltmeter at the 12-volt plug on the chassis of the equipment. If your mobile transceiver works in your car but not in your home, check the power supply.

It's important to provide adequate DC source supply filtering for a mobile transceiver to reduce stray noise and RF pick-up.

For a CW transmitter, power supply filtering eliminates modulation of the RF signal by AC hum.

A bad filter capacitor in the transmitter's power supply may cause a buzzing or hum in the signal of an HF transmitter.

You would connect a microphone to a transceiver for voice operation, a telegraph key to send Morse code.

Many amateurs use an electronic keyer to help form good Morse code characters.

For RTTY operation, you would connect a modem and a teleprinter or computer system to a transceiver. In a packet-radio link "connected" means a transmitting station is sending data to only one receiving station; it replies that the data is being received correctly. A transceiver designed for FM phone operation can also be used for SSB in the weak-signal portion of the 2-meter band if it's a "multi-mode" radio. A multi-mode VHF transceiver is good for weak-signal VHF communications.

An S meter is used to measure relative signal strength in a receiver. A squelch causes a receiver to reject signals below a certain strength. For proper operation, the squelch of an FM receiver should be set at the point that just silences background noise. If you set your receiver's signal squelch too low while attempting to receive packet mode transmissions, noise may cause the TNC to falsely detect a data carrier. One accurate way to check the calibration of your receiver's tuning dial is to tune to WWV or WWVH.

Figure T8-5: Label this figure "SSB / CW receiver". Label block 1 "product detector". All receivers have a detector (to detect the information signal in the RF carrier). The product detector circuit combines signals from an IF amplifier stage and a beat-frequency oscillator (BFO) to produce an audio signal.

Figure T8-6: Label this figure "FM receiver". The mixer in this superheterodyne receiver shifts the frequency of the received signal so that it can be processed by IF (intermediate frequency) stages. Label block 1 "frequency discriminator". Write "no frequency discriminator, no audio".

Figure T8-7: Label the figure "single conversion superheterodyne FM receiver".  
Write "can receive 157.7 + 10.7, 157.7 – 10.7" (147.0 MHz and 168.4 MHz).

Figure T8-1: Label this figure "VFO-controlled transmitter". Label block 1 "variable-frequency oscillator (VFO)".  
The purpose of the VFO is to control the frequency. Label block 1 "control frequency".

Figure T8-2: Label this figure "FM transmitter". Label block 1 "reactance modulator".  
Write "no audio amplifier = unmodulated carrier".  
Phase modulation is similar to FM. Like FM, it's produced using a reactance modulator.

### Antennas

"Rubber duck" antennas for hand-held transceivers are too short to work well.  
They are much less efficient than a quarter-wavelength telescopic antenna.  
An external antenna on the roof will improve the operation of a hand-held radio inside a vehicle.  
With a multiband antenna you can operate on several bands with a single feed line.  
A duplexer is used to connect a dual-band antenna to a mobile transceiver that has separate VHF and UHF output connectors.

Some antennas radiate more in some directions than others, which is to say they have gain.  
For example, if the ends of a half-wavelength dipole antenna (mounted at least a half-wavelength high) point east and west, the antenna will send out radio energy mostly north and south.  
Increasing antenna gain by 3 dB will double your signal's effective radiated power in the direction of maximum radiation.

Figure T8-8: Label the diagram "Yagi antenna", element 1 "reflector", element 2 "driven", element 3 "director".  
The feed point, where the feed line joins the antenna, is the driven element.  
The driven element is about 1/2 wavelength long. The driven element by itself is a simple dipole antenna.  
A Yagi antenna has one driven element and several other elements on a boom.  
Boom length has the greatest effect on the gain of a Yagi antenna.

A cubical quad antenna has two or more parallel four-sided wire loops, each approximately one electrical wavelength long.

EME (moonbounce, Earth-Moon-Earth) stations need a very high gain antenna, such as a parabolic-dish antenna, a multi-element array of collinear antennas, or a high-gain array of Yagi antennas. A ground-plane antenna is not high gain, so it would NOT be a good choice for an EME station.

A vertical antenna is vertically polarized. A horizontal antenna is horizontally polarized. The electric lines of force of a radio wave are in the same direction as the antenna that transmitted it. A satellite antenna is spinning, so its polarization is always changing. We call this circular polarization. Most VHF and UHF repeater antennas are vertically polarized, whereas horizontal polarization is used for weak signal VHF/UHF SSB operation.

Important considerations when selecting a location for a transmitting antenna are nearby structures, height above average terrain, and distance from the transmitter.  
If you plan to erect an antenna higher than 200 feet you must notify the Federal Aviation Administration (FAA) and the FCC.

### Feed lines and SWR meters

A feed line (transmission line) connects your antenna to your transceiver.  
Standing-wave ratio (SWR) is the ratio of maximum to minimum voltages on a feed line, measured with an SWR meter.  
An SWR of 1:1 means the impedance of the antenna and its transmission line are matched perfectly.  
An SWR reading of 4:1 indicates an impedance mismatch; something may be wrong with the antenna system.

Figure T8-3: Label block 1 "transceiver". Label block 2 "antenna switch". Label block 3 "dummy antenna".  
The antenna switch switches between the antenna and the dummy antenna.  
A dummy antenna for a 100-watt, single-sideband transmitter should have a rating of 100 watts continuous.  
You might connect an SWR meter between your transceiver and an antenna switch connected to several antennas.

Figure T8-4: Label block 1 "transceiver". Label block 2 "SWR meter". Label block 3 "antenna tuner".  
An antenna tuner might allow use of an antenna on a band it was not designed for.  
An antenna tuner matches a transceiver output impedance to the antenna system impedance.

The two common types of feed lines are coaxial cable and parallel-conductor. Coaxial cable is a center wire inside an insulating material covered by a metal sleeve or shield. To keep RF losses low, use only good quality coaxial cable and connectors. Radio energy that is sent through a poor quality coaxial cable is converted to heat in the cable. Parallel-conductor feed line is two wires side-by-side held apart by insulating material. Parallel-conductor, open-wire feed line will operate well even with a high SWR and has less loss than coaxial cable.

"Balun" means balanced to unbalanced. You would install a balun between the coaxial cable and the antenna to feed a dipole antenna with 50-ohm coaxial cable. An unbalanced line is a feed line with one conductor connected to ground.

### RF wattmeters

Peak envelope power (PEP) is the average power supplied to an antenna transmission line during one RF cycle at the crest of the modulation envelope. With regard to a transmitter and antenna system, "forward power" means the power traveling from the transmitter to the antenna. "Reflected power" means the power returned towards the source on a transmission line. If a directional RF wattmeter reads 90 watts forward power and 10 watts reflected power, the actual transmitter output power is 80 watts. Of the 90 watts forward, 10 watts were reflected back, leaving 80 watts. Most RF wattmeters operate at 50 ohm line impedance.

### Calculating antenna length

Antennas are often half-wavelength or quarter-wavelength. To find the length of an antenna, you need to find the wavelength using the formula wavelength x frequency = 300. To make a half-wavelength dipole antenna resonant at 147 MHz, we use wavelength = 300 / 147 MHz = 2.04 meters. This means a half-wavelength = 1.02 meters. A meter is about 40 inches, so the length is about 40 inches. The correct answer is 37 inches, close enough! (This method isn't exact, it ignores many other factors). You could add a loading coil to reduce the physical length of an antenna without changing its resonant frequency.

### Harmonics and filters

A high-pass filter will allow RF above a certain frequency to pass; the RF below that frequency will be filtered out. A low pass filter will allow RF below a certain value to pass. A band-pass filter will allow RF within a certain frequency range to pass. Because some emission types need more bandwidth than others to be received properly, many radio receivers have several IF filters of different bandwidths that can be selected by the operator.

Sometimes, while transmitting at some frequency, a "harmonic" signal will also be transmitted. The frequency of the harmonic is exactly 2, 3, or more times than the transmitted frequency. For example, the fourth harmonic of a 50.25 MHz signal is 201.00 MHz. A low-pass filter connected to an amateur HF transmitter can cut down on harmonic radiation.

## Operating Practice (you're halfway there!)

### Call Signs

The US is part of the ITU, International Telecommunications Union. There are 3 ITU regions. The US is in region 2, including Alaska. Guam is in region 3. The FCC issues new amateur radio call signs by ITU prefix letter(s), call sign district numeral and a suffix in strict alphabetic order. My first call sign was KC8UPE. Under the vanity call sign program you can get a call sign made up of your initials. My vanity call sign is W8BBS. The first letter in US amateur call signs is always A, K, N or W. The numbers used in US amateur call signs are a single digit, 0 through 9. My call sign district is 8, and BBS are my initials.

Group C and D station call sign format groups are available to Technician Class amateur radio operators (group A and B call sign format groups are reserved for Generals and Amateur Extras). An amateur radio licensee can change his call sign without applying for a vanity call by requesting a systematic call sign change on an NCVEC Form 605.

An amateur radio club can get a station call sign by applying through a Club Station Call Sign Administrator. Any licensed amateur is eligible to apply for temporary use of a 1-by-1 format Special Event call sign.

### Station identification

An amateur station must identify itself (by call sign) at least every ten minutes and at the end of a contact.

When two amateur stations end communications each station must transmit its own call sign.

You must always use English to identify your station (or CW).

Unidentified communications or signals are amateur communications that do NOT have the required station identification.

You should use the ITU phonetic alphabet when identifying your station because the words are internationally recognized substitutes for letters; "cute" phrases or word combinations are not easily understood by non-English-speaking amateurs.

### Control Operator, Control Point

The control operator of an amateur station is any licensed amateur operator who is responsible for the station's transmissions; (i.e. the licensed amateur who is operating the station). An amateur licensee may operate any amateur equipment and control any number of transmitters at the same time. A control operator of another amateur's station has the operating privileges of his own license, regardless of the license privileges of the station's owner. A station licensee is responsible for it's the proper operation; however, if you transmit from another amateur's station, both of you are responsible for its proper operation. To keep unauthorized persons from using your amateur station at home, use a key-operated on/off switch in the main power line. To keep them off a mobile amateur station in your car, disconnect the microphone when you are not using it.

The control point of an amateur station is the location at which the control operator function is performed, where the control operator has full control over the transmitter. An automatically controlled station does not require the control operator to be present at the control point. All other stations must have a control operator at the station's control point when transmitting.

### Third-party messages

The FCC assumes that you authorize ALL transmissions made with your call sign as the control operator. You may let an unlicensed third party use your amateur station; however, you must continuously monitor and supervise the third-party's participation. Unlicensed family members can't transmit when they're alone because control operators must be licensed amateurs. Third-party communications means "messages sent between two amateur stations for someone else". This usually means letting the third party take the microphone. You may send third-party messages to a foreign country when the US has a third-party agreement with the foreign country (or the third party is qualified to be a control operator). When sending third-party messages internationally, the US station must transmit both call signs at the end of each communication. No payment of any kind is allowed for third-party messages (it's amateur radio).

### Repeaters

A repeater is a station that receives radio signals on one frequency, and simultaneously re-transmits them on another frequency (usually at higher power and through a good antenna). The frequency difference is called the offset. Repeaters help mobile and low-power stations extend their usable range. To use a repeater, you need to know its input frequency and offset. The usual offset for repeaters in the 2-meter band is 600 kHz (.6 MHz), for the 70-centimeter band it's 5.0 MHz. A crossband repeater receives signals on one band and retransmits them on another band. If you set up a dual-band mobile transceiver to operate as a crossband repeater there must be a control operator at the system's control point.

To determine if a repeater is being used by other stations you could ask if the frequency is in use, then give your call sign. If you transmit to test access to a repeater without giving any station identification, this is an illegal unidentified transmission. To call another station on a repeater, say the station's call sign, then identify your own station. To break into a conversation on a repeater say your call sign during a break between transmissions. You should pause briefly between transmissions when using a repeater to listen for anyone wanting to break in. When you finish talking and release the microphone button, you'll hear a "courtesy tone" from the repeater, a sound used to indicate when a transmission is complete. The courtesy tone resets the "time out timer" (a device that limits the amount of time a repeater will transmit continuously).

The repeater owner and donations from its users usually pays for the site rental and upkeep of most repeaters. If you hear a closed repeater that you would like to use, you should contact the control operator and ask to join. You should keep transmissions short on a repeater so you don't prevent someone with an emergency from using the repeater. A "net" is when several amateurs take turns transmitting on a frequency when asked to do so by the net operator. During commuting rush hours, third-party communications nets should be discouraged on repeaters. "Simplex operation" means transmitting and receiving on the same frequency. To find out if simplex is possible, see if you can receive the station on the repeater's input frequency. When possible, you should use simplex instead of tying up a repeater.

A continuous tone-coded squelch system (CTCSS) tone is a sub-audible tone, added to a carrier, which may cause a receiver to accept the signal. If you are told that a "tone" is required to access a repeater, it means you must use a subaudible tone-coded squelch with your signal so the repeater will accept your signal.

Repeaters sometimes have an autopatch, a device that allows radio users to access the public telephone system. Communication through an autopatch is not private. You may use an autopatch to seek emergency assistance, call for a tow truck, call home, but not to pick up business messages. (Amateur radio is not for business use.)

Repeater frequency coordination is a system wherein a frequency coordinator recommends that you operate your repeater on a specific repeater frequency pair. If a repeater is causing harmful interference to another repeater and a frequency coordinator has recommended the operation of both repeaters, then both repeater licensees are responsible for resolving the interference. FM (frequency-modulated) phone is the voice emission most used on VHF/UHF repeaters. Repeaters often identify themselves in Morse code. Slow-scan television may be transmitted on a 2-meter repeater providing the repeater control operator authorizes it.

## Other types of stations

A beacon is an amateur station that transmits for the purpose of observation of propagation and reception. Automatic control is allowed in some band segments, one-way transmissions are allowed, and maximum output power is 100 watts.

An amateur space station (satellite) is an amateur station located more than 50 kilometers above the Earth's surface.

Any licensed amateur operator may be the control operator of an amateur space station.

The most distant point from the Earth in the satellite's orbit is called the "apogee"; the closest point is called the "perigee".

The mathematical parameters that describe a satellite's orbit are its Keplerian elements.

An amateur typically has 4 to 6 minutes per pass to communicate with the International Space Station.

The Doppler effect causes the frequency of a signal from an amateur satellite to increase or decrease as it passes overhead.

A telecommand station transmits telecommands- one way transmissions that control functions of a device at a distance (such as a model craft). Telecommand stations don't have to identify themselves, but must have a label with the station call sign and the station licensee's name and address. Telecommand stations must have all of these: a wire line or radio control link, a posted copy of the station license, and it must be protected so that no unauthorized transmissions can be made.

The FCC calls telemetry, telecommand or computer communications emissions Data.

You need a computer to conduct Amateur Radio communications using a data emission.

A gateway is an amateur radio station that is used to connect other amateur stations with the Internet.

## FCC Rules

Some general principles established by the FCC rules are: In an emergency anything and everything is allowed, you must always try to minimize interference, and amateur radio is not for business use or to make money.

An amateur operator must have a US mailing address so the licensee can receive mail from the FCC, otherwise your amateur license could be revoked. You may transmit from a location different from the address on your license whenever you want. If your mailing address changes, write (don't call!) the FCC in Gettysburg, PA (remember, write the Gettysburg address).

You may operate your amateur station aboard a cruise ship only with the approval of the master of the ship and not using the ship's radio equipment. Aboard an aircraft you need the approval of the pilot. Amateur stations are allowed to communicate with stations operating in other radio services only when authorized by the FCC or in an emergency. An amateur may operate in a country other than his home country if there is a reciprocal operating agreement with both countries. There is no distance limit restricting amateur transmissions. You're allowed to communicate with an amateur in a foreign country at any time, unless it is not allowed by either government.

Broadcasting means transmissions intended for the general public. Amateur stations may not broadcast. Amateurs may not transmit music, (except as part of an authorized rebroadcast of space shuttle communications). Codes and ciphers may not be used to obscure the meaning of a message (there are exceptions). If an amateur pretends there is an emergency and transmits the word "MAYDAY," this is called false or deceptive signals. An amateur station may never transmit false or deceptive signals. An amateur station may transmit unidentified communications only when sent from a space station or to control a model craft. Amateurs can't use indecent and obscene language because it is offensive, young children may hear it, and such language is prohibited by FCC Rules (ALL of these reasons).

Harmful interference is a transmission that disturbs other communications. Transmitting on a police frequency as a "joke" is harmful interference. It deserves a large penalty because it interrupts police communications. You may never deliberately interfere with another station's communications. If an amateur repeatedly transmits on a frequency occupied by amateurs in a net, this is called harmful or malicious interference.

Amateur stations must always use the minimum legal power necessary to communicate (to minimize interference).

Before you transmit on any frequency you should listen to make sure others are not using the frequency.

If someone tells you that signals from your hand-held transceiver are interfering with other signals on a frequency near yours, your hand-held may be transmitting spurious emissions. If an SSB transmitter is operated with the microphone gain set too high it may cause splatter interference to other stations operating near its frequency.

If the FCC rules say that the amateur service is a secondary user of a frequency band, and another service is a primary user, this means amateurs are allowed to use the band only if they do not cause harmful interference to primary users.

If a primary user causes you interference, you should change frequency; you could be causing him harmful interference.

If you learn that you are interfering with a radiolocation station outside the US, you must stop operating or take steps to eliminate the interference. If two amateur stations want to use the same frequency both station operators have an equal right to operate on the frequency (regardless of license class).

## Procedural signals, Q signals, and Signal Reports

The procedural signal "CQ" means calling any station.

The correct way to call CQ using voice is to say "CQ" three times, "this is", followed by your call sign spoken three times.

To answer a voice CQ, say the other station's call sign once, followed by "this is", then your call sign given phonetically.

When using Morse code:

"DE" means "From" or "this is," as in "KC8UPE DE W8BBS".

"K" means "any station transmit" (i.e. talk).

To call CQ, send the letters "CQ" three times, followed by "DE," followed by your call sign sent three times.

To answer a CQ call, send the other station's call sign twice, followed by "DE," followed by your call sign twice.

A Morse code CQ call should be transmitted at a speed at which you can reliably receive.

"QRS" means "Send more slowly".

A "QSO" is a conversation.

"73" means best regards.

A "QSL" card is a written acknowledgment of communications between two amateurs (a postcard).

In a signal report, RST means Readability, Signal strength, Tone.

"Your signal report is five nine plus 20 dB..." means a relative signal-strength meter reading is 20 decibels greater than strength 9.

"Your signal is full quieting..." means your signal is strong enough to overcome all receiver noise; it's a good signal.

## Emergencies

You may use your amateur station to transmit an "SOS" or "MAYDAY" only in a life- or property-threatening emergency. If you are in contact with another station and you hear an emergency call for help on your frequency, you should stop your QSO immediately and take the emergency call. If you hear a voice distress signal on a frequency outside of your license privileges, you are allowed to help on a frequency outside your privileges in any way possible. The proper way to interrupt a repeater conversation to signal a distress call is to say "BREAK" once, then your call sign.

If a disaster disrupts normal communication systems amateur stations may make transmissions that are necessary to meet essential communication needs and facilitate relief actions. An FCC declaration of a temporary state of communication emergency will include any special conditions and special rules to be observed. Tactical call signs such as "command post" or "weather center" are used during an emergency because they are more efficient and help coordinate public-service communications.

Messages sent into or out of a disaster area concerning a person's well being are called health and welfare traffic, those concerning the immediate safety of human life are called emergency traffic. If you are helping in an emergency and have checked into a net, do not transmit on the net frequency until asked to do so by the net operator (to minimize interference to the net).

It's a good idea to be able to operate your amateur station without using commercial AC power lines so you may provide communications in an emergency. The most important accessory to have for a hand-held radio in an emergency is several sets of charged batteries. A dipole antenna is good for setting up in an emergency.

You must register with the responsible civil defense organization before you can participate in RACES (Radio Amateur Civil Emergency Service) drills. You must identify messages sent during a RACES drill as drill or test messages.

## Television interference

If you are told that your amateur station is causing television interference, you should first make sure that your station is operating properly, and that it does not cause interference to your own television. If you cause interference to nearby radio or television broadcast receivers, the FCC rules can require that you discontinue operation on frequencies causing interference during certain evening hours and on Sunday morning (local time- so people can watch church on TV?).

"Receiver overload" is interference caused by strong signals from a nearby source. If signals from your transmitter are causing front-end overload in your neighbor's television receiver, the owner of the television receiver is responsible for resolving the interference. A high-pass filter should be connected to a TV receiver as the first step in trying to prevent RF overload from an amateur HF station. TV sets receive VHF and UHF, which are higher frequencies than HF, so a high-pass filter would filter out the HF signal. If harmonic radiation from your transmitter is causing interference to television receivers in your neighborhood, you alone are responsible for taking care of the interference, since your transmitter is causing the problem. By emitting harmonics, you are transmitting on frequencies not allocated for amateurs. You could connect a low pass filter to your HF transmitter to cut down on harmonic radiation.

A break in a cable television transmission line can cause TV interference to result when the amateur station is transmitting, or cause interference to the amateur receiver. The major cause of telephone interference is that the telephone was not equipped with interference protection when it was manufactured.

# Safety

## Tower Safety

Before climbing an antenna tower you should put on your safety belt and safety glasses. An old leather climbing belt is probably brittle and could break unexpectedly. When you're on the ground you should wear a hard hat to protect your head from something dropped from the tower. The MOST important safety precaution to take is to stay well clear of any power lines. You should take all reasonable safety precautions. The answer to most of the safety questions is "All of these".

## Electric Shock / Lightning

As little as 30 volts is usually dangerous to humans. The heart can be fatally affected by a very small amount of electrical current; as little as 1/10 of an ampere will probably be fatal. To protect from lightning damage, ground all antennas when they are not in use, and disconnect all station equipment from the power lines and antenna cables. To protect against electric shock, connect all station equipment to a common ground. The green wire in a three-wire electrical plug represents ground (think Green = Ground). Everyone should know the location of the main power switch in case of an emergency. The power supply should be controlled by a safety interlock switch in an amateur transceiver or power amplifier.

## Radiation Safety

Radio frequency radiation is non-ionizing radiation (as opposed to X-radiation, gamma radiation, and ultra violet radiation). Heating of body tissues is one effect of RF non-ionizing radiation on the human body. This can cause cataracts in the eyes. Amateur Radio operators are required to meet the FCC RF radiation exposure limits to ensure a safe operating environment for amateurs, their families and neighbors. The FCC RF radiation maximum permissible exposure (MPE) limits are defined in FCC Part 1 and Office of Engineering and Technology (OET) Bulletin 65.

Look at figure T0-1. This chart is taken from the Office of Engineering and Technology (OET) Bulletin 65.

This chart gives maximum exposure (MPE) limits for different frequencies for "controlled" environments (places you occupy, your home and yard) and "uncontrolled" environments (places where you have no control, where the general public might be). Notice that exposure limits vary with frequency. This is because the human body absorbs RF energy more at some frequencies than at others. The concept of "specific absorption rate (SAR)" is one factor used to determine safe RF radiation exposure levels because it takes into account the rate at which the human body absorbs RF energy at a particular frequency (remember, rate). The maximum permissible exposure (MPE) limits are based on the whole-body specific absorption rate (SAR).

These limits are not maximum power densities that may be emitted; FCC Rules specify exposure limits, not emission limits. These limits are the maximum AVERAGE power densities that are safe. The "duty cycle" of a station is the percent of the time the transmitter is operating at full power during a transmission. If a station has a low duty cycle, its average power density will be low, even if it transmits at high power. Lower duty cycles subject people in the environment to lower RF radiation, so the lower the duty cycle, the shorter the compliance distance (minimum safe distance). Notice that the exposure limits are more stringent for an "uncontrolled" environment than for a "controlled" environment. Notice that for controlled areas, power densities are averaged for 6 minutes, for uncontrolled areas it's 30 minutes. To comply with RF radiation exposure guidelines for "controlled" environments, you could reduce transmitting times within a 6-minute period to reduce the duty cycle (30 minutes for "uncontrolled" environments).

Figure T0-1: Find the equation for maximum permissible exposure for a controlled environment for the HF bands.

To do this, use the top half of the figure, and note that HF is "3.0 - 30" MHz. The answer is "900/f<sup>2</sup> squared" (circle it).

Circle the lowest and highest frequencies covered by the FCC's RF radiation exposure guidelines (.3 MHz and 100,000 MHz). Don't forget that 100,000 MHz = 100 giga Hz, or 100 GHz, and .3 MHz = 300 kHz.

Circle the frequency range where the RF radiation exposure limits are most stringent (30 MHz to 300 MHz, VHF).

Circle the units of measure for power density (milliwatts per square centimeter, or mW/cm<sup>2</sup>).

Circle the units of measure for RF electric field strength (volts per meter, or V/m).

Circle the averaging time for controlled environments (6 minutes) and for uncontrolled environments (30 minutes).

Figure T0-2: This figure actually has 5 different charts, the result of computer modeling.

For different power levels, these charts give "controlled" and "uncontrolled" minimum safe distance limits.

The power density limits on the charts were determined from figure T0-1.

The limits are different on the 5 charts because each chart is for a different frequency and different type of antenna.

Antenna gain is part of the formulas used to perform calculations, and ground interactions must be taken into account when using a computer program to model RF fields at your station (note the EPA ground reflection factor).

To answer the "minimum safe distance" questions, find the chart for the antenna type in the question.

Look in the "Transmitter power" column for the power level given in the question.

See if the question is asking for the "controlled" or "uncontrolled" limit.

RF exposure is affected by: frequency and power of the RF field, antenna height, distance, and radiation pattern (All of these). For the same PEP (power), single-sideband (SSB) results in less RF radiation exposure than phase-modulation, FM, or CW.

## Routine station evaluation

VHF stations operating above 50 watts PEP are required to perform a routine RF radiation evaluation.

FCC OET Bulletin 65 gives several ways you can determine that your station complies with FCC RF-exposure regulations:

- by calculation, based on FCC OET Bulletin No. 65
- by calculation, based on computer modeling
- by measurement, using a calibrated field strength meter with a calibrated field strength sensor; no calculations needed.

There are no mandatory procedures for evaluating compliance.

Records of a routine RF radiation exposure evaluation are not required, (but may prove useful).

An antenna close to the ground will usually create a stronger RF field on the ground beneath it than a higher antenna.

In the far field, as the distance from the source increases, power density is proportional to the inverse square of the distance.

In the near field it is difficult to accurately evaluate the effects of RF exposure; it depends on the type of antenna being used.

Wavelength and the physical size of the antenna determine the boundary between the near and far fields of an antenna.

## More radiation safety

To avoid excessive human exposure to RF fields, antennas should be mounted as far away from accessible areas as possible.

To prevent exposure to RF radiation in excess of FCC limits, an amateur can alter antenna patterns, relocate antennas, or revise station technical parameters, such as frequency, power, or emission type (All of these).

If your repeater station antenna will be located at a site that is occupied by antennas for transmitters in other services, your radiated signal must be considered as part of the total RF radiation from the site when determining RF radiation exposure levels.

The FCC considers a hand-held transceiver to be a portable device when evaluating for RF radiation exposure because its transmitting antenna is usually within 20 centimeters of the human body. Use the minimum power needed with a hand-held radio to reduce the level of RF radiation exposure to your head. A mobile transceiver might produce less RF radiation exposure than a hand-held because mobile antennas mounted on a metal vehicle roof are generally well shielded from vehicle occupants.

Don't look into the open end of a microwave feed horn antenna while it's transmitting because you could expose your eyes to excessive RF radiation. If you touch an antenna while it's transmitting high power, you could be injured by RF burns.

**Congratulations!** You're ready to take a practice exam. You can take a practice exam on-line at [WWW.AA9PW.COM](http://WWW.AA9PW.COM) or [WWW.WVARA.ORG](http://WWW.WVARA.ORG). If you take a practice exam on-line, be sure you take the current exam, the one to be used after July, 2003. There are 6 practice exams included in this study guide. Each exam has 10 groups of questions, with question numbers starting with T1,T2,T3... The answers to the practice exams are given by group. You'll probably want to re-read parts of the study guide before taking your test. Look over the graphics that you've been writing on. Be sure you can calculate frequencies and wavelengths. Be sure to take your calculator to the exam. Take this study guide also, you'll have time for last minute cramming before the exam starts. Be sure to bring 2 forms of identification to your exam.

Please email me at [W8BBS@YAHOO.COM](mailto:W8BBS@YAHOO.COM) with your comments, feedback, and new call sign!

**Practice exam 1**  
(The answer key is at the end)

T1A01- Who makes and enforces the rules for the amateur service in the United States?

- A. The Congress of the United States
- B. The Federal Communications Commission (FCC)
- C. The Volunteer Examiner Coordinators (VECs)
- D. The Federal Bureau of Investigation (FBI)

T1B01- What are the frequency limits of the 6-meter band in ITU Region 2?

- A. 52.0 - 54.5 MHz
- B. 50.0 - 54.0 MHz
- C. 50.1 - 52.1 MHz
- D. 50.0 - 56.0 MHz

T1C01- Which of the following is required before you can operate an amateur station in the US?

- A. You must hold an FCC operator's training permit for a licensed radio station
- B. You must submit an FCC Form 605 together with a license examination fee
- C. The FCC must grant you an amateur operator/primary station license
- D. The FCC must issue you a Certificate of Successful Completion of Amateur Training

T1D01- Who can become an amateur licensee in the US?

- A. Anyone except a representative of a foreign government
- B. Only a citizen of the United States
- C. Anyone except an employee of the US government
- D. Anyone

T1E01- Which of the following call signs is a valid US amateur call?

- A. UZ4FWD
- B. BL7766
- C. KB3TMJ
- D. VE3BKJ

T2A01- What happens to a signal's wavelength as its frequency increases?

- A. It gets shorter
- B. It gets longer
- C. It stays the same
- D. It disappears

T2B01- What are the frequency limits of the 80-meter band in ITU Region 2 for Technician class licensees who have passed a Morse code exam?

- A. 3500 - 4000 kHz
- B. 3675 - 3725 kHz
- C. 7100 - 7150 kHz
- D. 7000 - 7300 kHz

T3A01- What is the name of the area of the atmosphere that makes long-distance radio communications possible by bending radio waves?

- A. Troposphere
- B. Stratosphere
- C. Magnetosphere
- D. Ionosphere

T3B01- When a signal travels in a straight line from one antenna to another, what is this called?

- A. Line-of-sight propagation
- B. Straight line propagation
- C. Knife-edge diffraction
- D. Tunnel ducting

T4A01- When may you operate your amateur station aboard a cruise ship?

- A. At any time
- B. Only while the ship is not under power
- C. Only with the approval of the master of the ship and not using the ship's radio equipment
- D. Only when you have written permission from the cruise line and only using the ship's radio equipment

T4B01- What is the definition of a control operator of an amateur station?

- A. Anyone who operates the controls of the station
- B. Anyone who is responsible for the station's equipment
- C. Any licensed amateur operator who is responsible for the station's transmissions
- D. The amateur operator with the highest class of license who is near the controls of the station

T4C01- If you hear a voice distress signal on a frequency outside of your license privileges, what are you allowed to do to help the station in distress?

- A. You are NOT allowed to help because the frequency of the signal is outside your privileges
- B. You are allowed to help only if you keep your signals within the nearest frequency band of your privileges
- C. You are allowed to help on a frequency outside your privileges only if you use international Morse code
- D. You are allowed to help on a frequency outside your privileges in any way possible

T5A01- If you are the control operator at the station of another amateur who has a higher-class license than yours, what operating privileges are you allowed?

- A. Any privileges allowed by the higher license
- B. Only the privileges allowed by your license
- C. All the emission privileges of the higher license, but only the frequency privileges of your license
- D. All the frequency privileges of the higher license, but only the emission privileges of your license

T5B01- How often must an amateur station be identified?

- A. At the beginning of a contact and at least every ten minutes after that
- B. At least once during each transmission
- C. At least every ten minutes during and at the end of a contact
- D. At the beginning and end of each transmission

T5C01- If you answer someone on the air and then complete your communication without giving your call sign, what type of communication have you just conducted?

- A. Test transmission
- B. Tactical signal
- C. Packet communication
- D. Unidentified communication

T6A01- What is the advantage of using the International Telecommunication Union (ITU) phonetic alphabet when identifying your station?

- A. The words are internationally recognized substitutes for letters
- B. There is no advantage
- C. The words have been chosen to represent Amateur Radio terms
- D. It preserves traditions begun in the early days of Amateur Radio

T6B01- Which list of emission types is in order from the narrowest bandwidth to the widest bandwidth?

- A. RTTY, CW, SSB voice, FM voice
- B. CW, FM voice, RTTY, SSB voice
- C. CW, RTTY, SSB voice, FM voice
- D. CW, SSB voice, RTTY, FM voice

T6C01- What is meant by receiver overload?

- A. Too much voltage from the power supply
- B. Too much current from the power supply
- C. Interference caused by strong signals from a nearby source
- D. Interference caused by turning the volume up too high

T7A01- What is the name for the flow of electrons in an electric circuit?

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

T7B01- What type of electric circuit uses signals that can vary continuously over a certain range of voltage or current values?

- A. An analog circuit
- B. A digital circuit
- C. A continuous circuit
- D. A pulsed modulator circuit

T7C01- Which of the following lists include three good electrical conductors?

- A. Copper, gold, mica
- B. Gold, silver, wood
- C. Gold, silver, aluminum
- D. Copper, aluminum, paper

T8A01- What two bands are most commonly used by "dual band" hand-held transceivers?

- A. 6 meters and 2 meters
- B. 2 meters and 1.25 meters
- C. 2 meters and 70 cm
- D. 70 cm and 23 cm

T8B01- Can a transceiver designed for FM phone operation also be used for single sideband in the weak-signal portion of the 2-meter band?

- A. Yes, with simple modification
- B. Only if the radio is a "multimode" radio
- C. Only with the right antenna
- D. Only with the right polarization

T8C01- What type of circuit does Figure T8-5 represent if block 1 is a product detector?

- A. A simple phase modulation receiver
- B. A simple FM receiver
- C. A simple CW and SSB receiver
- D. A double-conversion multiplier

T8D01- Which of the following will improve the operation of a hand-held radio inside a vehicle?

- A. Shielding around the battery pack
- B. A good ground to the belt clip
- C. An external antenna on the roof
- D. An audio amplifier

T8E01- What does standing-wave ratio mean?

- A. The ratio of maximum to minimum inductances on a feed line
- B. The ratio of maximum to minimum capacitances on a feed line
- C. The ratio of maximum to minimum impedances on a feed line
- D. The ratio of maximum to minimum voltages on a feed line

T8F01- Which instrument would you use to measure electric potential or electromotive force?

- A. An ammeter
- B. A voltmeter
- C. A wavemeter
- D. An ohmmeter

T9A01- What is the purpose of repeater operation?

- A. To cut your power bill by using someone else's higher power system
- B. To help mobile and low-power stations extend their usable range
- C. To transmit signals for observing propagation and reception
- D. To communicate with stations in services other than amateur

T9B01- What is an amateur station called that transmits communications for the purpose of observation of propagation and reception?

- A. A beacon
- B. A repeater
- C. An auxiliary station
- D. A radio control station

T0A01- What is the minimum voltage that is usually dangerous to humans?

- A. 30 volts
- B. 100 volts
- C. 1000 volts
- D. 2000 volts

T0B01- How can an antenna system best be protected from lightning damage?

- A. Install a balun at the antenna feed point
- B. Install an RF choke in the antenna feed line
- C. Ground all antennas when they are not in use
- D. Install a fuse in the antenna feed line

T0C01- What is radio frequency radiation?

- A. Waves of electric and magnetic energy between 3 kHz and 300 GHz
- B. Ultra-violet rays emitted by the sun between 20 Hz and 300 GHz
- C. Sound energy given off by a radio receiver
- D. Beams of X-Rays and Gamma rays emitted by a radio transmitter

T0D01- What factors must you consider if your repeater station antenna will be located at a site that is occupied by antennas for transmitters in other services?

- A. Your radiated signal must be considered as part of the total RF radiation from the site when determining RF radiation exposure levels
- B. Each individual transmitting station at a multiple transmitter site must meet the RF radiation exposure levels
- C. Each station at a multiple-transmitter site may add no more than 1% of the maximum permissible exposure (MPE) for that site
- D. Amateur stations are categorically excluded from RF radiation exposure evaluation at multiple-transmitter sites

T0E01- If you do not have the equipment to measure the RF power densities present at your station, what might you do to ensure compliance with the FCC RF radiation exposure limits?

- A. Use one or more of the methods included in the amateur supplement to FCC OET Bulletin 65
- B. Call an FCC-Certified Test Technician to perform the measurements for you
- C. Reduce power from 200 watts PEP to 100 watts PEP
- D. Operate only low-duty-cycle modes such as FM

T0F01- Is it necessary for you to perform mathematical calculations of the RF radiation exposure if your VHF station delivers more than 50 watts peak envelope power (PEP) to the antenna?

- A. Yes, calculations are always required to ensure greatest accuracy
- B. Calculations are required if your station is located in a densely populated neighborhood
- C. No, calculations may not give accurate results, so measurements are always required
- D. No, there are alternate means to determine if your station meets the RF radiation exposure limits

Answers:

T1-BBCAC T2-AB T3-DA T4-CCD T5-BCD T6-ACC T7-DAC T8-CBBCDB T9-BA T0-ACAAAD

**Practice exam 2**  
(The answer key is at the end)

T1A02- What are two of the five fundamental purposes for the amateur service in the United States?

- A. To protect historical radio data, and help the public understand radio history
- B. To help foreign countries improve communication and technical skills, and encourage visits from foreign hams
- C. To modernize radio schematic drawings, and increase the pool of electrical drafting people
- D. To increase the number of trained radio operators and electronics experts, and improve international goodwill

T1B02- What are the frequency limits of the 2-meter band in ITU Region 2?

- A. 144.0 - 148.0 MHz
- B. 145.0 - 149.5 MHz
- C. 144.1 - 146.5 MHz
- D. 144.0 - 146.0 MHz

T1C02- What are the US amateur operator licenses that a new amateur might earn?

- A. Novice, Technician, General, Advanced
- B. Technician, Technician Plus, General, Advanced
- C. Novice, Technician Plus, General, Advanced
- D. Technician, Technician with Morse code, General, Amateur Extra

T1D02- What age must you be to hold an amateur license?

- A. 14 years or older
- B. 18 years or older
- C. 70 years or younger
- D. There are no age limits

T1E02- What letters must be used for the first letter in US amateur call signs?

- A. K, N, U and W
- B. A, K, N and W
- C. A, B, C and D
- D. A, N, V and W

T2A02- How does the frequency of a harmonic compare to the desired transmitting frequency?

- A. It is slightly more than the desired frequency
- B. It is slightly less than the desired frequency
- C. It is exactly two, or three, or more times the desired frequency
- D. It is much less than the desired frequency

T2B02- What are the frequency limits of the 10-meter band in ITU Region 2 for Technician class licensees who have passed a Morse code exam?

- A. 28.000 - 28.500 MHz
- B. 28.100 - 29.500 MHz
- C. 28.100 - 28.500 MHz
- D. 29.100 - 29.500 MHz

T3A02- Which ionospheric region is closest to the Earth?

- A. The A region
- B. The D region
- C. The E region
- D. The F region

T3B02- What can happen to VHF or UHF signals going towards a metal-framed building?

- A. They will go around the building
- B. They can be bent by the ionosphere
- C. They can be reflected by the building
- D. They can be polarized by the building's mass

T4A02- When may you operate your amateur station somewhere in the US besides the address listed on your license?

- A. Only during times of emergency
- B. Only after giving proper notice to the FCC
- C. During an emergency or an FCC-approved emergency practice
- D. Whenever you want to

T4B02- What is the FCC's name for the person responsible for the transmissions from an amateur station?

- A. Auxiliary operator
- B. Operations coordinator
- C. Third-party operator
- D. Control operator

T4C02- When may you use your amateur station to transmit an "SOS" or "MAYDAY"?

- A. Never
- B. Only at specific times (at 15 and 30 minutes after the hour)
- C. In a life- or property-threatening emergency
- D. When the National Weather Service has announced a severe weather watch

T5A02- Assuming you operate within your amateur license privileges, what restrictions apply to operating amateur equipment?

- A. You may operate any amateur equipment
- B. You may only operate equipment located at the address printed on your amateur license
- C. You may only operate someone else's equipment if you first notify the FCC
- D. You may only operate store-purchased equipment until you earn your Amateur Extra class license

T5B02- What identification, if any, is required when two amateur stations end communications?

- A. No identification is required
- B. One of the stations must transmit both stations' call signs
- C. Each station must transmit its own call sign
- D. Both stations must transmit both call signs

T5C02- What is one example of one-way communication that Technician class control operators are permitted by FCC rules?

- A. Transmission for radio control of model craft
- B. Use of amateur television for surveillance purposes
- C. Retransmitting National Weather Service broadcasts
- D. Use of amateur radio as a wireless microphone for a public address system

T6A02- What is one reason to avoid using "cute" phrases or word combinations to identify your station?

- A. They are not easily understood by non-English-speaking amateurs
- B. They might offend English-speaking amateurs
- C. They do not meet FCC identification requirements
- D. They might be interpreted as codes or ciphers intended to obscure the meaning of your identification

T6B02- What is the usual bandwidth of a single-sideband amateur signal?

- A. 1 kHz
- B. 2 kHz
- C. Between 3 and 6 kHz
- D. Between 2 and 3 kHz

T6C02- What type of filter might be connected to an amateur HF transmitter to cut down on harmonic radiation?

- A. A key-click filter
- B. A low-pass filter
- C. A high-pass filter
- D. A CW filter

T7A02- What is the name of a current that flows only in one direction?

- A. An alternating current
- B. A direct current
- C. A normal current
- D. A smooth current

T7B02- What type of electric circuit uses signals that have voltage or current values only in specific steps over a certain range?

- A. An analog circuit
- B. A digital circuit
- C. A step modulator circuit
- D. None of these choices is correct

T7C02- What is one reason resistors are used in electronic circuits?

- A. To block the flow of direct current while allowing alternating current to pass
- B. To block the flow of alternating current while allowing direct current to pass
- C. To increase the voltage of the circuit
- D. To control the amount of current that flows for a particular applied voltage

T8A02- If your mobile transceiver works in your car but not in your home, what should you check first?

- A. The power supply
- B. The speaker
- C. The microphone
- D. The SWR meter

T8B02- How is a CW signal usually transmitted?

- A. By frequency-shift keying an RF signal
- B. By on/off keying an RF signal
- C. By audio-frequency-shift keying an oscillator tone
- D. By on/off keying an audio-frequency signal

T8C02- If Figure T8-5 is a diagram of a simple single-sideband receiver, what type of circuit should be shown in block 1?

- A. A high pass filter
- B. A ratio detector
- C. A low pass filter
- D. A product detector

T8D02- Which is true of "rubber duck" antennas for hand-held transceivers?

- A. The shorter they are, the better they perform
- B. They are much less efficient than a quarter-wavelength telescopic antenna
- C. They offer the highest amount of gain possible for any hand-held transceiver antenna
- D. They have a good long-distance communications range

T8E02- What instrument is used to measure standing wave ratio?

- A. An ohmmeter
- B. An ammeter
- C. An SWR meter
- D. A current bridge

T8F02- How is a voltmeter usually connected to a circuit under test?

- A. In series with the circuit
- B. In parallel with the circuit
- C. In quadrature with the circuit
- D. In phase with the circuit

T9A02- What is a courtesy tone, as used in repeater operations?

- A. A sound used to identify the repeater
- B. A sound used to indicate when a transmission is complete
- C. A sound used to indicate that a message is waiting for someone
- D. A sound used to activate a receiver in case of severe weather

T9B02- Which of the following is true of amateur radio beacon stations?

- A. Automatic control is allowed in certain band segments
- B. One-way transmissions are permitted
- C. Maximum output power is 100 watts
- D. All of these choices are correct

T0A02- Which electrical circuit draws high current?

- A. An open circuit
- B. A dead circuit
- C. A closed circuit
- D. A short circuit

T0B02- How can amateur station equipment best be protected from lightning damage?

- A. Use heavy insulation on the wiring
- B. Never turn off the equipment
- C. Disconnect the ground system from all radios
- D. Disconnect all equipment from the power lines and antenna cables

T0C02- Why is it a good idea to adhere to the FCC's Rules for using the minimum power needed when you are transmitting with your hand-held radio?

- A. Large fines are always imposed on operators violating this rule
- B. To reduce the level of RF radiation exposure to the operator's head
- C. To reduce calcification of the NiCd battery pack
- D. To eliminate self-oscillation in the receiver RF amplifier

T0D02- Why do exposure limits vary with frequency?

- A. Lower-frequency RF fields have more energy than higher-frequency fields
- B. Lower-frequency RF fields penetrate deeper into the body than higher-frequency fields
- C. The body's ability to absorb RF energy varies with frequency
- D. It is impossible to measure specific absorption rates at some frequencies

T0E02- Where will you find the applicable FCC RF radiation maximum permissible exposure (MPE) limits defined?

- A. FCC Part 97 Amateur Service Rules and Regulations
- B. FCC Part 15 Radiation Exposure Rules and Regulations
- C. FCC Part 1 and Office of Engineering and Technology (OET) Bulletin 65
- D. Environmental Protection Agency Regulation 65

T0F02- What is one method that amateur radio licensees may use to conduct a routine station evaluation to determine whether the station is within the Maximum Permissible Exposure guidelines?

- A. Direct measurement of the RF fields
- B. Indirect measurement of the energy density at the limit of the controlled area
- C. Estimation of field strength by S-meter readings in the controlled area
- D. Estimation of field strength by taking measurements using a directional coupler in the transmission line

Answers:

T1-DADDB T2-CC T3-BC T4-DDC T5-ACA T6-ADB T7-BBD T8-ABDCB T9-BD T0- DDBCCA

**Practice exam 3**  
(The answer key is at the end)

T1A03- What is the definition of an amateur station?

- A. A radio station in a public radio service used for radiocommunications
- B. A radio station using radiocommunications for a commercial purpose
- C. A radio station using equipment for training new broadcast operators and technicians
- D. A radio station in the amateur service used for radiocommunications

T1B03- What are the frequency limits of the 1.25-meter band in ITU Region 2?

- A. 225.0 - 230.5 MHz
- B. 222.0 - 225.0 MHz
- C. 224.1 - 225.1 MHz
- D. 220.0 - 226.0 MHz

T1C03- How soon after you pass the examination elements required for your first Amateur Radio license may you transmit?

- A. Immediately
- B. 30 days after the test date
- C. As soon as the FCC grants you a license and the data appears in the FCC's ULS data base
- D. As soon as you receive your license from the FCC

T1D03- What government agency grants your amateur radio license?

- A. The Department of Defense
- B. The State Licensing Bureau
- C. The Department of Commerce
- D. The Federal Communications Commission

T1E03- What numbers are normally used in US amateur call signs?

- A. Any two-digit number, 10 through 99
- B. Any two-digit number, 22 through 45
- C. A single digit, 1 through 9
- D. A single digit, 0 through 9

T2A03- What does 60 hertz (Hz) mean?

- A. 6000 cycles per second
- B. 60 cycles per second
- C. 6000 meters per second
- D. 60 meters per second

T2B03- What name does the FCC use for telemetry, telecommand or computer communications emissions?

- A. CW
- B. Image
- C. Data
- D. RTTY

T3A03- Which region of the ionosphere is mainly responsible for absorbing MF/HF radio signals during the daytime?

- A. The F2 region
- B. The F1 region
- C. The E region
- D. The D region

T3B03- Ducting occurs in which region of the atmosphere?

- A. F2
- B. Ecosphere
- C. Troposphere
- D. Stratosphere

T4A03- What penalty may the FCC impose if you fail to provide your correct mailing address?

- A. There is no penalty if you do not provide the correct address
- B. You are subject to an administrative fine
- C. Your amateur license could be revoked
- D. You may only operate from your address of record

T4B03- When must an amateur station have a control operator?

- A. Only when training another amateur
- B. Whenever the station receiver is operated
- C. Whenever the station is transmitting
- D. A control operator is not needed

T4C03- If a disaster disrupts normal communication systems in an area where the FCC regulates the amateur service, what kinds of transmissions may stations make?

- A. Those that are necessary to meet essential communication needs and facilitate relief actions
- B. Those that allow a commercial business to continue to operate in the affected area
- C. Those for which material compensation has been paid to the amateur operator for delivery into the affected area
- D. Those that are to be used for program production or newsgathering for broadcasting purposes

T5A03- When an amateur station is transmitting, where must its control operator be, assuming the station is not under automatic control?

- A. At the station's control point
- B. Anywhere in the same building as the transmitter
- C. At the station's entrance, to control entry to the room
- D. Anywhere within 50 km of the station location

T5B03- What is the longest period of time an amateur station can operate without transmitting its call sign?

- A. 5 minutes                      B. 10 minutes                      C. 15 minutes                      D. 30 minutes

T5C03- What kind of payment is allowed for third-party messages sent by an amateur station?

- A. Any amount agreed upon in advance                      B. Donation of repairs to amateur equipment  
C. Donation of amateur equipment                      D. No payment of any kind is allowed

T6A03- What should you do before you transmit on any frequency?

- A. Listen to make sure others are not using the frequency  
B. Listen to make sure that someone will be able to hear you  
C. Check your antenna for resonance at the selected frequency  
D. Make sure the SWR on your antenna feed line is high enough

T6B03- What is the usual bandwidth of a frequency-modulated amateur signal?

- A. Less than 5 kHz                      B. Between 5 and 10 kHz                      C. Between 10 and 20 kHz                      D. Greater than 20 kHz

T6C03- What type of filter should be connected to a TV receiver as the first step in trying to prevent RF overload from an amateur HF station transmission?

- A. Low-pass                      B. High-pass                      C. Band pass                      D. Notch

T7A03- What is the name of a current that flows back and forth, first in one direction, then in the opposite direction?

- A. An alternating current                      B. A direct current                      C. A rough current                      D. A steady state current

T7B03- Which of the following is an example of an analog communications method?

- A. Morse code (CW)                      B. Packet Radio                      C. Frequency-modulated (FM) voice                      D. PSK31

T7C03- If two resistors are connected in series, what is their total resistance?

- A. The difference between the individual resistor values                      B. Always less than the value of either resistor  
C. The product of the individual resistor values                      D. The sum of the individual resistor values

T8A03- Which of the following devices would you need to conduct Amateur Radio communications using a data emission?

- A. A telegraph key                      B. A computer                      C. A transducer                      D. A telemetry sensor

T8B03- What purpose does block 1 serve in the simple CW transmitter pictured in Figure T8-1?

- A. It detects the CW signal                      B. It controls the transmitter frequency  
C. It controls the transmitter output power                      D. It filters out spurious emissions from the transmitter

T8C03- What circuit is pictured in Figure T8-6, if block 1 is a frequency discriminator?

- A. A double-conversion receiver                      B. A variable-frequency oscillator  
C. A superheterodyne receiver                      D. An FM receiver

T8D03- What would be the length, to the nearest inch, of a half-wavelength dipole antenna that is resonant at 147 MHz?

- A. 19 inches                      B. 37 inches                      C. 55 inches                      D. 74 inches

T8E03- What would an SWR of 1:1 indicate about an antenna system?

- A. That the antenna was very effective  
B. That the transmission line was radiating  
C. That the antenna was reflecting as much power as it was radiating  
D. That the impedance of the antenna and its transmission line were matched

T8F03- What happens inside a voltmeter when you switch it from a lower to a higher voltage range?

- A. Resistance is added in series with the meter                      B. Resistance is added in parallel with the meter  
C. Resistance is reduced in series with the meter                      D. Resistance is reduced in parallel with the meter

T9A03- During commuting rush hours, which type of repeater operation should be discouraged?

- A. Mobile stations                      B. Low-power stations  
C. Highway traffic information nets                      D. Third-party communications nets

T9B03- The control operator of a station communicating through an amateur satellite must hold what class of license?

- A. Amateur Extra or Advanced                      B. Any class except Novice  
C. Any class                      D. Technician with satellite endorsement

T0A03- What could happen to your transceiver if you replace its blown 5 amp AC line fuse with a 30 amp fuse?

- A. The 30-amp fuse would better protect your transceiver from using too much current
- B. The transceiver would run cooler
- C. The transceiver could use more current than 5 amps and a fire could occur
- D. The transceiver would not be able to produce as much RF output

T0B03- Why should you wear a hard hat and safety glasses if you are on the ground helping someone work on an antenna tower?

- A. So you won't be hurt if the tower should accidentally fall
- B. To keep RF energy away from your head during antenna testing
- C. To protect your head from something dropped from the tower
- D. So someone passing by will know that work is being done on the tower and will stay away

T0C03- Which of the following units of measurement are used to specify the power density of a radiated RF signal?

- A. Milliwatts per square centimeter
- B. Volts per meter
- C. Amperes per meter
- D. All of these choices are correct

T0D03- Why might mobile transceivers produce less RF radiation exposure than hand-held transceivers in mobile operations?

- A. They do not produce less exposure because they usually have higher power levels.
- B. They have a higher duty cycle
- C. When mounted on a metal vehicle roof, mobile antennas are generally well shielded from vehicle occupants
- D. Larger transmitters dissipate heat and energy more readily

T0E03- To determine compliance with the maximum permitted exposure (MPE) levels, safe exposure levels for RF energy are averaged for an "uncontrolled" RF environment over what time period?

- A. 6 minutes
- B. 10 minutes
- C. 15 minutes
- D. 30 minutes

T0F03- What document establishes mandatory procedures for evaluating compliance with RF exposure limits?

- A. There are no mandatory procedures
- B. OST/OET Bulletin 65
- C. Part 97 of the FCC rules
- D. ANSI/IEEE C95.1--1992

Answers:

T1-DBCDD T2-BC T3-DC T4-CCA T5-ABD T6-ACB T7-ACD T8-BBDBDA T9-DC T0-CCACDA

**Practice exam 4**  
(The answer key is at the end)

T1A04- When is an amateur station authorized to transmit information to the general public?

- A. Never
- B. Only when the operator is being paid
- C. Only when the broadcast transmission lasts less than 1 hour
- D. Only when the broadcast transmission lasts longer than 15 minutes

T1B04- What are the frequency limits of the 70-centimeter band in ITU Region 2?

- A. 430.0 - 440.0 MHz
- B. 430.0 - 450.0 MHz
- C. 420.0 - 450.0 MHz
- D. 432.0 - 435.0 MHz

T1C04- How soon before the expiration date of your license may you send the FCC a completed Form 605 or file with the Universal Licensing System on the World Wide Web for a renewal?

- A. No more than 90 days
- B. No more than 30 days
- C. Within 6 to 9 months
- D. Within 6 months to a year

T1D04- What element credit is earned by passing the Technician class written examination?

- A. Element 1
- B. Element 2
- C. Element 3
- D. Element 4

T1E04- In which ITU region is Alaska?

- A. ITU Region 1
- B. ITU Region 2
- C. ITU Region 3
- D. ITU Region 4

T2A04- What is the name for the distance an AC signal travels during one complete cycle?

- A. Wave speed
- B. Waveform
- C. Wavelength
- D. Wave spread

T2B04- What does "connected" mean in a packet-radio link?

- A. A telephone link is working between two stations
- B. A message has reached an amateur station for local delivery
- C. A transmitting station is sending data to only one receiving station; it replies that the data is being received correctly
- D. A transmitting and receiving station are using a digipeater, so no other contacts can take place until they are finished

T3A04- Which region of the ionosphere is mainly responsible for long-distance sky-wave radio communications?

- A. D region
- B. E region
- C. F1 region
- D. F2 region

T3B04- What causes VHF radio waves to be propagated several hundred miles over oceans?

- A. A polar air mass
- B. A widespread temperature inversion
- C. An overcast of cirriform clouds
- D. A high-pressure zone

T4A04- Under what conditions may you transmit from a location different from the address printed on your amateur license?

- A. If the location is under the control of the FCC, whenever the FCC Rules allow
- B. If the location is outside the United States, only for a time period of less than 90 days
- C. Only when you have written permission from the FCC Engineer in Charge
- D. Never; you may only operate at the location printed on your license

T4B04- What is the term for the location at which the control operator function is performed?

- A. The operating desk
- B. The control point
- C. The station location
- D. The manual control location

T4C04- What information is included in an FCC declaration of a temporary state of communication emergency?

- A. A list of organizations authorized to use radio communications in the affected area
- B. A list of amateur frequency bands to be used in the affected area
- C. Any special conditions and special rules to be observed during the emergency
- D. An operating schedule for authorized amateur emergency stations

T5A04- Where will you find a detailed list of your operating privileges?

- A. In the OET Bulletin 65 Index
- B. In FCC Part 97
- C. In your equipment's operating instructions
- D. In Part 15 of the Code of Federal Regulations

T5B05- What is the term for the average power supplied to an antenna transmission line during one RF cycle at the crest of the modulation envelope?

- A. Peak transmitter power
- B. Peak output power
- C. Average radio-frequency power
- D. Peak envelope power

T5C04- What is the definition of third-party communications?

- A. A message sent between two amateur stations for someone else
- B. Public service communications for a political party
- C. Any messages sent by amateur stations
- D. A three-minute transmission to another amateur

T6A04- How do you call another station on a repeater if you know the station's call sign?

- A. Say "break, break 79," then say the station's call sign
- B. Say the station's call sign, then identify your own station
- C. Say "CQ" three times, then say the station's call sign
- D. Wait for the station to call "CQ," then answer it

T6B04- What is the usual bandwidth of a UHF amateur fast-scan television signal?

- A. More than 6 MHz
- B. About 6 MHz
- C. About 3 MHz
- D. About 1 MHz

T6C04- What effect might a break in a cable television transmission line have on amateur communications?

- A. Cable lines are shielded and a break cannot affect amateur communications
- B. Harmonic radiation from the TV receiver may cause the amateur transmitter to transmit off-frequency
- C. TV interference may result when the amateur station is transmitting, or interference may occur to the amateur receiver
- D. The broken cable may pick up very high voltages when the amateur station is transmitting

T7A04- What is the basic unit of electrical power?

- A. The ohm
- B. The watt
- C. The volt
- D. The ampere

T7B04- Which of the following is an example of a digital communications method?

- A. Single-sideband (SSB) voice
- B. Amateur Television (ATV)
- C. FM voice
- D. Radioteletype (RTTY)

T7C04- What is one reason capacitors are used in electronic circuits?

- A. To block the flow of direct current while allowing alternating current to pass
- B. To block the flow of alternating current while allowing direct current to pass
- C. To change the time constant of the applied voltage
- D. To change alternating current to direct current

T8A04- Which of the following devices would be useful to create an effective Amateur Radio station for weak-signal VHF communication?

- A. A hand-held VHF FM transceiver
- B. A multi-mode VHF transceiver
- C. An Omni-directional antenna
- D. A mobile VHF FM transceiver

T8B04- What circuit is pictured in Figure T8-1 if block 1 is a variable-frequency oscillator?

- A. A packet-radio transmitter
- B. A crystal-controlled transmitter
- C. A single-sideband transmitter
- D. A VFO-controlled transmitter

T8C04- What is block 1 in the FM receiver shown in Figure T8-6?

- A. A frequency discriminator
- B. A product detector
- C. A frequency-shift modulator
- D. A phase inverter

T8D04- How long should you make a half-wavelength dipole antenna for 223 MHz (measured to the nearest inch)?

- A. 112 inches
- B. 50 inches
- C. 25 inches
- D. 12 inches

T8E04- What does an SWR reading of 4:1 mean?

- A. An impedance match that is too low
- B. An impedance match that is good, but not the best
- C. An antenna gain of 4
- D. An impedance mismatch; something may be wrong with the antenna system

T8F04- How is an ammeter usually connected to a circuit under test?

- A. In series with the circuit
- B. In parallel with the circuit
- C. In quadrature with the circuit
- D. In phase with the circuit

T9A04- Which of the following is a proper way to break into a conversation on a repeater?

- A. Wait for the end of a transmission and start calling the desired party
- B. Shout, "break, break!" to show that you're eager to join the conversation
- C. Turn on an amplifier and override whoever is talking
- D. Say your call sign during a break between transmissions

T9B04- How does the Doppler effect change an amateur satellite's signal as the satellite passes overhead?

- A. The signal's amplitude increases or decreases
- B. The signal's frequency increases or decreases
- C. The signal's polarization changes from horizontal to vertical
- D. The signal's circular polarization rotates

T0A04- How much electrical current flowing through the human body will probably be fatal?

- A. As little as 1/10 of an ampere
- B. Approximately 10 amperes
- C. More than 20 amperes
- D. Current through the human body is never fatal

T0B04- What safety factors must you consider when using a bow and arrow or slingshot and weight to shoot an antenna-support line over a tree?

- A. You must ensure that the line is strong enough to withstand the shock of shooting the weight
- B. You must ensure that the arrow or weight has a safe flight path if the line breaks
- C. You must ensure that the bow and arrow or slingshot is in good working condition
- D. All of these choices are correct

T0C04- Over what frequency range are the FCC Regulations most stringent for RF radiation exposure?

- A. Frequencies below 300 kHz
- B. Frequencies between 300 kHz and 3 MHz
- C. Frequencies between 3 MHz and 30 MHz
- D. Frequencies between 30 MHz and 300 MHz

T0D04- In the far field, as the distance from the source increases, how does power density vary?

- A. The power density is proportional to the square of the distance
- B. The power density is proportional to the square root of the distance
- C. The power density is proportional to the inverse square of the distance
- D. The power density is proportional to the inverse cube of the distance

T0E04- To determine compliance with the maximum permitted exposure (MPE) levels, safe exposure levels for RF energy are averaged for a "controlled" RF environment over what time period?

- A. 6 minutes
- B. 10 minutes
- C. 15 minutes
- D. 30 minutes

T0F04- Which category of transceiver is NOT excluded from the requirement to perform a routine station evaluation?

- A. Hand-held transceivers
- B. VHF base station transmitters that deliver more than 50 watts peak envelope power (PEP) to an antenna
- C. Vehicle-mounted push-to-talk mobile radios
- D. Portable transceivers with high duty cycles

Answers:

T1-ACABB T2-CC T3-DB T4-ABC T5-BDA T6-BBC T7-BDA T8-BDACDA T9-DB T0-ADDCAB

**Practice exam 5**  
(The answer key is at the end)

T1A05- When is an amateur station authorized to transmit music?

- A. Amateurs may not transmit music, except as an incidental part of an authorized rebroadcast of space shuttle communications
- B. Only when the music produces no spurious emissions
- C. Only when the music is used to jam an illegal transmission
- D. Only when the music is above 1280 MHz, and the music is a live performance

T1B05- What are the frequency limits of the 33-centimeter band in ITU Region 2?

- A. 903 - 927 MHz
- B. 905 - 925 MHz
- C. 900 - 930 MHz
- D. 902 - 928 MHz

T1C05- What is the normal term for an amateur station license grant?

- A. 5 years
- B. 7 years
- C. 10 years
- D. For the lifetime of the licensee

T1D05- If you are a Technician licensee who has passed a Morse code exam, what is one document you can use to prove that you are authorized to use certain amateur frequencies below 30 MHz?

- A. A certificate from the FCC showing that you have notified them that you will be using the HF bands
- B. A certificate showing that you have attended a class in HF communications
- C. A Certificate of Successful Completion of Examination showing that you have passed a Morse code exam
- D. No special proof is required

T1E05- In which ITU region is Guam?

- A. ITU Region 1
- B. ITU Region 2
- C. ITU Region 3
- D. ITU Region 4

T2A05- What is the fourth harmonic of a 50.25 MHz signal?

- A. 201.00 MHz
- B. 150.75 MHz
- C. 251.50 MHz
- D. 12.56 MHz

T2B05- What emission types are Technician control operators who have passed a Morse code exam allowed to use from 7100 to 7150 kHz in ITU Region 2?

- A. CW and data
- B. Phone
- C. Data only
- D. CW only

T3A05- When a signal travels along the surface of the Earth, what is this called?

- A. Sky-wave propagation
- B. Knife-edge diffraction
- C. E-region propagation
- D. Ground-wave propagation

T3B05- In which of the following frequency ranges does sky-wave propagation least often occur?

- A. LF
- B. UHF
- C. HF
- D. VHF

T4A05- Why must an amateur operator have a current US postal mailing address?

- A. So the FCC has a record of the location of each amateur station
- B. To follow the FCC rules and so the licensee can receive mail from the FCC
- C. Because all US amateurs must be US residents
- D. So the FCC can publish a call-sign directory

T4B05- What is the control point of an amateur station?

- A. The on/off switch of the transmitter
- B. The input/output port of a packet controller
- C. The variable frequency oscillator of a transmitter
- D. The location at which the control operator function is performed

T4C05- If you are in contact with another station and you hear an emergency call for help on your frequency, what should you do?

- A. Tell the calling station that the frequency is in use
- B. Direct the calling station to the nearest emergency net frequency
- C. Call your local Civil Preparedness Office and inform them of the emergency
- D. Stop your QSO immediately and take the emergency call

T5A05- If you transmit from another amateur's station, who is responsible for its proper operation?

- A. Both of you
- B. The other amateur (the station licensee)
- C. You, the control operator
- D. The station licensee, unless the station records show that you were the control operator at the time

T5B05- What is the term for the average power supplied to an antenna transmission line during one RF cycle at the crest of the modulation envelope?

- A. Peak transmitter power
- B. Peak output power
- C. Average radio-frequency power
- D. Peak envelope power

T5C05- When are third-party messages allowed to be sent to a foreign country?

- A. When sent by agreement of both control operators
- B. When the third party speaks to a relative
- C. They are not allowed under any circumstances
- D. When the US has a third-party agreement with the foreign country or the third party is qualified to be a control operator

T6A05- What does RST mean in a signal report?

- A. Recovery, signal strength, tempo
- B. Recovery, signal speed, tone
- C. Readability, signal speed, tempo
- D. Readability, signal strength, tone

T6B05- What name is given to an amateur radio station that is used to connect other amateur stations with the Internet?

- A. A gateway
- B. A repeater
- C. A digipeater
- D. FCC regulations prohibit such a station

T6C05- If you are told that your amateur station is causing television interference, what should you do?

- A. First make sure that your station is operating properly, and that it does not cause interference to your own television
- B. Immediately turn off your transmitter and contact the nearest FCC office for assistance
- C. Connect a high-pass filter to the transmitter output and a low-pass filter to the antenna-input terminals of the television
- D. Continue operating normally, because you have no reason to worry about the interference

T7A05- What is the basic unit of electric current?

- A. The volt
- B. The watt
- C. The ampere
- D. The ohm

T7B05- Most humans can hear sounds in what frequency range?

- A. 0 - 20 Hz
- B. 20 - 20,000 Hz
- C. 200 - 200,000 Hz
- D. 10,000 - 30,000 Hz

T7C05- If two equal-value capacitors are connected in parallel, what is their total capacitance?

- A. Twice the value of one capacitor
- B. Half the value of one capacitor
- C. The same as the value of either capacitor
- D. The value of one capacitor times the value of the other

T8A05- What would you connect to a transceiver for voice operation?

- A. A splatter filter
- B. A terminal-voice controller
- C. A receiver audio filter
- D. A microphone

T8B05- What circuit is shown in Figure T8-2 if block 1 represents a reactance modulator?

- A. A single-sideband transmitter
- B. A double-sideband AM transmitter
- C. An FM transmitter
- D. A product transmitter

T8C05- What would happen if block 1 failed to function in the FM receiver diagram shown in Figure T8-6?

- A. The audio output would sound loud and distorted
- B. There would be no audio output
- C. There would be no effect
- D. The receiver's power supply would be short-circuited

T8D05- How long should you make a quarter-wavelength vertical antenna for 146 MHz (measured to the nearest inch)?

- A. 112 inches
- B. 50 inches
- C. 19 inches
- D. 12 inches

T8E05- What does an antenna tuner do?

- A. It matches a transceiver output impedance to the antenna system impedance
- B. It helps a receiver automatically tune in stations that are far away
- C. It switches an antenna system to a transceiver when sending, and to a receiver when listening
- D. It switches a transceiver between different kinds of antennas connected to one feed line

T8F05- Which instrument would you use to measure electric current?

- A. An ohmmeter
- B. A wavemeter
- C. A voltmeter
- D. An ammeter

T9A05- When using a repeater to communicate, which of the following do you need to know about the repeater?

- A. Its input frequency and offset
- B. Its call sign
- C. Its power level
- D. Whether or not it has an autopatch

T9B05- Why do many amateur satellites operate on the VHF/UHF bands?

- A. To take advantage of the skip zone
- B. Because VHF/UHF equipment costs less than HF equipment
- C. To give Technician class operators greater access to modern communications technology
- D. Because VHF and UHF signals easily pass through the ionosphere

T0A05- Which body organ can be fatally affected by a very small amount of electrical current?

- A. The heart
- B. The brain
- C. The liver
- D. The lungs

T0B05- Which of the following is the best way to install your antenna in relation to overhead electric power lines?

- A. Always be sure your antenna wire is higher than the power line, and crosses it at a 90-degree angle
- B. Always be sure your antenna and feed line are well clear of any power lines
- C. Always be sure your antenna is lower than the power line, and crosses it at a small angle
- D. Only use vertical antennas within 100 feet of a power line

T0C05- Which of the following categories describes most common amateur use of a hand-held transceiver?

- A. Mobile devices
- B. Portable devices
- C. Fixed devices
- D. None of these choices is correct

T0D05- In the near field, how does the field strength vary with distance from the source?

- A. It always increases with the cube of the distance
- B. It always decreases with the cube of the distance
- C. It varies as a sine wave with distance
- D. It depends on the type of antenna being used

T0E05- Why are Amateur Radio operators required to meet the FCC RF radiation exposure limits?

- A. The standards are applied equally to all radio services
- B. To ensure that RF radiation occurs only in a desired direction
- C. Because amateur station operations are more easily adjusted than those of commercial radio services
- D. To ensure a safe operating environment for amateurs, their families and neighbors

T0F05- Which of the following antennas would (generally) create a stronger RF field on the ground beneath the antenna?

- A. A horizontal loop at 30 meters above ground
- B. A 3-element Yagi at 30 meters above ground
- C. A 1/2 wave dipole antenna 5 meters above ground
- D. A 3-element Quad at 30 meters above ground

Answers:

T1-ADCCC T2-AD T3-DB T4-BDD T5-ADD T6-DAA T7-CBA T8-DCBCAD T9-AD T0-ABBDDC

**Practice exam 6**  
(The answer key is at the end)

T1A06- When is the transmission of codes or ciphers allowed to hide the meaning of a message transmitted by an amateur station?

- A. Only during contests
- B. Only during nationally declared emergencies
- C. Codes and ciphers may not be used to obscure the meaning of a message, although there are special exceptions
- D. Only when frequencies above 1280 MHz are used

T1B06- What are the frequency limits of the 23-centimeter band in ITU Region 2?

- A. 1260 - 1270 MHz
- B. 1240 - 1300 MHz
- C. 1270 - 1295 MHz
- D. 1240 - 1246 MHz

T1C06-

What is the "grace period" during which the FCC will renew an expired 10-year license?

- A. 2 years
- B. 5 years
- C. 10 years
- D. There is no grace period

T1D06- What is a Volunteer Examiner (VE)?

- A. A certified instructor who volunteers to examine amateur teaching manuals
- B. An FCC employee who accredits volunteers to administer amateur license exams
- C. An amateur, accredited by one or more VECs, who volunteers to administer amateur license exams
- D. An amateur, registered with the Electronic Industries Association, who volunteers to examine amateur station equipment

T1E06- What must you transmit to identify your amateur station?

- A. Your "handle"
- B. Your call sign
- C. Your first name and your location
- D. Your full name

T2A06- What is a radio frequency wave?

- A. Wave disturbances that take place at less than 10 times per second
- B. Electromagnetic oscillations or cycles that repeat between 20 and 20,000 times per second
- C. Electromagnetic oscillations or cycles that repeat more than 20,000 times per second
- D. None of these answers are correct

T2B06- What emission types are Technician control operators who have passed a Morse code exam allowed to use on frequencies from 28.3 to 28.5 MHz?

- A. All authorized amateur emission privileges
- B. CW and data
- C. CW and single-sideband phone
- D. Data and phone

T3A06- What type of solar radiation is most responsible for ionization in the outer atmosphere?

- A. Thermal
- B. Non-ionized particle
- C. Ultraviolet
- D. Microwave

T3B06- Why should local amateur communications use VHF and UHF frequencies instead of HF frequencies?

- A. To minimize interference on HF bands capable of long-distance communication
- B. Because greater output power is permitted on VHF and UHF
- C. Because HF transmissions are not propagated locally
- D. Because signals are louder on VHF and UHF frequencies

T4A06- What is one way to notify the FCC if your mailing address changes?

- A. Fill out an FCC Form 605 using your new address, attach a copy of your license, and mail it to your local FCC Field Office
- B. Fill out an FCC Form 605 using your new address, attach a copy of your license, and mail it to the FCC office in Gettysburg, PA
- C. Call your local FCC Field Office and give them your new address over the phone
- D. Call the FCC office in Gettysburg, PA, and give them your new address over the phone

T4B06- When you operate your transmitting equipment alone, what is your official designation?

- A. Engineer in Charge
- B. Commercial radio operator
- C. Third party
- D. Control operator

T4C06- What is the proper way to interrupt a repeater conversation to signal a distress call?

- A. Say "BREAK" once, then your call sign
- B. Say "HELP" as many times as it takes to get someone to answer
- C. Say "SOS," then your call sign
- D. Say "EMERGENCY" three times

T5A06- If you let another amateur with a higher class license than yours control your station, what operating privileges are allowed?

- A. Any privileges allowed by the higher license, as long as proper identification procedures are followed
- B. Only the privileges allowed by your license
- C. All the emission privileges of the higher license, but only the frequency privileges of your license
- D. All the frequency privileges of the higher license, but only the emission privileges of your license

T5B07- What amount of transmitter power must amateur stations use at all times?

- A. 25 watts PEP output
- B. 250 watts PEP output
- C. 1500 watts PEP output
- D. The minimum legal power necessary to communicate

T5C06- If you let an unlicensed third party use your amateur station, what must you do at your station's control point?

- A. You must continuously monitor and supervise the third-party's participation
- B. You must monitor and supervise the communication only if contacts are made in countries that have no third-party communications agreement with the US
- C. You must monitor and supervise the communication only if contacts are made on frequencies below 30 MHz
- D. You must key the transmitter and make the station identification

T6A06- What is the meaning of: "Your signal report is five nine plus 20 dB...?"

- A. Your signal strength has increased by a factor of 100
- B. Repeat your transmission on a frequency 20 kHz higher
- C. The bandwidth of your signal is 20 decibels above linearity
- D. A relative signal-strength meter reading is 20 decibels greater than strength 9

T6B06- What is a band plan?

- A. A voluntary guideline beyond the divisions established by the FCC for using different operating modes within an amateur band
- B. A guideline from the FCC for making amateur frequency band allocations
- C. A plan of operating schedules within an amateur band published by the FCC
- D. A plan devised by a club to best use a frequency band during a contest

T6C06- If harmonic radiation from your transmitter is causing interference to television receivers in your neighborhood, who is responsible for taking care of the interference?

- A. The owners of the television receivers are responsible
- B. Both you and the owners of the television receivers share the responsibility
- C. You alone are responsible, since your transmitter is causing the problem
- D. The FCC must decide if you or the owners of the television receivers are responsible

T7A06- How much voltage does an automobile battery usually supply?

- A. About 12 volts
- B. About 30 volts
- C. About 120 volts
- D. About 240 volts

T7B06- Why do we call electrical signals in the frequency range of 20 Hz to 20,000 Hz audio frequencies?

- A. Because the human ear cannot sense anything in this range
- B. Because the human ear can sense sounds in this range
- C. Because this range is too low for radio energy
- D. Because the human ear can sense radio waves in this range

T7C06- What does a capacitor do?

- A. It stores energy electrochemically and opposes a change in current
- B. It stores energy electrostatically and opposes a change in voltage
- C. It stores energy electromagnetically and opposes a change in current
- D. It stores energy electromechanically and opposes a change in voltage

T8A06- What would you connect to a transceiver to send Morse code?

- A. A key-click filter
- B. A telegraph key
- C. An SWR meter
- D. An antenna switch

T8B06- How would the output of the FM transmitter shown in Figure T8-2 be affected if the audio amplifier failed to operate (assuming block 1 is a reactance modulator)?

- A. There would be no output from the transmitter
- B. The output would be 6-dB below the normal output power
- C. The transmitted audio would be distorted but understandable
- D. The output would be an unmodulated carrier

T8C06- What circuit function is found in all types of receivers?

- A. An audio filter
- B. A beat-frequency oscillator
- C. A detector
- D. An RF amplifier

T8D06- How long should you make a quarter-wavelength vertical antenna for 440 MHz (measured to the nearest inch)?

- A. 12 inches
- B. 9 inches
- C. 6 inches
- D. 3 inches

T8E06- What is a coaxial cable?

- A. Two wires side-by-side in a plastic ribbon
- B. Two wires side-by-side held apart by insulating rods
- C. Two wires twisted around each other in a spiral
- D. A center wire inside an insulating material covered by a metal sleeve or shield

T8F06- What test instrument would be useful to measure DC resistance?

- A. An oscilloscope
- B. A spectrum analyzer
- C. A noise bridge
- D. An ohmmeter

T9A05- When using a repeater to communicate, which of the following do you need to know about the repeater?

- A. Its input frequency and offset
- B. Its call sign
- C. Its power level
- D. Whether or not it has an autopatch

T9B06- Which antenna system would NOT be a good choice for an EME (moonbounce) station?

- A. A parabolic-dish antenna
- B. A multi-element array of collinear antennas
- C. A ground-plane antenna
- D. A high-gain array of Yagi antennas

T0A06- For best protection from electrical shock, what should be grounded in an amateur station?

- A. The power supply primary
- B. All station equipment connected to a common ground
- C. The antenna feed line
- D. The AC power mains

T0B06- What should you always do before attempting to climb an antenna tower?

- A. Turn on all radio transmitters that use the tower's antennas
- B. Remove all tower grounding to guard against static electric shock
- C. Put on your safety belt and safety glasses
- D. Inform the FAA and the FCC that you are starting work on a tower

T0C06- From an RF safety standpoint, what impact does the duty cycle have on the minimum safe distance separating an antenna and people in the neighboring environment?

- A. The lower the duty cycle, the shorter the compliance distance
- B. The compliance distance is increased with an increase in the duty cycle
- C. Lower duty cycles subject people in the environment to lower radio-frequency radiation
- D. All of these answers are correct

T0D06- Why should you never look into the open end of a microwave feed horn antenna while the transmitter is operating?

- A. You may be exposing your eyes to more than the maximum permissible exposure of RF radiation
- B. You may be exposing your eyes to more than the maximum permissible exposure level of infrared radiation
- C. You may be exposing your eyes to more than the maximum permissible exposure level of ultraviolet radiation
- D. All of these choices are correct

T0E06- At what frequencies do the FCC's RF radiation exposure guidelines incorporate limits for Maximum Permissible Exposure (MPE)?

- A. All frequencies below 30 MHz
- B. All frequencies between 20,000 Hz and 10 MHz
- C. All frequencies between 300 kHz and 100 GHz
- D. All frequencies above 300 GHz

T0F06- How may an amateur determine that his or her station complies with FCC RF-exposure regulations?

- A. By calculation, based on FCC OET Bulletin No. 65
- B. By calculation, based on computer modeling
- C. By measurement, measuring the field strength using calibrated equipment
- D. Any of these choices

Answers:

T1-CBACB T2-CC T3-CA T4-BDA T5-ADA T6-DAC T7-ABB T8-BDCCDD T9- CC T0-BCDACD

# Element 2 (Technician) Graphics – For use on/after July 1, 2003

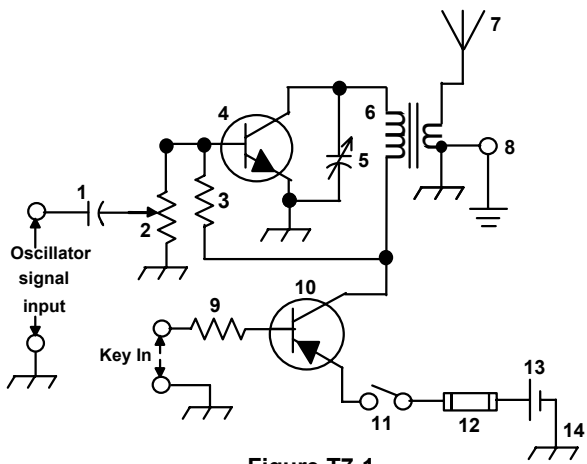


Figure T7-1

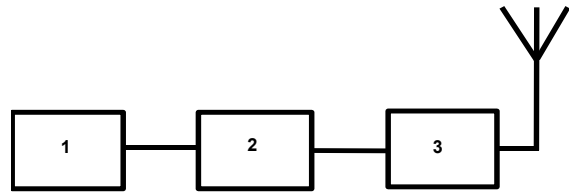


Figure T8-4

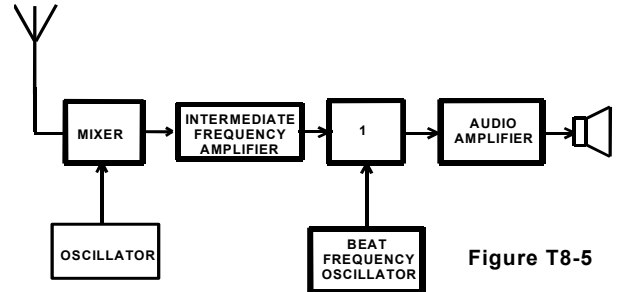


Figure T8-5

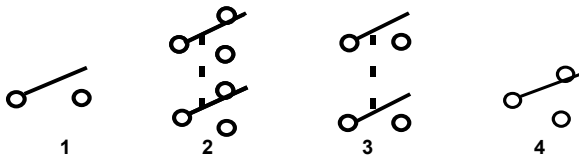


Figure T7-2

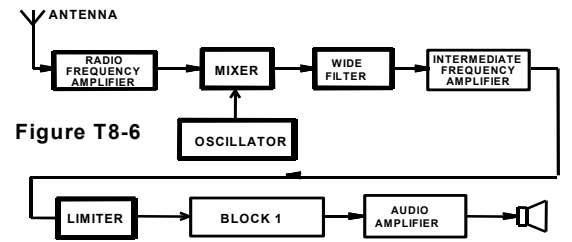


Figure T8-6

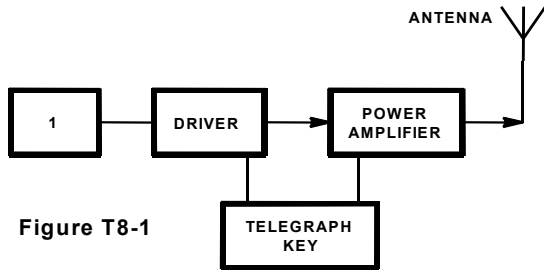


Figure T8-1

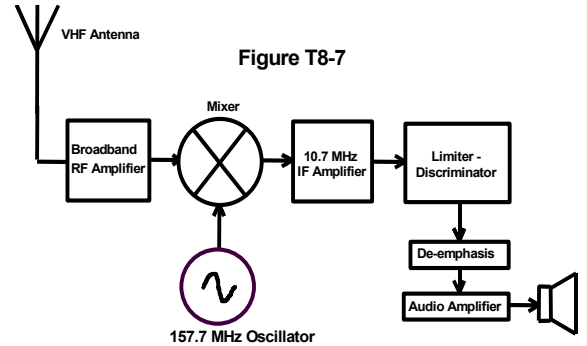


Figure T8-7

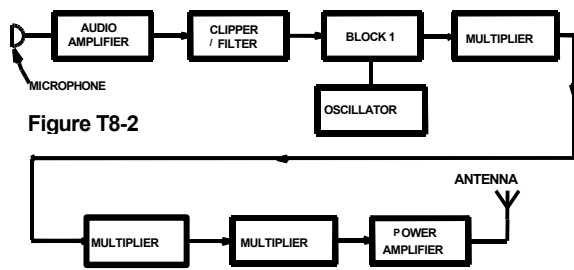


Figure T8-2

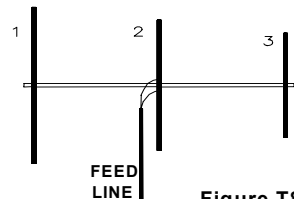


Figure T8-8

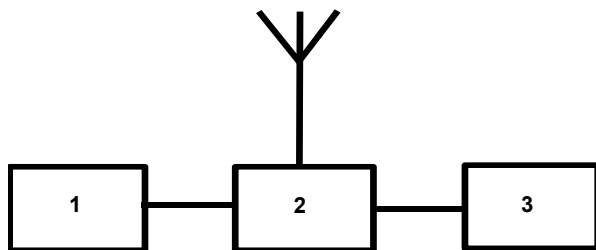


Figure T8-3

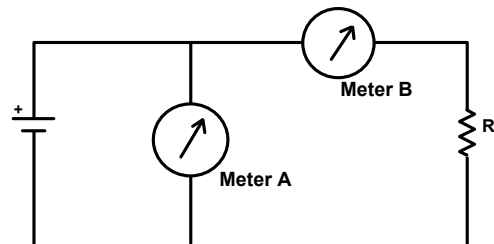


Figure T8-9

**Figure T0- 1**

(A) Limits for Occupational/Controlled Exposure				
Frequency Range (MHz)	Electrical Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm <sup>2</sup> )	Averaging Time (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842/f	4.89/f	(900/f <sup>2</sup> )*	6
30-300	61.4	0.163	1.0	6
300-1500	----	----	f/300	6
1500-100,000	----	----	5	6

(B) Limits for General Population/Uncontrolled Exposure				
Frequency Range (MHz)	Electrical Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm <sup>2</sup> )	Averaging Time (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	(180/f <sup>2</sup> )*	30
30-300	27.5	0.073	0.2	30
300-1500	----	----	f/1500	30
1500-100,000	----	----	1.0	30

f=frequency in MHz    \*=Plane-wave equivalent power density

Estimated distances to meet RF power density guidelines in the main beam of a 17-element Yagi on a five-wavelength boom designed for weak signal communications on the 144 MHz amateur radio band (estimated gain, 16.8 dBi). Calculations include the EPA ground reflection factor of 2.56.

Frequency: 144 MHz  
 Estimated antenna gain: 16.8 dBi  
 Controlled limit: 1 mw/cm<sup>2</sup>  
 Uncontrolled limit: 0.2 mw/cm<sup>2</sup>

Transmitter power (watts)	Distance to controlled limit	Distance to uncontrolled limit
10	10.2'	22.9'
100	32.4'	72.4'
500	72.4'	162'
1500	125.5'	280.6'

**Figure T0- 2**

Estimated distances to meet RF power density guidelines with a horizontal half-wave dipole antenna (estimated gain, 2 dBi). Calculations include the EPA ground reflection factor of 2.56.

Frequency: 7 MHz  
 Estimated antenna gain: 2 dBi  
 Controlled limit: 18.37 mw/cm<sup>2</sup>  
 Uncontrolled limit: 3.67 mw/cm<sup>2</sup>

Transmitter power (watts)	Distance to controlled limit	Distance to uncontrolled limit
100	1.4'	3.1'
500	3.1'	6.9'
1000	4.3'	9.7'
1500	5.3'	11.9'

Estimated distances to meet RF power density guidelines with a VHF quarter-wave ground plane or mobile whip antenna (estimated gain, 1 dBi). Calculations include the EPA ground reflection factor of 2.56.

Frequency: 146 MHz  
 Estimated antenna gain: 1 dBi  
 Controlled limit: 1 mw/cm<sup>2</sup>  
 Uncontrolled limit: 0.2 mw/cm<sup>2</sup>

Transmitter power (watts)	Distance to controlled limit	Distance to uncontrolled limit
10	1.7'	3.7'
50	3.7'	8.3'
150	6.4'	14.4'

Estimated distances to meet RF power density guidelines in the main beam of a typical 3-element "triband" Yagi for the 14, 21 and 28 MHz amateur radio bands. Calculations include the EPA ground reflection factor of 2.56.

Frequency: 28 MHz  
 Antenna gain: 8 dBi  
 Controlled limit: 1.15 mw/cm<sup>2</sup>  
 Uncontrolled limit: 0.23 mw/cm<sup>2</sup>

Transmitter power (watts)	Distance to controlled limit	Distance to uncontrolled limit
100	11'	24.5'
500	24.5'	54.9'
1000	34.7'	77.6'
1500	42.5'	95.1'

Estimated distances to meet RF power density guidelines in the main beam of UHF 5/8 ground plane or mobile whip antenna (estimated gain, 4 dBi). Calculations include the EPA ground reflection factor of 2.56.

Frequency: 446 MHz  
 Estimated antenna gain: 4 dBi  
 Controlled limit: 1.49 mw/cm<sup>2</sup>  
 Uncontrolled limit: 0.3 mw/cm<sup>2</sup>

Transmitter power (watts)	Distance to controlled limit	Distance to uncontrolled limit
10	1.9'	4.3'
50	4.3'	9.6'
150	7.5'	16.7'