Amateur Radio – Technician License Notes

Web resources:

Ham Radio Organizations:
ARRL – http://www.arrl.org – National organization – general info
NC-ARRL – http://www.ncarrl.org – State branch – general info
Tucson Amateur Packet Radio – http://www.tapr.org - digital modes, software
QRZ – http://www.qrz.org – callsign search, new and used gear
QRZ – http://www.qrz.com – callsign search
QRZ – http://qrz.com/hamtest/ – Practice exams
Lenoir Club – http://n4lnr.org – local club, meets at Gamewell FD on 2nd Thursday
Federal Communications Commission – http://www.fcc.gov
Question Pools – http://www.arrl.org/question-pools

Weather:
National Weather Service – http://www.nws.noaa.gov
Weather Forecasts – http://wunderground.com – includes local monitoring stations

Suppliers:
Ham Radio Outlet – http://www.hamradio.com -- general supplier
Amateur Electronic Supply – http://www.aesham.com - general supplier
Texas Towers – http://texastowers.com -- Radios, antennas, towers
Ten-Tec – http://tentec.com - Radios, kits
MFJ – http://www.mfjenterprises.com – Accessories

Layout of the Exam

SUBELEMENT T1 – COMMISSION'S RULES - [6 Exam Questions - 6 Groups] 67 Questions

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

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

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

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

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

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

SUBELEMENT T2 - OPERATING PROCEDURES - [3 Exam Questions - 3 Groups] 36 Questions

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

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

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

SUBELEMENT T3 – RADIO WAVE PROPAGATION – [3 Exam Questions - 3 Groups] 34 Questions

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

T3B - Electromagnetic wave properties: wavelength vs frequency, nature and velocity of electromagnetic waves,relationship of wavelength and frequency; Electromagnetic spectrum definitions: UHF, VHF, HFT3C - Propagation modes: sporadic E, meteor scatter, auroral propagation, tropospheric ducting; F region skip; Line of sight and radio horizon

SUBELEMENT T4 – AMATEUR RADIO PRACTICES – [2 Exam Questions - 2 Groups] 24 Questions

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

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

SUBELEMENT T5 – ELECTRICAL PRINCIPLES – [4 Exam Questions - 4 Groups] 52 Questions

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

T5B - Math for electronics: conversion of electrical units, decibels

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

T5D – Ohm’s Law; Series and parallel circuits

SUBELEMENT T6 – ELECTRONIC AND ELECTRICAL COMPONENTS – [4 Exam Questions - 4 Groups] 47 Questions

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

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

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

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

SUBELEMENT T7 – PRACTICAL CIRCUITS – [4 Exam Questions - 4 Groups] 44 Questions

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

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

T7C – Antenna and transmission line measurements and troubleshooting: measuring SWR, effects of high SWR, causes of feed line failures; Basic coaxial cable characteristics; Use of dummy loads when testingT7D – Using basic test instruments: voltmeter, ammeter, and ohmmeter; Soldering

SUBELEMENT T8 – SIGNALS AND EMISSIONS – [4 Exam Questions - 4 Groups] 48 Questions

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

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

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

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

SUBELEMENT T9 – ANTENNAS AND FEED LINES - [2 Exam Questions - 2 Groups] 24 Questions

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

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

SUBELEMENT T0 – SAFETY – [3 Exam Questions - 3 Groups] 36 Questions

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

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

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

Metric System

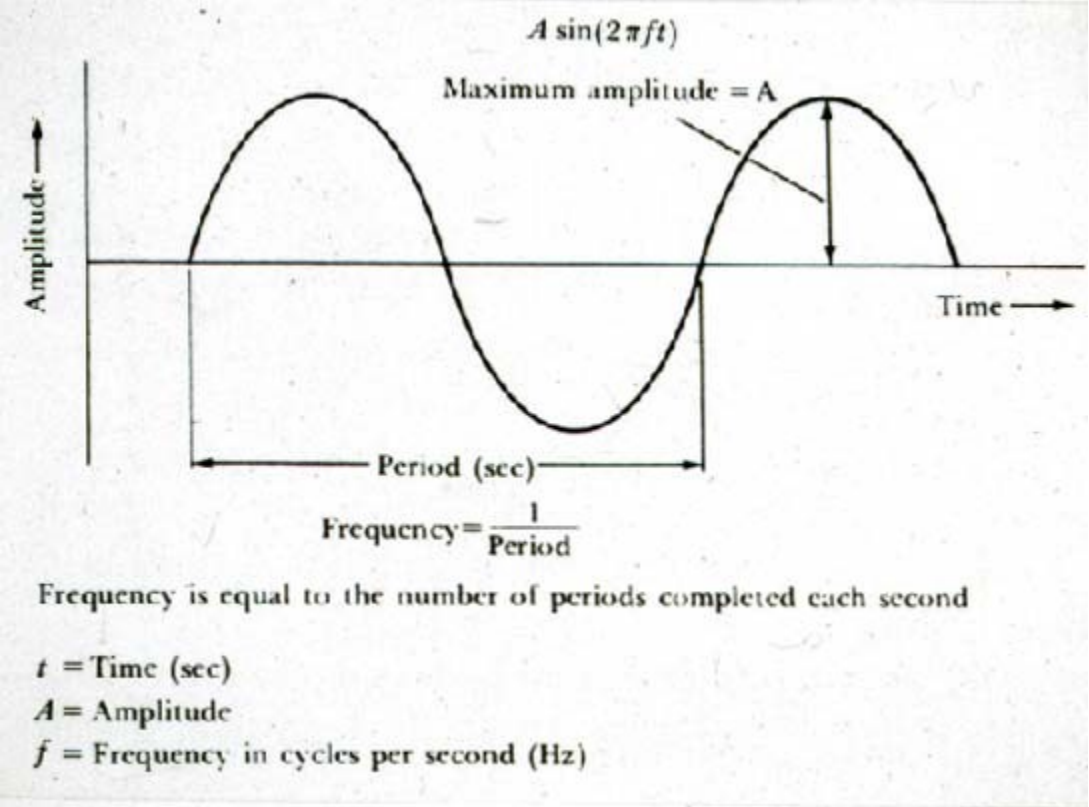
The metric system is based on powers of 10. Prefixes are used to represent common values. Often, prefixes starting with a capital letter are used for values greater than 1 and prefixes starting with small letters are used for values less than 1.

Prefix	*Symbol(s)*	*Power*	*Value*	*Common Name*
Exa	E	10^{18}	1,000,000,000,000,000,000	Quintillion
Peta	P	10^{15}	1,000,000,000,000,000	Quadrillion
Tera	T	10^{12}	1,000,000,000,000	Trillion
Giga	G	10^{9}	1,000,000,000	Billion
Mega	M	10^{6}	1,000,000	Million
Kilo	K	10^{3}	1,000	Thousand
Hecto	H	10^{2}	100	Hundred
Deka	D	10^{1}	10	Ten
		10^{0}	1	unit
deci	d	10^{-1}	0.1	tenth
centi	c	10^{-2}	0.01	hundredth
milli	m	10^{-3}	0.001	thousandth
micro	u or μ	10^{-6}	0.000001	millionth
nano	n	10^{-9}	0.000000001	billionth
pico	p	10^{-12}	0.000000000001	trillionth
femto	f	10^{-15}	0.000000000000001	quadrillionth
atto	a	10^{-18}	0.000000000000000001	quintillionth

Conversion Hints:
1. If the prefix becomes smaller, the number must become bigger
2. If the prefix becomes bigger, the number must become smaller
3. For values greater than 1, the exponent indicates how many places to move the point to the right (filling with zeros)
4. For values less than 1, the exponent indicates how many places to move the point to the left (fill with zeros)
5. The most common values use exponents that are multiples of 3

Basic Terminology

Radio is based on waves (actually transverse waves) based on a sine function. These are called sine waves and have some terminology associated with them.



Amplitude – the maximum swing or peak away from the center – measured in volts, amps, or watts.

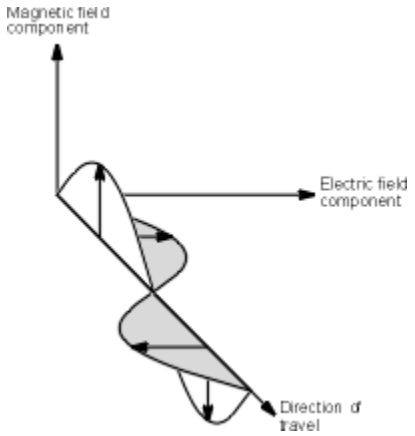
Period (T) – the time from one peak to same spot on the next peak or the time required for the wave to complete one complete cycle – measured in seconds.

Frequency (f) – the number of complete cycles that the wave completes in 1 second. Measured in cycles per second (cps) which is given the name **Hertz** (Hz).

Wavelength (symbol λ) is the distance that the wave travels in one cycle – measured in meters.

Audio Frequencies are from 20 to 20000 Hz. **Radio Frequencies** are usually considered to be above 100000Hz (100 KiloHz or 100 KHz). Radio waves are usually designated by frequency in **KHz**, **MHz**, or **GHz**; or by wavelength in meters, centimeters, or millimeters.

Radio waves are **Electromagnetic waves** which means that they are composed of an electrical part (called the electrical vectors) and a magnetic part (called magnetic vectors) which are at right angles to each other. The direction of propagation is at right angles to both vectors. FYI: This is described by a Right-Hand-Rule.



Other Electromagnetic waves include, X-Rays, Light, UV, Infrared and gamma rays. FYI: The frequency of light is in the THz range with a wavelength in nanometers.

Wavelength times frequency gives the speed of the wave. The speed of light in a vacuum is usually picked as a standard. This is given the symbol **c** and has an approximate value of **$3x10^8$ meters/sec.**

Results: $\lambda = 3x10^8 / f$ also $f = 3x10^8 / \lambda$ for f in Hz, and λ in meters.

Or $\frac{300}{meters} = MHz$ or

$\frac{300}{MHz} = meters$

Rule of Thumb: If Frequency increases, wavelength decreases by the same amount.

The range of frequencies are broken up into

High Frequency (**HF**) -	3 MHz to 30 MHz	100 m to 10 m
Very High Frequency (**VHF**) -	30 MHz to 300 MHz	10 m to 1 m
Ultra High Frequency (**UHF**) -	300 MHz to 3 GHz	1 m to 10 cm
Super High Frequency (**SHF**) -	3 GHz to 30 GHz	10 cm to 1 cm
Extra High Frequency (**EHF**) -	30 GHz to 300 GHz	1 cm to 1 mm

These are further broken up into Amateur Radio **Bands** by approximate wavelength.
FYI: AM broadcast Radio 540KHz- 1.6 MHz (called Medium Frequency MF)
FM broadcast Radio 88 MHz – 108 MHz – VHF
Broadcast TV – VHF (Ch 2-13) and UHF (ch 14 up)
Cell Phones – 800 MHz or 1.8 GHz (UHF)
802.11x (wireless) – 1.4 Ghz (UHF) or 5.4 Ghz (SHF)

Section 1 – FCC Rules

US radio regulations are enforced by the Federal Communications Commission (**FCC**) located in Gettysburg, PA. The FCC jurisdiction is the US and all US territories. Most of the US is in **ITU Region 2**. Some outlying territories may be in other regions. For example, Guam is in **ITU Region 3**.

International Regulations are created by treaty with the International Telecommunications Union (**ITU**) under the UN. The Amateur Radio Service is for personal use with no pecuniary (money) interest.

Definitions:

Harmful Interference – seriously degrades, obstructs or interrupts communications service operating within regulations.

Space Station - an Amateur station more than 50km above the Earth's Surface.

Telecommand – One way communication to control a device at a distance.

Telemetry – One way communications of distant measurements.

Frequency Coordinator – selected by amateurs and recommends channels for repeaters.

Amateur Station – in amateur service consisting of communications equipment.

Auxillary Station – transmits signals from a remote location to a repeater for retransmission.

Simplex – transmit and receive on the same frequency.

Full duplex – transmit and receive simultaneously on different frequencies.

The section of the FCC rules that covers Amateur Radio is **Part 97**.

The five assigned principles of the Amateur Radio Service:
1. Recognize the value to the public of emergency communications.
2. Advancement of the radio art.
3. Improve communications and technical skills.
4. Create a reservoir of trained operators, technicians, and electronics experts.
5. Enhance international goodwill.

An **Amateur Operator** has been granted a license in the Amateur Radio Service. The person granted the license is the **Operator** or **Control Operator** and may operate amateur radio equipment anywhere in the jurisdiction of the FCC. Exceptions – *to operate on a ship, the ham must get permission from the master of the ship; to operate on an airplane, the ham must get permission from the pilot.*

An **Amateur Station license** indicates the **primary** location (mailing address) of the amateur station. *Station licenses have no privileges. The address must be kept accurate so that the FCC can contact the ham.* The holder of the station license is responsible for correct operation of the station.

The operator portion of the license contains the **license class.** The license is valid as soon as it appears in the FCC database. It is good for 10 years and can be renewed no sooner than 90 days from expiration. There is a 2 year grace period for renewal without having to re-take exams, but the license may not be used during the grace period.

The original license or a photocopy must be posted at the primary station location and must be accessible for any transmitting.

Anyone who is not a representative of a foreign government or has not had a license revoked is eligible for a license. Note that there is no age limit or citizenship requirement.

License exams are given by Volunteer Examiners (**VE**s) who are hams authorized to give the exams. There are 3 classes of license, in order of privileges **Technician, General, and Amateur Extra.**

The Technician exam is referred to as **Element 2** and consists of 35 questions. A technician has all privileges on all ham bands above 50 Mhz. **Element 1** (5 word per minute Morse Code), is no longer required for any Amateur license class but Morse code (also referred to as CW) is allowed as a **mode**. Element 3 (a theory exam) must be also passed for a technician to get a General license. Element 4 (additional theory) must also be passed to get the Amateur Extra class license. Passing of any additional elements is shown by a **Certificate of Successful Completion (CSCE) .** A ham may use any additional privileges as soon as the CSCE is issued. CSCE's are only good for 1 year.

Callsigns consist of a prefix, a number, and a suffix. The prefix identifies the country, the number, some division within that country or territory.

All US callsigns must begin with an A, K, N, or W. The prefix is 1 or 2 letters, followed by one digit 0-9 followed by 1 to 3 letters. Callsigns are described as n by m. For example kd4ytu is a 2 x 3 call (2 character prefix, 3 character suffix). Any amateur may apply for a temporary 1 x 1 call, valid for a short period for a special event.

Technicians may obtain callsigns from group C (2 x 2) or group D (2 x 3). Callsigns are assigned sequentially from the FCC database. A licensed ham may request a new sequential callsign or a custom "vanity" callsign. Also, a club may apply for a station callsign through a Club Station Callsign Administrator.

A ham must **identify** using the callsign **every 10 minutes** and at the **end of a transmission.**

Amateur Radio is a point-to-point, non-commercial service. This means that a ham:
1) May not use vulgar or obscene language over the air.
2) May not broadcast.
3) May not play music.
4) May not use false or deceptive signals or codes.
5) May not use encryption or codes meant to hide the meaning of the signal except for radio control.
6) May not accept money or any other value for using the radio.
7) May only communicate with other amateurs.

Section 2 – Methods of Communication

A **Harmonic** is an integer multiple of a frequency. For example using 7MHz (1st Harmonic), then 14MHz would be the 2nd Harmonic (7x2) and 21MHz would be the 3rd Harmonic (7x3).

Communication occurs when a radio wave (the **carrier)** is modified (**modulated**) by the desired information at the **transmitter**. The two are separated at the **receiver.**

The FCC defines emission types as phone (voice), image (fax and video), RTTY (teletype), data (computer info). CW (Morse Code), Pulse (remote control), and test.
CW is the only emission type allowed anywhere in the amateur bands. Other types are restricted by FCC rules or by Band plans. The term **mode** is used to more narrowly define emission types. The 10, 2, 6, and 1.25 meter bands have mode-restricted sub-bands.

Phone can be:

AM – amplitude modulation – the amplitude of the carrier is modified.
FM – frequency modulation – the frequency of the carrier is modified.
SSB – single sideband – a modified AM in which only one sideband is sent.

Another modulation type is PM – phase modulation, which affects the starting point of the waves. PM has the same effect as FM and is sometimes used to generate FM. Be careful at the edge of each band since the bandwidth may cause signal to be outside the band edge. Due to tolerance in the transmitters, drift and bandwidths, the transmit frequency should never be set to the band-edge.

Technicians can use all allowed modes on all bands above 50 Mhz. A technician can also use CW and SSB phone on parts of the 10 meter band and CW on parts of the 15, 40, and 80 meter bands. Some modes like fast-scan tv image and spread-spectrum are only allowed on UHF and higher bands. One restriction is that only point-to-point messaging is allowed on the lower part of the 1.25 meter band (219-220 MHz). On some bands, amateurs are a **secondary** service, which means that amateurs may not cause harmful interference to **primary** users.

A special mode is Radio Control, which is normally found on the 6 meter band. The identification for RC is the Station Call, and Address on a label attached to the transmitter.

One of the digital modes is **Packet** (Similar to the Internet) which can be operated unconnected (group) or connected (sending to a specific station).

Each mode has a particular **Bandwidth** which is the difference between the highest and lowest frequency required to transmit a signal. Some common bandwidths are:
FM – 15 KHz, AM – 6 KHz, SSB – 3 KHz, CW – 250 Hz, PSK31 (a data mode) 31 Hz.

Most repeater contacts are via FM. It has lower noise and better sound than AM or SSB. A good signal will cause “full quieting” which greatly reduces the noise. Most SSB contacts above the 40 meter band use the upper sideband (USB) while 40, 80, and 160 meter bands use lower sideband (LSB).

Section 4 – Station Licensee Duties

License applications are sent in on FCC **Form 605** which provides the FCC with information, including an accurate mailing address. The amateur license received from the FCC contains both operator and station privileges. Even though the primary station location is the address on the

license, an amateur may operate at any location under the jurisdiction of the FCC, with a few exceptions.

There are certain restrictions on antenna structures. An antenna structure (tower) may not be over 200 feet high without getting FCC approval and notification of the FAA. There may be additional local zoning or other regulations. In general, the higher the antenna, the better the performance of the radio.

A control operator is an amateur operator designated by the licensee of the station (usually the same person). Only a licensed ham may be a control operator and a control operator must be present anytime the station is transmitting. The control operator may control any number of transmitters. The control operator may use all privileges allowed by his/her license and only uses the control operator's call. If the control operators license is lower than the station license, the control operator is still restricted to the privileges or his/her license. The location where the station is controlled is call the **control point**.

It is the station licensee's responsibility to ensure that the station cannot be operated without a licensed ham as the control operator. This could be done by installing a key operated switch in the power line for a home station or disconnecting the microphone or locking the unit in the trunk of a car.

Even though a station is not required to keep logs of operation. It is advantageous to keep records of testing and any other control operators. The FCC may inspect the station and any records at any time. The station licensee and the control operator share responsibility for proper operation of the station. If the station causes interference to properly designed nearby radio or TV receivers, the FCC may apply time or power restrictions to the station.

In an emergency, where there is an immediate threat to life or property, the ham may do anything necessary to get or provide assistance. This includes transmitting outside of license privileges, transmitting out of the ham bands, or allowing a third party (ie a doctor) to use the radio.

Distress calls should be made using "**MAYDAY**" on voice or "**SOS**" on CW. If interrupting a conversation in progress, a ham should say "**BREAK**" and the his/her callsign during a gap. (Note that this is the only time a ham should call "BREAK"). When recognized, provide the nature of the emergency, the location, the type of assistance required and any other useful information.

During a disaster, hams should only make transmissions that are necessary to provide essential communications and facilitate relief. The FCC may declare a temporary state of emergency communications in which they specify special conditions and rules for use during the emergency.

Messages being passed are referred to as "**traffic**". Traffic is classified as: **Emergency** – concerns immediate safety of life (ie. injuries); **Priority** – additional needs for life or safety (ie. reporting downed live power lines); **Health and Welfare** – condition and well being of persons in the disaster area; and **Routine** – all other traffic.

Often, during an event, **tactical** calls may be used (ie. "net control", "aid station 1") but proper identification using official callsigns must still be used every 10 minutes and at the end.

Since one of the purposes of Amateur Radio is to provide emergency communications, it is useful for a ham to have portable or mobile transceivers, portable antennas such as a roll-up

dipole, and backup power (generator or extra batteries).

RACES is the Radio Amateurs Civil Emergency Service and is an official part of FEMA. Government agencies may declare a Civil emergency and allow only RACES registered stations to transmit. RACES drills are conducted periodically and any transmissions during the drill must be identified as drill or test messages.

ARES is the Amateur Radio Emergency Service which is a volunteer emergency service registered with the ARRL. ARES may be activated as needed by any member or affiliated organization (Emergency Management, Red Cross, Salvation Army, NWS etc,)Note: in North Carolina ARES members are also registered in RACES by the state ARES

AUXCOM is the current merger of RACES, ARES, and other emergency radio services. It is administered by the state.

SKYWARN – is a severe weather network associated with the National Weather Service. It is not limited to hams, but hams are encouraged to join. Training in severe weather spotting is provided by the NWS.

Section 5 – Control Operator Duties

The control operator and station licensee share responsibility for the proper operation of the station. Control operators are always restricted to the privileges of their own license but may operate any amateur equipment within those privileges. The detailed responsibilities are found in the FCC rules Part 97. The control operator must be at the control point unless the station is automatically controlled (usually a repeater).

Power output from a station is measured in **Watts.** The average power of the highest peak of the signal is called the **Peak Envelope Power (PEP)**. Hams are required to use the minimum power necessary for reliable communications. Maximum power for most bands is 1500 Watts PEP. There are lower power restrictions for some bands and band segments (usually 200W or 100W PEP).

Hams are not allowed to produce harmful interference to anyone. On bands where hams have a secondary status, hams may not cause interference to the primary service. If the primary service causes interference, the ham should change frequency in order not to interfere with the primary service.

One-way communication is prohibited except for: control of a model craft (telecommand); transmitting for Morse code practice; transmitting general information and bulletins for the Amateur community; and beacon operation.

Third party communications is to or for the benefit of someone not allowed to be a control operator. A control operator must supervise all third party communications. International third party communications are only allowed with countries that have a third party agreement with the US. The US station must transmit both callsigns at the end of international third party communications.

Section 6 – Good Operating Practices

Good operating habits require experience. Even so, there are some general rules that should be followed. These are to minimize interference to other hams and services; ensure compliance with FCC regulations; and help ensure clarity of communications, especially during emergencies.

The first rule is to always listen before transmitting to ensure that the frequency is not already in use. Another is to talk as you would in a face to face talk. Avoid the use of jargon. CW abbreviations (Q signals) should not be used on voice. "10 codes" should never be used. Another problem is the use of "Roger" which means "I understand" not "yes".

Under noisy conditions, standard phonetics are used for clarity. These are an ITU standard listed as follows.

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

Note that some of these have unusual pronunciations (think Boston). The strange ones are Lima (**Lee-**Ma , the city, not the bean), Oscar (**Oss** – Kah), Papa (Pah **Pah),** Victor (**Vik**- Tah), and Whiskey (**Wiss**- Key). Only if the standard phonetics cannot be understood, should non-standard ones be used. You will hear people trying to be cute who will nearly always use something off-the-wall. This is confusing to non-English speakers (and some English speakers).

The term **CQ** literally means Seek You and is used as a general call for anyone to answer. CQ's should be short with much listening between calls. The preferred method of calling CQ on phone (voice) is to call CQ three times followed by "this is" and your call three times. Example "CQ CQ Calling CQ this is KD4YTU Kilo Delta 4 Yankee Tango Uniform KD4YTU calling CQ and listening".

The proper way to answer a CQ is to say the other station's call once followed by "this is" followed by your call phonetically. Example "DE1ROK this is Kilo Delta 4 Yankee Tango Uniform".

If you are calling a specific station on a repeater simply say the other stations call followed by your call. Example "K4FCW KD4YTU". By putting your call last, if the other station doesn't answer, then FCC rules of "identifying at the end" is met.

On non-repeater contacts, a common exchange is the **RST** (Readability, Signal Strength, Tone) report in the form of three numbers. The first number is 0 (unreadable) to 5 (perfectly readable) the 2nd and 3rd number are from 0 (weakest/worst) to 9 (strong/best). The signal strength is usually available on an S-meter on the radio. All three numbers are only used with CW. On

phone, only the first two – Readability, and Signal Strength – are used. Really strong signals will be greater than 9 so you might give a report of "5 9 plus 10 dB" to indicate 10 deciBels greater than S9.

On a repeater, the term "Full Quieting" is used to tell the other station that their signal is strong enough to blank out all background noise.

Other terms to know: A QSO (Que- So) is a conversation, a QSL card is a written confirmation of a contact, DX refers to long distance communications, "73" means best wishes, "88" means love and kisses (be careful with this last one).

Bandwidth and Band plans

All signals occupy a range of frequencies. The **Bandwidth** is the highest frequency minus the lowest frequency used by the signal. The carrier frequency is the frequency tuned on the radio. The carrier may be at the lower end, upper end or middle of the bandwidth.

In general, the more information carried by a signal, the greater the bandwidth. This means that common modes increase bandwidth as : CW (500 Hz), RTTY (1 KHz), SSB voice (2 – 3 KHz) , AM (6 Khz) , FM voice (10 – 20 KHz) , TV (6 MHz). Digital data can be in several bandwidths.

The FCC mandates some **Band Plans** which restricts modes that can be used in certain frequency ranges. However, most band plans are voluntary and are used to allow all modes some dedicated frequencies to operate on. Note that CW can be used on any Amateur frequency.

One mode gaining popularity is to use an **Internet Gateway** to connect two amateur stations over the Internet.

Morse Code

Even though Morse Code is not required for any license, since it is still allowed, some operators use CW.

Abbreviations called **Procedural Signals** are used with CW to gain efficiency. Some of them are:

CQ – calling any station
DE – "This is" -- normally used only with CW
K - "Other station go ahead (phone is "over") - normally used only with CW

QRM – man made interference (eg. Other stations)
QRN – natural interference (eg. Static)
QRP – decrease power – or I am using low power (less than 5W)
QRS – Send more slowly
QRT – signing off – end of transmission
QRZ – Who is calling me?
QSL – acknowledge – confirm reception
QSO – a conversation
QSY – Change frequency
QTH -- Location

You should never send a CQ at a faster speed than you can reliably receive. To send a CQ via CW send "CQ" three times followed by "DE" followed by your call three times. To answer a CW call, send the other station's call twice followed by "DE" followed by your call twice. Note that the use of CW Procedural Signals, or any other jargon when using phone (voice) is considered bad operating practice.

TVI and RFI reduction

TVI (TeleVision Interference) and **RFI** (Radio Frequency Interference) can be reduced by filters. Reduction of interference to *well designed* televisions, telephones, etc. is the responsibility of the ham. If the ham station is operating within specifications, the ham has no responsibility for interference to *poorly designed* equipment. Even so, to prevent hard feelings, the ham may attempt to reduce the interference. Interference may also be to the ham station. Anytime the ham station is accused of TVI, the first thing for the ham to do is check to see if there is interference to his/her own TV.

A strong signal near a receiver may result in overload to that receiver. Usually, changing frequency does not help, but there are special filters (called traps) that may help if placed in the receiver's antenna wire. If the transmitter is an HF transmitter, placing a **High Pass Filter** (pass high – block low frequencies) in a TV antenna lead may eliminate the interference. The owner of the receiver is responsible for correcting the interference. Most telephones fall into this category since many do not have the proper filtering installed at the factory.

Harmonic interference is due to the transmitter radiating harmonics (multiples) of the transmitting frequency. This is a problem with the transmitter. The interference may be reduced or eliminated by placing a **Low Pass Filter** (pass low – block high frequencies) in the transmitters antenna cable.

Spurious emissions are extra frequencies emitted from a transmitter near the transmitting frequency. The ham is responsible for clearing up any interference due to spurious emissions. These may be caused by having the MIC gain on a SSB transmitter set too high – resulting in splatter.

Broken shielding from TV cable can cause interference to the ham station's receiver, or cause TV interference when the ham is transmitting. There is much potential from the new BPL (Broadband over Powerline) Internet providers to have the same problem.

Two other filters that are useful in certain applications are: Notch Filters – block a specifc range of frequencies allowing others to pass; and BandPass Filters – allow only a specific frequency range to pass, blocking all others.

Repeaters

A repeater is a station at a high place such as a mountain or water tower, which is used to extend the range of radio transmissions. Repeaters can be used on any amateur band but the most common are 2m, 70cm, 6m, 1.25m, and 10m. The mode for phone repeaters is FM. There are also repeaters for digital, packet, and television.

Any amateur allowed to operate in a band can operate a repeater. Repeaters being used on more than a temporary basis should be coordinated to prevent interference with other repeaters. If a

conflict arises between an un-coordinated repeater and a coordinated repeater, then the ruling is in favor of the coordinated repeater.

Repeaters work by receiving on one frequency and re-transmitting on another frequency. The difference between the receive an transmit frequency is the **offset**, which is commonly **600KHz** for 2m repeaters. and **5MHz** for 70cm repeaters. Many repeaters also have a sub-audible tone (CTCSS) that must be present on the signal. Radios designed to use repeaters should be set for the repeater receive frequency, the repeater offset, and the tone (if needed). The radio will then automatically switch to the proper transmit frequency when needed.

Example:

> A 2m repeater is said to operate on 145.210MHz with a (+) offset and a tone of 91.5. The radio should be set for the receive frequency, which in this case is 145.210MHz. The offset should be put in the radio as +. This means that when the PTT is pressed, the radio will shift to 145.210 + 0.6 = 125.810MHz to transmit (the repeater's receive frequency). However, the repeater will not respond until the tone is set to 91.5 Hz. This tone will be transmitted any time that the radio is transmitting.

Normally, the frequency, offset and tone are set with the radio in VFO (Variable Frequency Oscillator) mode. Then the settings are saved as a **memory channel**, which can then be used separately. Newer radios may have hundreds of memory channels and may also save things such as an alpha-numeric name for the repeater.

Most radios can also switch into **reverse**. In this mode, the transmit and receive frequencies are switched so that the radio can talk direct to radios set up to use the repeater. Some radios also support **cross-band repeat** so that they can act as a repeater between the 2m and 70cm band (for example).

Sections 5 & 6 Electronics

An electrical **current** is a net movement of electric charge. Charge can be positive (+) or negative (-). In solids, the charge is most often carried by **electrons**, which have a negative charge.

Electrical current is measured in **Amps (A)**, an can be compared to the **flow** of water. In math formulas, current is represented by "I". To have a current, there must be a complete circular path, a **circuit**, containing a **source**, which provides the current, and a **load**, which uses the current.

Materials that support a current are called **conductors** and include most metals and salt water. It is the current that does the work and is dangerous. Materials that do not (easily) support a current are called **insulators** and include most non-metals, distilled water, and air.

A current that flows in only one direction is called **Direct Current (DC)**. Batteries and most power supplies are sources for DC. If the current periodically reverses direction, it is referred to as **Alternating Current (AC)**. Most residential power outlets provide AC. Just like an electromagnetic wave, AC has a frequency and wavelength. The velocity of currents in wires is slightly less than the speed of light.

For a current to be produced, there must be a force, similar to pressure in a water system. The electric force is called the **Electromotive Force**, often referred to as **Voltage**. This force is measured in **(V)**. Math formulas use a "V" or "E" to represent voltage. The most common voltages in use by Ham Radio are 12V and 120V. Just like water can have pressure without any flow, a circuit can have voltage without any current. Also, there are no "perfect" insulators. If the voltage is high enough, a current can be forced through any insulator.

The opposition to a current flow is referred to as **Resistance**. Resistance is measured in **Ohms(Ω)** and is represented in math formulas by "R". Resistance is similar to friction in mechanical systems. The effect of resistance is that energy is dissipated as heat.