Ham Radio License Manual - Supplemental Material

1 July 2009

The following text is presented on the *Ham Radio License Manual* Web page as "Supplemental Material" intended to support or correct the 1st edition of the text. It is reproduced here for instructors and students to use independently from Web access.

A separate document "New Technician Rules from FCC Rule Changes" covers changes to the Technician Class material resulting from the December 2006 FCC rule changes.

The question pool for the Technician Class license will update on July 1, 2010—not 2009 as printed in the Online Exams section of Chapter 1.

Section I

What is an Elmer?

The term "Elmer"--meaning someone who provides personal guidance and assistance to would-be hams--first appeared in QST in a March 1971 "How's DX" column by Rod Newkirk, W9BRD (now also VA3ZBB). Newkirk called them "the unsung fathers of Amateur Radio." While he probably was not trying to coin a term at the time, here's how Newkirk introduced "Elmer" in his column and, as it turned out, to the rest of the Amateur Radio world:

"Too frequently one hears a sad story in this little nutshell: 'Oh, I almost got a ticket, too, but Elmer, W9XYZ, moved away and I kind of lost interest.'"

Newkirk went on to say, "We need those Elmers. All the Elmers, including the ham who took the most time and trouble to give you a push toward your license, are the birds who keep this great game young and fresh."--Rick Lindquist, N1RL

Section II

The Decibel

In the sidebar, the correct decibel value for 20 log (0.1/2) is -26 dB, not -13 dB as in the text. (Note - previous copies of this document show the argument of the log as (0.1/20), not (0.1/2).)

Amplitude Modulation

In Figure 2-24's right-hand graph, the x-axis labels should be, in order: 797.0, 799.7, 800.3, and 803.0
In Figure 2-25, the x-axis labels should be, in order: 600.3 and 603.0

Comparing Modulations

With all the different types of modulation and signals available, how do you choose one over the other? What are the strengths and weaknesses of each? What makes one "better" than another? All of these are excellent questions. Luckily, a lot of experimenting has already been done! As a result, hams know which kind of modulation provides the best results for the desired use.

Lets start with repeaters. Repeaters provide local and regional communications between mobile and portable stations. These stations aren't trying to contact the most distant or weakest station--they just want to stay in touch with each other as they move between home, work, and other day-to-day activities. The job of the repeater is to provide a strong, low-noise signal that everyone can hear and understand well, especially in emergencies. While it is possible for repeaters to use almost any type of modulation, FM has been determined to provide the best performance for these uses. FM signals have much less noise under most circumstances, but they are typically much broader than an AM or SSB signals. Repeaters use FM because the benefits of clear speech reproduction outweigh the drawbacks of consuming more power and bandwidth.

Even though FM may provide better fidelity, SSB is often used where available spectrum space is not sufficient to support a large number of FM users. The HF bands below 30 MHz are almost exclusively SSB (or CW) for this reason. SSB's primary advantage over FM is that the signals use much less bandwidth as described in Table 2-TBD. It is also possible to communicate with SSB over much longer ranges and in poorer conditions than with FM or AM, particularly on the VHF and UHF bands. That is why the VHF and UHF "DX-ers" use SSB signals. All of the SSB signal's power carries information in a narrow channel for maximum range.

For the best range of all, the extremely narrow CW signals are easiest for a human operator to send and receive, particularly in noisy or fading conditions. Digital signals with built-in error correction methods, generated and recovered by computer, can achieve the highest "miles per watt" of any type of modulation.

If an SSB signal can be either an upper or lower sideband--which one do you use? There is no technical reason why USB is preferred over LSB. However, in order to reduce uncertainty and make communications easier, amateur radio has standardized on the following conventions:

Below 10 MHz, LSB is used
Above 10 MHz, USB is used--including all of the VHF and UHF bands

There is one exception: amateurs are required to use USB on the five 60-meter band (5 MHz) channels. This convention is even programmed into radio equipment as the normal operating mode!

Table 2-TBD (TBD will be changed when the manual is reprinted) shows the bandwidths of typical amateur and common broadcast signals. There is quite a range from the narrowest (CW) to the broadest (Video). Each has its merits and is chosen for a particular type of use.

Table 2-TBD

Signal Bandwidths	
Type of Signal	*Typical Bandwidth*
AM voice	6 kHz
AM broadcast	10 kHz
Commercial video broadcast	6 MHz (see note following the table)
SSB voice	2 to 3 kHz
SSB digital	500 to 3000 Hz (0.5 to 3 kHz)
CW	100 to 300 Hz (0.1 to 0.3 kHz)
FM voice	5 to 15 kHz
FM broadcast	150 kHz

Note - On June 12, 2009 US broadcasters converted all over-the-air TV signals to digital modulation. The channel width allocated to these signals remains the same – 6 MHz. However, within the channels, there may be from 4 to 5 distinct digital TV signals, each carrying a digitally-compressed audio-video program in a 1.2-1.5 MHz bandwidth. Most broadcasters will choose to fill the available channel space with programming, so the channel will contain multiple digital signals. If viewed on a spectrum analyzer, the composite digital signal will look like a "haystack" of approximately the same bandwidth as the channel. Amateurs will continue to use the analog format for fast-scan television for the foreseeable future and the bandwidth of those signals will be approximately 6 MHz.

Saying the Same Thing -- Frequency & Wavelength

The formula $\lambda = c / f$ also illustrates two important relationships between frequency and wavelength. First, as frequency increases, wavelength decreases and vice versa. This is true because the wave is moving at a constant velocity. A higher frequency wave takes less time and so moves less far during the time it takes to complete one cycle. Waves at very high frequencies have very short wavelengths--such as microwaves that have frequencies above 1 GHz. The so-called "long waves" are those with frequencies below 1 MHz, such as those used by AM broadcast stations.

Second, if you know the frequency of a radio wave, you automatically know its wavelength, too! This means that you can use the most convenient way of referring to a wave and still be accurate. For this reason, it's very common for the amateur bands to be referred to by wavelength. For example, it's not uncommon to hear a ham say something like, "I'll call you on 2-meters. Let's try 146.52 MHz." The frequency band is referred to as "2-meters" because the radio waves are all approximately that long. The exact frequency then tells the hams precisely where to tune.

SHF and EHF Bands

In some printings of the HRLM, Figure 2-20 incorrectly reverses the SHF and EHF bands. The correct range for SHF is 3 to 30 GHz and for EHF 30 to 300 GHz as shown in Table 2-3 immediately above the figure.

Section III

Table 3-1 should list the 902 MHz band's wavelength designation as 33 cm, not 32 cm.

Memory Channels

Question T5B02, answer B refers to "CTCSS tones" -- these are explained in the section "Using A Repeater". Memories used for repeaters store all the necessary information to access the repeater, which includes the output frequency and transmit offset, as well as any necessary controlling tones and codes. Transmit power level may also be stored.

Digital Data Modes

When using digital data modes, the microphone is not required. The transmit audio is provided by a computer via a data interface or by a TNC that is controlled by a computer. To return to voice operation, either the data connection is replaced by the microphone either by physically exchanging the connectors or using a microphone-data switch.

Antenna Elements

Elements are the radiating portions of an antenna. A dipole antenna and a ground-plane antenna are both *single-element* antennas.

"Rubber Duck" Antennas

When using a handheld transceiver inside a vehicle, a rubber duck may not be an effective antenna. The vehicle's metal roof and doors act like shields, trapping the radio waves inside. Some of the signal gets out through the windows (unless they're tinted by thin metal coating), but it's much weaker than if radiated by an external antenna, weaker by as much as 10 to 20 times.

Calculating Antenna Length

Here are some examples of antenna lengths calculated by using the formulas for dipoles and ground-plane antenna:

20-meter dipole (14.150 MHz): 468/14.15 = 33' 1"
6-meter dipole (50.1 MHz): 468/50.1 = 9' 4" = 112"
2-meter ground-plane (147 MHz): 234/147 = 1' 7" = 19"
70-cm ground-plane (446 MHz): 234/446 = 6-1/4"

Coaxial Cable Loss

Table 3.3 was found to have some errors in the coaxial loss data. Technician Class exams do not include this information. In the interest of providing the correct information, a new table is presented here. Cable loss and other parameters such as velocity of propagation vary between manufacturers and sometimes from batch to batch. If you are using the cable in a way that depends on an exact value, measure the cable with test equipment. The values in the table below were calculated using the on-line calculator at Times-Microwave (http://www.timesmicrowave.com/cgi-bin/calculate.pl).

Type	Impedance (ohms)	Loss per 100 feet (in dB) at 30 MHz	Loss per 100 feet (in dB) at 150 MHz
RG8	50	1.08	2.53
RG8X	50	1.96	4.53
RG58	50	2.47	5.63
RG59	75	1.79	4.11
RG174	50	4.56	10.3
RG213	50	1.08	2.53

Coaxial Cable Jackets

Ultraviolet light (UV) damages almost any organic material exposed to it for long periods of time. This includes plastic, wood, and skin! Coaxial cables rely on a plastic jacket to keep water out and the cables are usually installed outside. That means they need some defense against UV and that usually means the plastic contains a black pigment. The black pigment absorbs and blocks the UV so that the plastic does not weather or crack, allowing water into the cable. Other colors of pigment can be used if they protect against UV, but black is the most common.

Batteries

Table 3.4 mistakenly shows the full charge voltage for a 9V Alkaline-Disposable battery as 1.5 V. It should be 9 V.

Battery Life

Rechargeable battery packs for handheld radios are available with several different types of internal batteries; Ni-Cad, Ni-MH, and Li-ion or Lithium-ion. (Lithium-ion cells are usually not sold separately because of special charging requirements.) For a given size of battery pack, Li-ion has the highest energy capacity, followed by Ni-MH and Ni-Cad.

The higher the energy capacity, the longer the battery pack will last. Disposable alkaline batteries have about the same energy capacity as Ni-MH rechargeables.

Filtering & Noise Sources

Once signals have been generated by a transmitter and radiated by an antenna, it is not possible for a filter to tell an interfering signal from a desired signal if they are on the same frequency. Therefore, to prevent harmonics and spurious signals from causing interference, a filter must be applied at the output of the transmitter--before the signals are radiated.

Strong signals may overwhelm a receiver's ability to reject them. This is called fundamental overload. Symptoms include severe interference on all channels of a TV or FM receiver or an amateur may hear bursts or fragments of conversations when the strong signal is present. If the interfering frequency is similar to that of the desired signal, it may not be possible to remove the transmitted signal with a high-pass or low-pass filter because the desired signal will be removed, as well. In cases like these, such as when a TV receiver is overloaded by a nearby 2-meter transmitter, a notch filter is required that removes a specific band of frequencies. The notch filter is installed at the receiver and is used to reduce the interfering signal to a level that can be handled properly by the receiver.

Sometimes amateurs will experience interference from a transmitter that is mistakenly transmitting on an amateur frequency or from a ham's transceiver that is transmitting unintentionally. For example, sitting on one's microphone PTT switch while driving is not unknown! Rarely, cases of intentional interference or jamming occur. In either case, it's important to be able to locate the source of the interference. This is done by radio direction finding or RDF. By using directional antennas and maps, it's often possible to quickly find the offending transmitter. RDF is also discussed in Section 4.
Regardless of the source, you can reduce or eliminate much interference by making sure your own station follows good amateur practices for grounding and filtering. Be diplomatic in dealing with your neighbors, even though it may be their responsibility to deal with interference to or from their devices. Remember that they are probably unaware of most FCC rules!

Since the ac grid operates at 60 Hz, why does power line noise crackle at 120 Hz? Power-line noise is caused by arcs that occur when the waveform reaches the required voltage to jump the gap. This threshold is reached two times during every cycle; once on the positive half-cycle and once on the negative half-cycle. So the arcs generated by power-lines generally occur at twice the line operating frequency, or 120 Hz.

Section IV

IRLP and Echolink

If you are interested in using or listening to stations using VoIP, first explore the Web pages listed in the Ham Radio License Manual for each system. You'll find comprehensive information on how the system works, procedures for using it, and directories of access and control codes. The codes are entered by using your transceiver's keypad.

Net Operating

It is important to remember that no matter what the purpose or status of a net, a station with emergency traffic should break in at any time. The NCS and members of the net should always immediately suspend any lower-priority operation and respond to the emergency.

Specialty Activities -- Video

The bandwidth of a video signal is 6 MHz, not 4 MHz as stated in the text. Amateur video signals are transmitted in NTSC format -- the standard over-the-air method for analog video signals used by commercial broadcasters.

Section V & VI

Call Signs

W6CF is mistakenly described as a “2-by-2 or 2x2” call. It should be a “1-by-2 or 1x2” because it has a single letter prefix and a two-letter suffix.

Club Calls

The process described in the text is incorrect. There are three Club Station Call Sign Adminstrators (CSCSA) appointed by FCC; ARRL, W5YI and W4VEC. Since Jan 2001, CSCSAs handle routine Club, Military Recreation and RACES applications for the FCC. FCC will still accept applications for new vanity Club licenses and for the renewal of a vanity club license.

Section VII

Electrical Safety - Shock Hazards

There are several different standards for defining electrical shock hazards, depending on the environment in which the standard is applied. For example, current leakage standards in medical equipment are different than for home appliances and those standards are different than on-the-job industrial standards. The following table is from OSHA Publication 3075, "Controlling Electrical Hazards" (http://www.osha.gov/Publications/3075.html). It is in broad agreement with the table used in the *Ham Radio License Manual*.

Effects of Electric Current in the Human Body

Current	Reaction
Below 1 milliampere	Generally not perceptible
1 milliampere	Faint tingle
5 milliamperes	Slight shock felt; not painful but disturbing. Average individual can let go. Strong involuntary reactions can lead to other injuries.
6–25 milliamperes (women)	Painful shock, loss of muscular control*
9–30 milliamperes (men)	The freezing current or " let-go" range.* Individual cannot let go, but can be thrown away from the circuit if extensor muscles are stimulated.
50–150 milliamperes	Extreme pain, respiratory arrest, severe muscular contractions. Death is possible.
1,000–4,300 milliamperes	Rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur; death likely.
10,000 milliamperes	Cardiac arrest, severe burns; death probable

* If the extensor muscles are excited by the shock, the person may be thrown away from the power source.

Source: W.B. Kouwenhoven, " Human Safety and Electric Shock," Electrical Safety Practices, Monograph, 112, Instrument Society of America, p. 93. November 1968.

The Wikipedia article on electric shock (http://en.wikipedia.org/wiki/Electric_shock) states, "A low-voltage (110 to 220 V), 50 or 60-Hz AC current travelling through the chest for a fraction of a second may induce ventricular fibrillation at currents as low as 60mA. With DC, 300 to 500 mA is required. If the current has a direct pathway to the heart (e.g., via a cardiac catheter or other kind of electrode), a much lower current of less than 1 mA, (AC or DC) can cause fibrillation. Fibrillations are usually lethal because all the heart muscle cells move independently. Above 200mA, muscle contractions are so strong that the heart muscles cannot move at all."

The reference on page 7-2 to the disruption of normal heart rhythms should be to a current level of 100 mA, not 50 mA as stated in the text. The statement is intended to convey the answer to question T0A02 and is not meant to be an exact specification.

Miscellaneous Safety Issues

Lightning protection is done to provide fire protection for your home. Most of the damage to home resulting from a lightning strike is from fire.

RF energy can only cause injury to the human body if the combination of frequency and power cause excessive energy to be absorbed.

Follow the manufacturer's directions and recommendations. For example, how tight should guy wires be? The tower manufacturer will tell you--do what they say to do. This holds true for all types of antenna and tower work.