Amateur Radio Technician Class Licensing Course

Sponsors
Scout Venturing Crew 80
First Christian Church
Mount Vernon Amateur Radio Club (MVARC)

Instructors:
Dick – WA4USB
Demi – K4BSA
Jim – K3BUC
Bill – W2BSA
Meet your Instructors
Dick Harman  WA4USB

• First licensed in 1964
  Novice, Tech, General, Advanced, Extra
• Control Op K4US Repeater
• 35+ years Scout Leader
  Cubs, Boy Scouts, Explorer
• Committee Chair Crew 80
• Retired 20+ years
• Computers since '59

Meet your Instructors
Demi Pulas  K4BSA

• First licensed in 1965
  Extra the Hard Way (20 wpm Morse Code)
• Crew 80 Advisor since 1995
• ~ 40 years Scout Leader

Meet your Instructors
Bill Stewart  W2BSA

• First licensed in 1993
• Amateur Extra License
• Scout Leader 20+ years
• Crew 80 COR
• Crew 80 Committee Member
• Scout leader since 1990
• Colonial District STEM Coordinator
Meet your Instructors
Jim Buchanan  K3BUC
• First licensed in High School
  • Novice - 1 year non-renewable
• BSEE, + Digital Computers
• Naval Air Systems Command
• Maintained interest in Radio
• Tech, General, Extra & Crew in 2004
• Scout + Scouter 30 years

Amateur Radio Technician Class
• Other groups using nearby rooms
• House Keeping
  • Restrooms
  • Fire Exits
  • Outside Access

Goals of this Course
1. Learn about Amateur Radio activities
2. Learn about Radio and Electronics
Goals of this Course

3. Pass the Exam and Obtain your FCC Technician Class Amateur Radio License!
4. The license will authorize you to operate a Amateur (Ham) Radio Station (transmitter)

Introductions

• Your name and a little about yourself
• Someone you know who is a Ham
• What you hope to gain by being a Ham
• Do you have experience with amateur radio?
• What are your expectations?

Our history
We have been teaching this course for about 20 years
We have learned what works and have included lessons learned in this course
How to study to ensure passing exam

- Read assignments when due
  - Each and every question is in the handbook
  - Correct answers are in the manual
- You MUST take the on line practice tests at home and pass at least 80% to ensure success
  - arrl.org/examreview
- How class will be run
  - Q&A’s at end of each section

Methods of Learning

- Some courses teach you to memorize exam questions and answers
- That method does not lead to real advancement in your knowledge

We are NOT teaching answers

We give you the concepts and knowledge so you will understand what is going on

- There are many on line practice exams that you can take as often as you wish at no cost
A BAG lunch is RECOMMENDED

- Lunch: about Noon
  30 minutes for lunch

- Exam Sat Feb 14 9:30 am

Expectations

- Class will start and end on time
- Instructors will be prepared
- Students are expected to read assigned material before class and be prepared to learn
- Ham radio is not a spectator sport, active participation during class discussions is vital to success - obtaining your License

Course Outline

- Welcome to amateur radio
- Electricity, Components and Circuits
- Radio and Signals Fundamentals
- Propagation, Antennas and Feedlines
- Amateur Radio Equipment
- Communicating with other hams
- Licensing regulations
- Operating regulations
- Safety
- Test preparation and review
Let’s Get Started
We intend to give you the knowledge to pass the exam.
Your knowledge and understanding will grow as you enjoy and use amateur radio.

October 2012
- BSA Jamboree On The Air
- Boy Scouts in Irving Texas spoke with an astronaut on the International Space Station using Amateur Radio relayed through amateur stations in Australia - here is a short clip.

Steps to obtaining your ticket
- Study the *Ham Radio License Manual*
- Review the questions in the book
- Take interactive practice exams
- Pass a 35-question multiple choice test
  - Questions are from the question pool in the back of the book
  - Answer 26 correctly
- No Morse code is required
About the exam
Back of the book page 11-1
Sub-elements..T1A T2A T3A T4A
One question on your exam from each of the 35 "Sub-elements"
Exact text of Q and A .... But
Q and A (both) may be re-sequenced
26 correct to pass

Let's say it another way
1. Read the assigned pages
2. Pay attention in class
3. Do the practice exams
Most probably (> 90%) earn your license – when you do 1 and 2 and 3

Sequence of Presentations
• We do not follow the exact book sequence
• We generally follow Chapter content
• Our purpose is to make it easy to understand and make sense
• Page numbers will be in the bottom left corner of slides
Chapter 1

What is Amateur Radio?

Today's Topics

1. What makes Amateur Radio unique
2. Why the FCC makes rules
3. Activities involving Amateur Radio
4. How to find other hams
5. Technician License
6. Next week

1-1

What is Amateur Radio?

- Amateur Radio is a personal radio service authorized by the Federal Communications Commission (FCC)

1. The purpose is to advance skills in the technical and communication phases of the radio art
What is Amateur Radio?

• Amateur Radio is a personal radio service authorized by the Federal Communications Commission (FCC)

2. To promote the development of an emergency communication capability to assist communities when needed

3. To develop a pool of trained radio operators

4. To promote international goodwill by connecting private citizens in countries around the globe
What is Amateur Radio?
- Amateur Radio is a personal radio service authorized by the Federal Communications Commission (FCC)
- Through ham radio, you will become an ambassador for your community and your country

Why does the FCC make rules
- Amateur Radio is a Licensed Service
- Hams can buy or build or modify their own equipment
- Knowledge and skills are required
- That’s why we have licenses

What do hams do?
- Communicate
- Participate
- Experiment
- Build
- Compete
- Serve their communities
- Life-long learning
The Amateur Radio Service is intended for persons who are interested in radio technique solely with a personal aim and without pecuniary interest.

There is no age requirement for holding an FCC Amateur Radio License.

The agency that regulates and enforces the rules for the Amateur Radio Service in the United States is the FCC.

You may operate to transmit after you pass the examination elements required for your first amateur radio license as soon as your name and call sign appear in the FCC’s ULS database.
The normal term for an FCC-issued primary station/operator license grant is ten years.

The grace period following the expiration of an amateur license within which the license may be renewed is two years.

About Ham Radio
- If your license has expired and is still within the allowable grace period, you may not continue to operate to transmit until the ULS database shows that the license has been renewed.
- The FCC Part 97 definition of an amateur station is a station in the Amateur Radio Service consisting of the apparatus necessary for carrying on radio communications.

Take Aways
Purpose of the amateur service
- The Amateur Radio Service is intended for those persons who are interested in radio technique solely with a personal aim and without pecuniary interest. [97.3(a)(4)]

The Federal Communications Commission (FCC) is the government agency that regulates and enforces the rules for the Amateur Radio Service in the United States. [97.1]
Element 2 Technician Class
Question Pool!

About Ham Radio
Valid July 1, 2014
Through June 30, 2018

How soon may you operate a transmitter on an amateur service frequency after you pass the examination required for your first amateur radio license?

A. Immediately
B. 30 days after the test date
C. As soon as your name and call sign appear in the FCC's ULS database
D. As soon as you receive your license in the mail from the FCC

What is the normal term for an FCC-issued primary station/operator license grant?

A. Five years
B. Life
C. Ten years
D. Twenty years
What makes ham radio different?

- There are many other radio services available
  - CB – no license required
  - FRS & GMRS
- Some are licensed to commercial carriers and leased to consumers
- Cell phones

What makes ham radio different?

- Ham radio has:
  - Less restrictions
  - More frequencies (channels or bands to utilize)
  - More power (to improve range and quality)
  - More ways to communicate
  - It’s free to operate your radio

With more privileges comes more responsibility

- Ham radios have the potential of interfering with other radio services
- Ham radios have unlimited reach - easily reach around the globe and into space
- No commercial use
With more privileges comes more responsibility
- FCC authorization is required to ensure the operator is qualified to operate the radio safely, appropriately, and within the rules and regs – that is why we are here

Amateur Radio Activities
- We make contacts with other hams
- Support emergencies and public service events
- Awards and contests
- Build, Invent, and modify our radios and other equipment

How do I get a License?
- Learn
- Understand
- Be prepared to pass the FCC exam, administered by volunteer examiners on February 14, 2014 at 9:30 am
Some things can be reasoned or calculated

- A few things have to be memorized
  - FCC rules
  - A few formulas
  - Authorized frequencies

<table>
<thead>
<tr>
<th>Class</th>
<th>Requirements</th>
<th>Frequency Privileges</th>
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<tbody>
<tr>
<td>TECHNICIAN</td>
<td>Basic Theory, Rules and Regulations</td>
<td>HF (CW + Limited Voice &amp; Data)</td>
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<td>GENERAL</td>
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<td>More HF (All Modes)</td>
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<td>All UHF (All Modes)</td>
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</tbody>
</table>

Course Schedule

- Four Consecutive Saturdays
  - January 17 3:00 PM – 5:00 PM (Introduction)
  - January 24 9:00 AM – 3:00 PM (Instruction)
  - January 31 9:00 AM – 3:00 PM (Instruction)
  - February 7 9:00 AM – 3:00 PM (Instruction, Review, Exam prep)
Course Schedule
Exam one week after the end of the course
35 questions - 26 correct to pass
If you are close to passing they usually offer a retest immediately
The VE team usually has several versions of the exam

License Exam :
February 14 9:30 AM – 10:30 AM
MVARC offers VE Exams on the Second Saturday of each month at 9:30 – no fee

Course Schedule
We have enough time in the class to cover the information needed to pass the license exam
We must stay on topic to stay on time
If you need something off topic, please ask an instructor off-line
Let’s begin your ham radio journey

• We have touched briefly on what ham radio is — more will follow

Let’s look at some exam questions now

**T1A01**
**T1C10**
**T1C13**
**T1A05**
**T1A10**
They are in the back of your book

We have discussed much of this

**T1A01**
Which of the following is a purpose of the Amateur Radio Service as stated in the FCC rules and regulations?

A. Providing communications for international non-profit organizations
B. Advancing skills in the technical and communication phases of the radio art
C. Providing personal radio communications for as many citizens as possible
D. All of these choices are correct
How soon after passing the examination for your first amateur radio license may you operate a transmitter on an amateur service frequency?
A. Immediately
B. 30 days after the test date
C. As soon as your operator/station license grant appears in the FCC's license database
D. You must wait until you receive your license in the mail from the FCC

For which licenses classes are new licenses currently available from the FCC?
A. Novice, Technician, General, Advanced
B. Technician, Technician Plus, General, Advanced
C. Novice, Technician Plus, General, Advanced
D. Technician, General, Amateur Extra

Which of the following is a purpose of the Amateur Radio Service rules and regulations as defined by the FCC?
A. Enhancing international goodwill
B. Providing inexpensive communication for local emergency organizations
C. Training of operators in military radio operating procedures
D. All of these choices are correct
What is the definition of an amateur radio station?
A. A station in an Amateur Radio Service consisting of the apparatus necessary for carrying on radio communications
B. A building where Amateur Radio receivers, transmitters, and RF power amplifiers are installed
C. Any radio station operated by a non-professional
D. Any radio station for hobby use

Next week
- Read Chapters 1, 3, 2 and 4
- Chapter 4 may be next week or the week after next - it depends
- Bring your questions
- If you have time, try a practice exam or two

Next Week’s Topics
1. Electricity, Components and Circuits
2. Radio and Signal Fundamentals
3. Types of Radios
4. Propagation Antennas and Feed lines
February 14 Exam

- Please bring the following:
  - 1) Picture ID or a DMV "child's ID" which looks like a drivers license.
    OR a parent with the same last name and address AND info that only a parent would have such as a birth certificate - parent ID IS NOT the preferred ID
  - 2) SSN

February 14 Exam

- If you hold any FCC license and have a FRN please bring that also
- Such as GMRS

What are you going to do before next Saturday?

Read 1, 3, 2 and 4
Try a practice exam or two
The score does not matter
Questions?
Something you don't understand?
What is bothering you?

Day 2 Starts Here

Today’s Topics
1. Electricity, Components and Circuits
2. Radio and Signal Fundamentals
3. Types of Radios
4. Propagation Antennas and Feed lines
5. What to prepare for next week
Chapter 3
Electricity, Components, Circuits

- In the following presentations, we provide an overview of the topic
- In later sessions, we come back with greater detail
- Don't hesitate to ask questions
- If we ask you to hold that thought, please jot it down

VIDEO Segments
- These videos are from a pre-2006 video for the Technician License Course
- The concepts have not changed
- References to specific exam questions are no longer current
The video mentions “the test”

The test is revised every 4 years -- you should rely on the current question pool in the back of your book

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Fundamentals of Electricity

When dealing with electricity what we are referring to is the flow of electrons through a conductor

- Electrons are negatively charged atomic particles
  - The opposite charge is the positive charge
- A conductor is a material that allows electrons to move with relative freedom

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Fundamentals of Electricity

- In electronics and radio, we control the flow of electrons to make things happen
- Knowledge of how we control the flow of electrons helps you understand how to operate your radio
We are going to watch a video segment about Electrical Principles. In other words, Basic Electricity, Electrical components, and Units that we use to measure electricity.

### Characteristics of Electricity
- Three characteristics of electricity:
  - Voltage
  - Current
  - Resistance
- Each can be measured.

The flow of water through a hose is a good analogy to the three characteristics of electricity and how they are related.
Characteristics of Electricity

Characteristics are Inter-related

- Voltage, current, and resistance must be present to have current flow
- Just like water flowing through a hose, changes in voltage, current, and resistance affect each other
- That effect is mathematically expressed in Ohm’s Law
Ohm’s Law

- E is voltage
  - Unit is volt
- I is current
  - Unit is ampere
- R is resistance
  - Unit is ohm

- \( R = \frac{E}{I} \)
- \( I = \frac{E}{R} \)
- \( E = I \times R \)

When you take the exam, write this down on the scratch paper:

- \( E = \text{Volts} \)
- \( I = \text{Amps} \)
- \( R = \text{Ohms} \)
Ohm's Law:
"Resistance is not futile"

It is voltage divided by current

\[ R = \frac{E}{I} \]

Moving Electrons – Doing Something Useful

- Anytime energy is expended to do something, work is performed
- When moving electrons do some work, power is consumed
- Power is measured in Watts
**Power Formula**

Power - the amount of current that is pushed through a conductor or device to do work

- P is power
- E is voltage
- I is current

- Unit is watt
- Unit is volt
- Unit is ampere

\[ P = E \times I \]
\[ E = \frac{P}{I} \]
\[ I = \frac{P}{E} \]

When you take the exam, write this down on the scratch paper

- P = Watts
- E = Volts
- I = Amps
### Two Kinds of Current

<table>
<thead>
<tr>
<th>Alternating Current (AC)</th>
<th>Direct Current (DC)</th>
</tr>
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</table>

**Alternating Current (AC)**

When current flows alternatively in one direction and then in the opposite direction, it is called **Alternating Current (AC)**

- Your household current is AC
- Cross country power lines use AC
- Radio waves are AC

**Direct Current (DC)**

When current flows in only one direction, it is called **Direct Current (DC)**

- Batteries are a source of DC
- Most electronic devices are powered by DC
- Batteries are in flashlights and start your car
Alternating Current
The speed at which the Alternating Current changes direction is called **Frequency**
It is measured in Hertz
It used to be Cycles (same thing)
**Hertz** (per second)
Much more later!

The Electric Circuit – an Electronic Roadmap
- For current to flow, there must be a path from one side of the source of the current to the other side of the source – this path is called a circuit
  - There must be a hose (conductive path) through which the water (current) can flow

The Electric Circuit – an Electronic Roadmap
- Next, we will introduce some terms that are used to describe circuits

3-12
**Series Circuits**

- Series circuits provide only one path for current flow

![Series Circuit Diagram]

**Parallel Circuits**

- Parallel circuits provide alternative paths for current flow

![Parallel Circuit Diagram]

**Short Circuit**

- When there is an unintentional current path that by-passes areas of the circuit – this is a short circuit

![Short Circuit Diagram]
Open Circuit

• When the current path is broken so that there is a gap that the electrons can not jump – this is an open circuit.
Controlling the Flow of Current

• To make an electronic device (like a radio) do something useful (like a receiver), we need to control and manipulate the flow of current.

• There are a number of different electronic components that we use to do this.

Components

An introduction to names and symbols

Video

Practical Electronics
Switch

- The function of the switch is to permit or not permit the flow of current through it.

Resistor

- The function of the resistor is to restrict (limit) the flow of current through it.

Capacitor

- The function of the capacitor is to temporarily store electric current:
  - Like a very temporary storage battery
  - Stores energy in an electrostatic field
**Inductor**

- The function of the inductor is to temporarily store electric current
  - Is basically a coil of wire
  - Stores energy in a magnetic field

**Transistor**

- The function of the transistor is to variably control the flow of current
  - Much like an electronically controlled valve
  - Like the faucet in your sink

**Integrated Circuit**

The integrated circuit is a collection of components contained in one device that accomplishes a specific task
- Acts like a “black-box”
Protective Components – Intentional Open Circuits

Fuses and circuit breakers are designed to interrupt the flow of current if the current becomes uncontrolled.

Fuses blow – one time protection
Circuit Symbol

Circuit breakers trip – can be reset and reused
Circuit Symbol

Some Circuit Symbols
Video
Power Amps and other devices

Putting it all together – a circuit diagram

Questions?
Dealing with Very Big and Very Small Numeric Values

- In electronics we deal with large and small numbers
- The international metric system provides a method of dealing with the wide range of values

Metric Units

International System of Units (SI)
- Kilo-
- Mega-
- Centi-
- Milli-
- Micro-
<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Multiplication Factor</th>
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<tbody>
<tr>
<td>Tera</td>
<td>T</td>
<td>$10^{12}$</td>
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<tr>
<td>Giga</td>
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<tr>
<td>Pico</td>
<td>p</td>
<td>$10^{-12}$</td>
</tr>
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**T5B01**

How many milliamperes is the same as 1.5 amperes?

A. 15 milliamperes  
B. 150 milliamperes  
C. 1500 milliamperes  
D. 15000 milliamperes
Radio Waves are AC
- In alternating current (AC) the electrons flow in one direction one moment and then the opposite direction the next moment
- Radio waves (electromagnetic radiation) are AC waves
- Radio waves are used to carry the information you want to convey to someone else

Wave Vocabulary
As we study radio waves, we will learn some new terms:
- Amplitude
- Frequency (Hertz)
- Period
- Wavelength (Meters)
- Harmonics
Wavelength

- The distance a radio wave travels during one cycle
  - One complete change between magnetic and electric fields

Finding where you are on the radio dial

- There are two ways to tell someone where to meet you on the radio dial (spectrum)
  - Band
  - Frequency

Radio Frequency (RF) Spectrum

- The RF Spectrum is the range of wave frequencies which will leave an antenna and travel through space
- The RF Spectrum is divided into segments of frequencies that have a unique behavior
Radio Frequency (RF) Spectrum

3 kHz to 30 kHz is primarily an audio (sound wave) portion of the spectrum. In some cases, RF waves can also be generated at these frequencies.

So, Where am I?
- How to tell where you are in the spectrum -
- Bands identify the segment of the spectrum where you will operate
  - Wavelength is used to identify the band
  - Frequencies identify specifically where you are within the band

Another use for frequency and wavelength
- For the station antenna to efficiently send the radio wave out into space, the antenna must be designed for the specific operating frequency
  - The antenna length needs to closely match the wavelength of the frequency to be used
Another use for frequency and wavelength
Any mismatch between antenna length and frequency wavelength will result in radio frequency energy being reflected back to the transmitter, not going (being emitted) into space.

Practice problem frequency and wavelength
What is the wavelength in meters of a RF signal of 7 Mhz?
300 divided by 7
42 meters (common use 40 m.)
*70 goes into 300 about 4 times*
7 times 4 is 28

Practice problem frequency and wavelength
What is the wavelength in meters of a RF signal of 144 Mhz?
300 divided by 144
2 meters
*144 goes into 300 twice*
Calculators

• You may use a calculator during the exam
• Be prepared to show that all memories are clear
• You can not store formulas or answers to questions on your calculator and use it on the exam

Antennas are part **capacitor** – part **inductor** – part **resistor**

Antennas have characteristics of capacitors, inductors, and resistors

We discussed these earlier

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Antennas are part **capacitor** – part **inductor** – part **resistor**

• Capacitors and inductors, because they store energy in fields, react differently to AC and DC
  • Special kind of resistance to the flow of AC – called **reactance**
Resonance

- Because capacitors and inductors store energy in different ways, the stored energy can actually cancel each other under the right conditions
  - Capacitors – electrostatic field
  - Inductors – magnetic field
- Cancelled energy (current) = zero reactance, leaving only resistance

Resonant Antenna

- If an antenna is designed correctly, the capacitive reactance cancels the inductive reactance
- Theoretically, the resulting reactance is zero
- Leaving only resistance – meaning minimum impedance to the flow of the radio frequency currents flowing in the antenna and sending the radio wave into space

Harmonics

- A harmonic is a multiple of the original frequency
- A second harmonic is 2 x Frequency
- A third harmonic is 3 x Frequency
- In antennas, even harmonics cancel but odd harmonics may radiate causing interference
Ham Slang

• An antenna is a sky hook
• Something that transmits is a rig
• A bunch of antennas is an antenna farm

Questions?

Chapter 2.2
Introduction to Modulation
Adding Information - Modulation

- When we imprint some information on the radio wave, we modulate the wave
- Turn the wave on and off
- Voice AM and FM
- Data
- Different modulation techniques are called modes

Video Types of Emissions

Morse Code – on and off
Characteristics of voice

- Sound waves that make up your voice are a range of audio frequencies.
- Most voices range from 300 hertz to about 3000 Hz.
- Our hearing range goes to about 20 kHz.

Amplitude Modulation (AM)

In AM, the amplitude of the carrier wave is modified in step with the waveform of the information (voice).

Combining Voice with an RF carrier produces 2 identical sidebands.
Amplitude Modulation (AM)

Single Sideband Modulation (SSB)
- Combining Voice with an RF carrier produces 2 identical sidebands
- We can improve efficiency of transmission by transmitting only one sideband and then reconstruct the missing sideband at the receiver
**Frequency Modulation (FM)**

- Instead of varying amplitude, if we **vary the frequency** in step with the information waveform – FM is produced.
- We shift the frequency of the transmitter up and down to carry information.

**Transmitting Data**

- Data is made up of binary bits 1 and 0 - On and off states.
- Modems translate the data into a format capable of modulating a carrier wave.
Transmitting Data

- A terminal node controller (TNC) is a special modem used in ham radio
- There are many more kinds of modems developed as data transmission technology advances

Data Transmission Setup

Questions?
Chapter 2.3

Basic Types of Radios Equipment Definitions

Terms

Receiver
Transmitter
Transceiver
Antenna

Basic Station Organization

- Station Equipment
  - Receiver
  - Transmitter
  - Antenna
  - Power Supply
- Accessory Station Equipment
- Repeaters
**What happens during radio communication?**

**Transmitting** (sending a signal):
1. Information (voice, data, video, commands, etc.) is converted to an **electronic form**
2. The electronic form is attached or imbedded in a **radio wave** (a carrier)
3. The **radio wave** is sent out from the station antenna into space

**Receiving:**
1. The antenna intercepts the radio wave (carrier) with the information
2. The receiver extracts the information from the carrier wave
3. The information is presented as a sound, picture, or words on a computer screen ...

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This sounds simple, but it in reality is complex
Complexity is one thing that makes ham radio fun...learning all about how radios work
Don’t be intimidated, you will be required to only know the basics, but you can learn as much about the “art and science” of radio as you want
**Receiver Controls**

- Main tuning dial for received frequency (or channel) selection
- Frequency display
- Volume control
- Other accessory controls for mode (kind of information to process), filters (to mitigate interference), etc.
Transmitter Controls
- Main tuning dial for transmitted frequency (or channel) selection
- Frequency display
- Power control (transmitted signal strength)
- Other accessory controls for mode (kind of information to process), etc.

Transceiver
- Modern transmitters and receivers are combined in one unit – a transceiver
  - Saves space, Costs less
- Many of the controls of the transmitter and receiver are the same
- Many electronic circuits are shared in the transceiver
**Transceiver Controls**

- Some are physical knobs that you manually adjust.
- Some are controlled by an internal computer; you control the settings with keypad entries that control the computer in the transceiver.

**Antenna**

The antenna exposes your station to the world.

1. Facilitates the radiation of your signal into space (electromagnetic radiation).
2. Intercepts someone else’s signal.
Antenna

- Many times the transmitting and receiving antenna are the same antenna
- Your antenna is connected to your station by a wire called a feed line

TR Switch

- When the antenna is shared between the transmitter and receiver, the TR switch allows the antenna to be switched to the transmitter when sending and to the receiver when receiving
- In a transceiver, this TR switch is inside the unit and requires no attention by the operator

Transmit/Receive (TR) Switch
Your radio station needs some sort of power to operate
- Battery
- Household current converted to proper voltage
- Alternative sources

Most modern radios operate on 12 volts direct current (DC)
- A power supply converts household current to the type of current and the correct voltage to operate your station
- Could be internal or external
- You are probably familiar with “wall-wart” power supplies
Accessory Equipment

Radio Circuits
- Oscillators and Amplifiers
- Filters
- Modulators
- Mixers
- Demodulators
- Detectors
- Product Detectors
- Frequency Discriminators
- Receivers - Direct Conversion
- Receivers - Superhetrodyne
- Transverters

Oscillators
- Produces a steady low power signal at a specific frequency
- Feeds a Driver that isolates the load on the oscillator
- Runs all the time

Some things you may see on the exam
Don't need to know how each works, just what it does

You may see on the exam

Don't need to know how each works, just what it does
Amplifier

Increases a low power signal
Could also be a power Amplifier

Filters

- High Pass
- Low Pass
- Band Pass
- Notch
- Cutoff is ½ signal level

Modulator

Adds voice or data to a RF signal or carrier which can then be transmitted by radio
Could be a telegraph key or microphone output
Mixer

- Combines two RF signals
- Produces the sum and difference of the input signals
- Shifts frequencies for some purpose (filtering)
- Is NOT an AUDIO mixer

Demodulator

- Reverses what a Modulator does
- Separates the RF from the voice
- A computer Modem is a Modulator and Demodulator in a single box - works two ways - does both jobs
- Many different types
  - We will talk about several types

Detector

Demodulates AM
Can be used in AM broadcast radio receivers
**Product Detector**
Demodulates CW and SSB signals

**Frequency Discriminator**
Demodulates Frequency Modulation (FM) signals

**Receiver - Direct Conversion**
- Single Conversion of RF back into the original modulating signal
Receiver - Superhet

- Uses Intermediate Frequency (IF) amplifier and filters
- Uses a Beat Frequency Oscillator to recover CW and SSB

Transverter

- Converts one RF frequency to another
- For example 28 Mhz to 222 Mhz and from 222 Mhz to 28 Mhz allowing a single transceiver to operate on both bands

T7A05
What is the name of a circuit that generates a signal of a desired frequency?
A. Reactance modulator
B. Product detector
C. Low-pass filter
D. Oscillator
Radio Circuits

- Oscillators and Amplifiers
- Filters
- Modulators
- Mixers
- Demodulators
- Detectors
- Product Detectors
- Frequency Discriminators
- Receivers - Direct Conversion
- Receivers - Superhetrodyne
- Transverters

Let's review what these things are used for

Basic Station Accessories

- Human interface
  - Microphones
  - Speakers
  - Earphones
  - Computer
  - Morse code key
  - TV camera

- Station performance
  - Antenna tuner
  - SWR meter (antenna match checker)
  - Amplifier
  - Antenna rotor (turning antenna)
  - Filters

Questions?
Types of Radios

Generalized Transceiver Categories

- Single Band FM
- Dual Band VHF/UHF FM
- Multi-mode VHF/UHF
- Multi-band VHF/UHF
- Hand-held (HT)

Single Band Transceiver

- Probably the most common starter rig
- Operated from 12 volts DC, will require external power supply
- Will require an external antenna
- Can be operated mobile or as a base station
- Limited to frequency modulation (FM) and either 2 meters or 70 cm bands
- Up to approximately 50 watts output
**Dual Band Transceiver**
- Same as the single band transceiver but includes additional band(s)
- Most common 2 m and 70 cm bands
- Could be tri-bander
- Depending on antenna connectors, might require separate coax for each band or duplexer for single coax

**Multi-mode Transceiver**
- Can be single or dual band
- Main difference is that these rigs can operate on all major modes SSB/AM/FM, CW, Data, RTTY etc.
- More features add complexity and cost
- Most flexible of the rigs that will allow you to explore new modes as you gain experience

**Multi-band Transceiver**
- Covers several bands – can be limited to HF or can be HF/VHF/UHF
- Also covers all modes
- Frequently 100 watts on HF, some power limitations on high bands (50 watts)
- Larger units have internal power supplies, smaller units require external power (12 V)
Hand-held (HT) Transceiver

- Small hand-held FM units
- Can be single band or dual band
- Limited power (usually 5 watts or less)
- Includes power (battery) and antenna in one package
- An attractive first starter rig – but make sure it is what you want

Comparison

<table>
<thead>
<tr>
<th></th>
<th>Single Band</th>
<th>Dual Band</th>
<th>Multi-mode</th>
<th>Multi-band</th>
<th>HT</th>
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<tbody>
<tr>
<td><strong>Freq Agility</strong></td>
<td>Limited</td>
<td>Medium</td>
<td>Medium</td>
<td>Full</td>
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<tr>
<td><strong>Functionality</strong></td>
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<td>Full</td>
<td>Full</td>
<td>Limited</td>
<td></td>
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<tr>
<td><strong>Ease of Use</strong></td>
<td>Easy</td>
<td>Medium</td>
<td>Medium</td>
<td>Difficult</td>
<td>Easy</td>
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<td><strong>Programming</strong></td>
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<td>Easy</td>
<td>Medium</td>
<td>Challenging</td>
<td>Easy/Medium</td>
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<td><strong>Power</strong></td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>Low</td>
<td>Modest</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

More on equipment

In future lessons
Introduction to Repeaters

- Extend your coverage range
- Normally VHF or UHF
- Some on HF (6 and 10 meters)

Special stations you will use (Repeaters)

- Repeaters are automated stations located at high places that receive and then retransmits your signal simultaneously
  - Dramatically improves range
- The basic components of a repeater are the same as your station: receiver, transmitter, antenna, and power supply
Repeaters

But, repeaters are **transmitting** and **receiving** at the same time, on **different frequencies** using the same antenna.

Repeaters do not use T/R switches because they are **transmitting** and **receiving** simultaneously.

**The K4US repeater**
- Receives on 146.055 Mhz
- Transmits on 146.655 Mhz

**Your radio**
- Receives on 146.655
- Transmits on 146.055

This requires a very high quality and specialized filter to prevent the transmitted signal from over-powering the receiver.

This specialized filter is called a **duplexer**.

The receiver sees the antenna.

The transmitter sees the antenna.

The receiver **does NOT see** the repeater's transmitter (else smoke).
We will cover repeaters in detail in a later lesson.
Day 3 Starts Here

Questions?
Something you don't understand?
What is bothering you?

Chapter 4
Propagation
Radio Wave Propagation

Topics
• How signals travel
• Antenna Basics
• Feed Lines
• What is SWR
• How to build a practical antenna

Getting from Point A to Point B
• Radio waves propagate by many mechanisms
  ▪ The science of wave propagations has many facets
• We will discuss 3 basic ways:
  ▪ Line of sight
  ▪ Ground wave
  ▪ Sky-wave

Line-of-Sight
• If a source of radio energy can be seen by the receiver, then the radio energy will travel in a straight line from transmitter to receiver
  ▪ There is some attenuation of the signal as the radio wave travels
• This is the primary propagation mode for VHF and UHF signals
Ground Wave

- Some radio frequency ranges (lower HF frequencies) will hug the earth’s surface as they travel
- These waves will travel beyond the range of line-of-sight
- A few hundred miles

Ionosphere

- Radiation from the sun momentarily will strip electrons away from the parent atom in the upper reaches of the atmosphere
  - Creates ions
- The region where ionization occurs is called the Ionosphere

Levels of the Ionosphere

Density of the atmosphere affects:
- The intensity of the radiation that can penetrate to that level
- The amount of ionization that occurs
- How quickly the electrons re-combine with the nucleus
**Ionosphere – a leaky RF Mirror**

- The ionized layers of the atmosphere actually act as an RF mirror that reflect certain frequencies back to earth
- Sky-wave propagation is responsible for most long-range, over the horizon communication
- Reflection depends on frequency and angle of incidence

**What are LUF and MUF?**

- **Lowest Usable Frequency**
- **Maximum Usable Frequency**
- If too low => absorbed
- If too high => goes into space
- Just right => bounces back to earth miles and miles away
**Sun Spot Cycle**
- The level of ionization depends on the radiation intensity of the sun.
- Radiation from the sun is related to the number of sun spots on the sun’s surface.
- High number of sun spots, high ionizing radiation emitted from the sun.
- Sun spot activity follows an 11-year cycle.

**Antennas and Feed Lines**
- Feed line delivers the signal to and from the antenna.

More on this shortly.

**What are Decibels?**
- dB is the ratio of two quantities as a power of 10.
  - -3 dB is half power.
  - +3 dB is twice power.
Exam Questions T5B09, 10 and 11

• T5B9 The approximate amount of change, measured in decibels (dB), of a power increase from 5 watts to 10 watts is 3dB.

• T5B10 The approximate amount of change, measured in decibels (dB), of a power decrease from 12 watts to 3 watts is 6dB.

• T5B11 The approximate amount of change, measured in decibels (dB), of a power increase from 20 watts to 200 watts is 10 dB.

Two times or ½ of the power is a 3db change.

Ham Bands

Let's think about

Ohms Law

Power

Frequency

As we look at Band Plans
\[ \text{Band} = \frac{300}{\text{Freq}(\text{MHz})} \]
Band = \frac{300}{Freq(MHz)}
<table>
<thead>
<tr>
<th>Band in METERS</th>
<th>Frequency in Hz</th>
</tr>
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<tbody>
<tr>
<td>80</td>
<td>3.5</td>
</tr>
<tr>
<td>40</td>
<td>7</td>
</tr>
<tr>
<td>30</td>
<td>10</td>
</tr>
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<td>20</td>
<td>14</td>
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<td>12</td>
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<td>6</td>
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</tr>
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<td>1.25</td>
<td>222</td>
</tr>
<tr>
<td>0.7</td>
<td>420</td>
</tr>
<tr>
<td>0.33</td>
<td>902</td>
</tr>
</tbody>
</table>

HF = 3 to 30

### VHF = 30 to 300

<table>
<thead>
<tr>
<th>Frequency in Hz</th>
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<tbody>
<tr>
<td>2.4</td>
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</tbody>
</table>

### UHF 300 - 3000

<table>
<thead>
<tr>
<th>Frequency in Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.25</td>
</tr>
</tbody>
</table>

Radio Frequency (RF) Spectrum

This has been corrected with your book

3kHz to 30kHz is primarily an audio (sound wave) portion of the spectrum. In some cases, RF waves can also be generated at these frequencies.

Chapter 4

Antennas
The Antenna System

- **Antenna**: Facilitates the sending of your signal to some distant station

- **Feed line**: Connects your station to the antenna

- **Test and matching equipment**: Allows you to monitor antenna performance

Antenna vocabulary

- **Driven element**: where the transmitted energy enters the antenna

- **Polarization**: the direction of the electric field relative to the surface of the earth
  - Same as the physical direction
  - Vertical – Horizontal - Circular
**Antenna vocabulary**
- **Omni-directional** - radiates in all directions
- **Directional beam** - focuses radiation in specific directions
- **Gain** – apparent increase in power in a particular direction because energy is focused in that direction
  - Measured in decibels (dB)

**Antenna Radiation Patterns**
- Radiation patterns are a way of visualizing antenna performance
- The further the line is away from the center of the graph, the stronger the signal at that point

4-7
**Impedance – AC Resistance**

- A quick review of a previous concept: impedance
- Antennas have characteristics of capacitors, inductors, and resistors
- The combined response of these component parts to alternating currents (radio waves) is called **Impedance**

**Antenna Impedance**

- Antennas have a characteristic impedance
- Expressed in Ohms – common value 50 Ohms
- Depends on:
  - Antenna design
  - Height above the ground
  - Distance from surrounding obstacles
  - Frequency of operation
  - Other factors

**Feed Line - Antenna - SWR**

- For **efficient** transfer of energy from the transmitter to the feed line and from the feed line to the antenna, the impedances need to **match**
- When there is mismatch of impedances, things may still work, but not as effectively as they could
Video

Feed Lines

Feed line types
- The purpose of the feed line is to get energy from your station to the antenna
- Basic feed line types
  - Coax cable
  - Open-wire or ladder line
- Each has a characteristic impedance, each has its unique application

Coaxial Cable (Coax)
- Most common feed line
- Easy to use
- Matches impedance of modern radio equipment (50 Ohms)
- Some loss of signal depending on coax quality (cost)
Open-wire/Ladder Line
• Used in special applications
• Need an antenna tuner to make impedance match – but allows a lot of flexibility
• Theoretically a very low loss

Test and Matching Equipment
• Proper impedance matching is important enough to deserve some simple test equipment as you develop your station repertoire
• Basic Test Equipment: S.W.R. Meter
• Matching Equipment: Antenna Tuner

Standing Wave Ratio (SWR)
• If the antenna and feed line impedances are not perfectly matched, some RF energy is not radiated into space and is returned (reflected) back to the source
Standing Wave Ratio (SWR)

- Reflected energy must go somewhere
- Usually it is converted into heat
- Sometimes it just floats around looking for somewhere to go
- If the energy is not going out the antenna, it is wasted and may cause damage to the transmitter

Video

Standing Wave Ratio (SWR)

The ratio of energy going out to energy coming back

SWR Meter

- The SWR meter is inserted in the feed line and indicates the reflected energy – measures the mismatch between feed line impedance and antenna impedance
- You make adjustments to the antenna to minimize the reflected energy (minimum SWR)
### Nothings Perfect

- Although the goal is to get 100% of your radio energy radiated into space, that is virtually impossible.
- What is an acceptable level of loss (reflected power or SWR?)
  - 1:1 is perfect
  - 2:1 should be the max you should accept (as a general rule)
  - Modern radios will start lowering power automatically when SWR is above 2:1
  - 3:1 is when you need to do something to reduce SWR

### Antenna Tuner

- One way to make antenna matching adjustments is to use an antenna tuner.
- Antenna tuners are impedance transformers (they actually do not tune the antenna).
  - When used appropriately they are effective
  - When used inappropriately they just make a bad antenna look good to the transmitter...a bad antenna is still bad

### How to use an Antenna Tuner

- Monitor the SWR meter.
- Make adjustments on the tuner until the minimum SWR is achieved.
  - The impedance of the antenna is transformed to more closely match the impedance of the transmitter.

---

<table>
<thead>
<tr>
<th>Monitor the SWR meter</th>
<th>Make adjustments on the tuner until the minimum SWR is achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The impedance of the antenna is transformed to more closely match the impedance of the transmitter.</td>
</tr>
</tbody>
</table>
How long should the antenna be?
When working with antennas, it is important to know how long.
Antenna length is based on the wavelength that we want to use.
There is a relationship between frequency and wavelength.
Antennas can be full or fractional wavelengths long.
Symbol and Formula
This is one of those things that needs to be memorized

\[ \lambda = \text{Wavelength} \]

\(\frac{1}{2}\) Wave antenna length in Feet is 468 divided by the Frequency in MHz

\(\frac{1}{4}\) Wavelength is 234 divided by the Frequency in MHz

The Dipole

- A basic antenna
  - Two conductive, equal length parts
  - Feed line connected in the middle
- Total length is \(\frac{1}{2}\) wavelength (1/2 \(\lambda\))
- Dipole Length (in feet) = 468 / Frequency (in MHz)
The Ground-plane

- Simply a dipole that is oriented perpendicular (vertical) to the earth's surface
- One half of the dipole is replaced by the ground-plane
  - Earth
  - Car roof or trunk lid - or other metal surface
  - Radial wires

The Ground-plane

Length (in feet) = \( \frac{234}{\text{Frequency (in MHz)}} \)

Wavelength

\( \frac{1}{2} \) Wavelength - Dipole
\( \frac{1}{4} \) Wavelength - Ground-plane above ground
## Loop Antennas – Dipole Variations
- Quad
- Delta
- Horizontal

## Beam Antennas
- Beam antennas focus or direct RF energy in a desired direction
  - Gain - An apparent increase in power in the desired direction (both transmit and receive)

## Beam Antennas
- Yagi (rod like elements – TV antennas)
- Quad (square wire loop elements)
Beam Antenna Elements

- Driven element connected to the radio by the feed line
- Reflector element is on the back side
- Director element is on the front side toward the desired direction
Coax Feed lines
- RG-58
- RG-8
- RG-213
- RG-174
- Hardline

Coax Connectors
- SO-239/PL259
- BNC
- N
- SMA

Adaptors
Antenna Supports

- Trees
- Towers or masts
- Covenants and antenna restrictions must be considered

Antenna System Devices

- Balun
- Duplexer
- Antenna Switches
- SWR Meter
- Antenna Analyzer
- Antenna tuners

Antenna System Devices

Antenna Analyzer

Connect to antenna
Very low power signal
Adjustable in frequency
Meter shows SWR
Determine resonant frequencies of the antenna
Vocabulary

- **RX** = Receiver
- **TX** = Transmitter
- **VFO** = Variable Frequency Oscillator – a frequency control

Rig Vocabulary

- We will now talk about vocabulary specific to the functions and controls of a transmitter and receiver
- Leading to “How to operate a Transceiver”

Radios have Instructions

Pictures
Explanations
Operating Instructions

Here are some samples
**Transmitter Controls and Functions**

- Microphone (Audio) control
  - Gain
  - How loudly you need to talk to be heard

- Microphone (Audio) control
  - Speech Compressor or Speech Processor
    - Compacting your speech into a narrow frequency range to enhance “punch”

- Microphone (Audio) control
  - Too much gain or compression can cause problems
    - Splatter
    - Over-deviation
    - Over-modulation
**Transmitter Controls and Functions**

- **Automatic Level Control (ALC)**
  - Automatically limits transmitter drive (output level) to prevent problems associated with too much gain or compression
  - Also can control external power amplifier operation

- **Transmission on/off (not power)**
  - Push-to-Talk (PTT)
  - Voice-Operated Transmission (VOX)
    - VOX Gain
    - VOX Delay
    - Anti-VOX
    - Key Jack

**Microphones**
- Hand mikes
- Desk mikes
- Speaker-mikes
- Headsets or boom-sets
- Internal mikes

- Speak across the mike, not into the mike
Transmitter Controls and Functions

- Morse Keys
  - Straight
  - Semi-automatic (Bug)
  - Electronic keyer, paddle

Receiver Controls and Functions

- **AF** Gain or Volume
  - Controls the audio level to the speaker or headphones
- **RF** Gain or Sensitivity
  - Controls the strength of radio signal entering the receiver’s detector
  - Used to limit (attenuate) very strong local signals
  - Usually operated in the full-open position
**Receiver Controls and Functions**

- Automatic Gain Control (AGC)
  - Automatically limits the incoming signals during signal (voice) peaks
  - Prevents peaks from capturing the receiver and limiting reception of lower level portions of the incoming signal
- Fast setting for CW
- Slow settings for SSB and AM
- Not used in FM because of the type of signal used in FM

**Recipe for a Transceiver**

- Take -
  - A **Receiver** and
  - A **Transmitter** and
  - Put them in the same box, and
  - Share common controls and circuits (mix well)
- You have a **Transceiver**
Multi-Band Tranceiver

Transceiver Controls and Functions

• **Main tuning dial** (both TX and RX)
  - Controls the frequency selection via the Variable Frequency Oscillator (VFO)
  - Could be an actual dial or key pad or programmed channels

• **Variable frequency step size** (tuning rate, resolution)
  - Could have more than one VFO (control more than one frequency at a time)
**Transceiver Controls and Functions**

- **Mode Selector** (both TX and RX multi-mode rigs)
  - AM/FM/SSB (LSB or USB)
  - CW
  - Data (RTTY)
- Could be automatic based on recognized band-plan

**Transceiver Controls and Functions**

- **Reception and Transmission Meter**
  - In transmit indicates output power or ALC or other functions as selected by switch setting
  - In receive indicates signal strength
    - In “S” units S1 through S9 – S9 is strongest
    - Also have dB over S9 for very strong signals

**Power Amplifier**
What is a Repeater?

- Specialized transmitter/receiver interconnected by computer controller
- Generally located at a high place

Receives your signal and simultaneously re-transmits your signal on a different frequency

Dramatically extends line-of-sight range, if both users can "see the repeater’s antenna"
A Little Vocabulary

**Simplex**
- Transmitting and receiving on the same frequency
- Each user takes turns to transmit
- Is the preferred method if it works

**Duplex**
- Transmitting on one frequency while simultaneously listening on a different frequency
- Repeaters use duplex
A Little Vocabulary

Duplex

**Output frequency** – the frequency the **repeater** **transmits** on and **you listen to**

**Input frequency** – the frequency the **repeater** **listens to** and **you transmit on**

Things to Know to Use a Repeater

- **Output frequency**
- **Frequency offset**
- **Repeater access tones (if any)**

Repeater Output Frequency

- Repeaters are frequently identified by their output frequency
  - “Meet you on the 443.50 machine.”
    - Here the specific frequency is used
  - “Let’s go to 94.”
    - Here an abbreviation for a standard repeater channel is used, meaning 146.94 MHz
  - “How about the MVARC repeater?”
    - Here the repeater is referenced by the sponsoring club name
Standard Repeater Frequency Offset

- The shift or offset frequencies are standardized to help facilitate repeater use
- There are + and – shifts depending on the band plan
- Different bands have a different standardized amount of shift

Repeater Frequency Offset

<table>
<thead>
<tr>
<th>Band</th>
<th>Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Meters</td>
<td>−100 kHz</td>
</tr>
<tr>
<td>6 Meters</td>
<td>Varies by region: −500 kHz, −1 MHz, −1.7 MHz</td>
</tr>
<tr>
<td>2 Meters</td>
<td>+ or −600 kHz</td>
</tr>
<tr>
<td>1.25 Meters</td>
<td>−1.6 MHz</td>
</tr>
<tr>
<td>70 cm</td>
<td>+ or −5 MHz</td>
</tr>
<tr>
<td>902 MHz</td>
<td>12 MHz</td>
</tr>
<tr>
<td>1296 MHz</td>
<td>12 MHz</td>
</tr>
</tbody>
</table>

Repeater Access Tones

- Sometimes multiple repeaters on the same frequency pair can be accessed at the same time
- To preclude unintentional access, many repeaters require a sub-audible tone be present before the repeater controller will recognize the signal as a valid and turn on
Repeater Access Tones

- These tones are called by various names (depending on equipment manufacturer)
  - CTCSS – Continuous Tone Coded Squelch System
  - PL
  - Privacy codes or tones

Repeater Access Tones

- Access tones are usually published along with repeater frequencies
- Could also be announced when the repeater identifies: “PL is 141.3”
- Tones are generally programmed into the radio along with frequency and offset

K4US Repeater Access

- 146.655 (-)
- PL 141.3
Repeater Controller

Computer that controls repeater
- Sends Repeater ID (callsign)
- Time-out protection
- Courtesy tone
- Auto Patch
- DTMF pad test

Station ID - Morse or voice
- Same ID requirements as you have
- Every 10 minutes
- Time-out protection
- Sometimes called the alligator
- Protects against continuous transmission in the event of a stuck PPT or long winded hams

Repeater Controller

-Courtesy tone – Wait for the tone before transmitting
- Repeater timer – limits a single transmission to 3 minutes
- Press 9-1-1 for Alexandria PD/EMS
- Press 555 to test your tone pad
- Press 725* for record - playback
- Many other functions
K4US Repeater

- When you use any of these (sending tones only) you still must ID at the end – otherwise it is an unidentified transmission
  911 for Alexandria PD/EMS
  555 to test your tone pad
  725* for record - playback
At the base of the antenna looking up

Mast is 20 feet long
Looking down from 40' below antenna

Questions?
Chapter 5.2

Equipment

Digital Modes

Data (Digital) Modes

- There are several different ways to send data over amateur radio
- Here is a brief overview

Yes, CW using Morse Code is a Digital Mode

Digital Modes

- HF using SSB
  - RTTY - 5 bit Baudot
  - Winlink 2000 (Pactor, Winmor)
  - Keyboard to keyboard - PSK31, MFSK
- VHF & UHF
  - Packet AX.25
  - Winlink 2000 (B2F)
Data Modes

- Connecting computers via ham radio
  - Some systems use radio to connect to Internet gateways
- The bulk of the work is done by specialized modems or computer software/sound card
  - Terminal Node Controller (TNC)
  - Multiple Protocol Controller (MPC)

TNC – MPC

- Provide digital interface between computer and radio
  - Package the data into proper format
  - Convert digital data into audio tones representing 1s and 0s of digital data
  - Send/receive tones to transceiver
  - Control the transceiver

Data Station Setup
Chapter 5.3
Equipment
Power Supplies and Batteries

Power Supplies
• Most modern radio equipment runs on 12 volts DC
• Household current is 120 volts AC
• Power supplies convert 120 volts AC to 12 volts DC
  ▪ 13.8 volts DC is the common voltage you will see
  ▪ This is the charging voltage for motorized vehicles
Power Supply Ratings

Voltage and Current

- **Continuous** duty – how much current can be supplied over the long term
- **Intermittent** duty – how much surge current can be supplied over the short term
- **Regulation** – how well the power supply can handle rapid current changes

Types of Power Supplies

- **Linear**
  - Transformers
  - Heavy (physically)
  - Heavy duty current
  - Expensive
- **Switching**
  - Electronics instead of transformers
  - Light weight and small
  - Not as robust
  - Less expensive
  - May be source of RFI

Inverters and Generators

- Inverters convert DC into AC
  - Square, triangle, sine-wave inverters
- Generators create AC
  - Gas powered
  - Various voltage and current ratings
  - Special precautions
Batteries

- Create current through a chemical reaction
- Made up of individual cells (approximately 1.5 volts per cell) connected in series or parallel

Batteries

- Battery types
  - Disposable
  - Rechargeable
  - Storage
- Power capabilities rated in Ampere-hours
  - Amps X time

Battery Charging

- Some batteries can be recharged, some cannot
- Use the proper charger for the battery being charged
- Batteries will wear out over time
Battery Charging

- Best if batteries are maintained fully charged
  - Over-charging will cause heating and could damage the battery
- Some batteries (lead-acid) will release toxic fumes during charging so require ventilation

Handheld Transceivers

- Single, dual and multi-band versions (with increasing cost and complexity)
  - Some have expanded receiver coverage (wide-band receive)
- Very portable and self-contained
  - Internal microphone and speaker
  - Rubber duck antenna
  - Battery powered

Nice to have handheld accessories

- Extra battery packs
- Drop-in, fast charger
- Extended antenna
- External microphone and speaker
- Headset
Chapter 5.4

Radio Frequency Interference

- Also known as RFI
- May be man made

Radio Frequency Interference

- Strong signals
- Automobile ignition noise
- Electric Welding
- Fluorescent lights - Grow lights
- Air Cleaners
- Power Lines
- Computers
- Fare Card Machines

Radio Frequency Interference

- Unwanted, un-intentional signals from some electronic device that interferes with radio wave reception
- You can prevent creating RFI by operating your transmitting equipment properly
RFI Mitigation

• Filters attenuate (reduce) interfering signals – but do not totally eliminate them

• Types
  • High Pass
  • Low Pass
  • Band Pass

RFI Mitigation

• Ferrite - the RFI Buster
• Snap on ceramic magnets

Filters

• High pass – generally on the receive side
• Low pass – generally on the transmit side
• Band-pass – used within most radio equipment
Types of RFI
- Direct detection – offending signals get into the electronics circuits to cause interference
- Overload – strong signal that overwhelms the weaker, wanted signal
- Harmonics – even multiples of the offending signal that coincided with the wanted signal

Cable TV Interference
- Usually the result of broken shielding somewhere in the cable
  - Loose connections
  - Broken connections
  - Corroded connections
- Usually solved by proper cable maintenance by cable supplier
  - If the subscriber is a legitimate subscriber

Noise Sources
- Electrical arcs (motors, thermostats, electric fences, neon signs)
- Power lines
- Motor vehicle ignitions
- Motor vehicle alternators
- Switching power supplies
- Computers, networks, TV sets
Dealing with RFI

- Make sure you operate your equipment properly.
- Eliminate interference in your own home first.

Dealing with RFI

- 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.

Dealing with RFI

- 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 a low-pass filter because the desired signal will be removed as well.
Dealing with RFI

- 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.

Dealing with RFI

- Take interference complaints seriously
- Make sure that you're really not the cause (demonstrate that you don't interfere within your own home)

Dealing with RFI

- Offer to help eliminate the RFI, even if you are not at fault
- Consult ARRL RFI Resources for help and assistance
What the Rules Say

- RFI from and to unlicensed devices is the responsibility of the users of such devices
- Bottom line – if your station is operating properly, you are protected against interference complaints

What the Rules Say

BUT – be a good neighbor because they may (probably) not be familiar with Part 15 rules and regulations

Questions?
Chapter 6
Communicating with other hams
Contact Basics
Band Plans
Making a Contact

Typical Telephone Conversation
- Greeting
- Identify who is participating
- Exchange information, generally taking turns
- Salutations
- End the conversation

Typical Ham Contact (QSO)
- Greeting
- Identify who is participating
- Exchange information, generally taking turns
- Salutations
- End the conversation
Radio Manners

- Speak clearly and distinctly
- It is a GIANT party line, select topics accordingly
- Shared use of frequencies

Radio Manners

- Signal Reports
  - Power level
  - Location

Signal Reports

- RST
  - Readability (1-5)
  - Strength (1-9)
  - Tone (CW only 1-9)

- “Your RST is 58” 6-3
Readability (1-5)
1 - Unreadable
2 - Barely readable, occasional words distinguishable
3 - Readable with considerable difficulty
4 - Readable with practically no difficulty
5 - Perfectly readable

Strength (1-9)
1 - Faint signals, barely perceptible
2 - Very weak signals
3 - Weak signals
4 - Fair signals
5 - Fairly good signals
6 - Good signals
7 - Moderately strong signals
8 - Strong signals
9 - Extremely strong signals

Tone (CW & Digital only 1-9)
1 - Sixty cycle AC or less, very rough and broad
2 - Very rough AC, very harsh and broad
3 - Rough AC tone, rectified but not filtered
4 - Rough note, some trace of filtering
5 - Filtered rectified AC but strongly ripple-modulated
6 - Filtered tone, definite trace of ripple modulation
7 - Near pure tone, trace of ripple modulation
8 - Near perfect tone, slight trace of modulation
9 - Perfect tone, no trace of ripple or modulation of any kind
**Q Signals**

- Shorthand from the telegraph and CW world, some migrated to voice
- Followed by question mark is asking
- No question mark is answer or statement

**Some Q Signals**

- QTH ? "Where are you located"
- QTH "Alexandria Va"
- QSY up 2 "move up 2 Khz to a clearer frequency"
- QRZ ? "Who is calling me"
- **Slang: QLF - please send with your Left Foot - (not on test)**

**Radio Manners**

- Ham radio is self-regulated
  - ARRL Official Observers
  - Logging
  - QSL’s
    - Awards Program
Band Plans

- A band plan is a way of organizing the use of radio frequencies
  - Formal and legal plan
  - Informal – gentleman's agreement

Operating Dos and Don'ts

- Use CQ versus “monitoring”
- Use phonetics
- Taking turns and breaking-in
- Station identification
- Using repeaters
- Using simplex

Radio Manners

Appropriate topics
- Indecent & obscene PROHIBITED
- Try to stay clear of provocative subjects: politics, religion, sexual
- Weather and radio equipment are frequently good topics
Using Repeaters
- Offset
- Access tones
- How to ID
- Linked Repeaters
- Autopatch
- Open/Closed

Digital and Internet
- Echolink
- IRLP
- WinLink
- D-Star

Questions?
Chapter 6
Communicating with other hams
Nets

Nets
• Net is short for “Network”
  ▪ Evolved over the years of radio to share and exchange information in an organized and efficient way with accuracy
• Social Nets
• Traffic Nets
• Emergency and Public Service Nets

Traffic Nets
• Traffic refers to formal messages that are relayed via ham radio
• Formal structure to ensure accuracy – National Traffic System (NTS)
  ▪ Procedures
  ▪ Accountability
Emergency and Public Service Nets

- Public Service Nets – training for emergency nets
  - Training for ham operators as well as supported emergency managers
- Emergency Nets

Net Structure

- Net Control Station (NCS)
  - Traffic cop that controls the flow of information
- Check-in and check-out procedures
- Communications discipline vital
  - Learn and follow procedures
  - Speak only when directed, and only to whom directed
  - Follow through with your commitments
Day 4 Starts Here

Questions?
Something you don't understand?
What is bothering you?

Chapter 6
Communicating with other hams
Emergency Communications
Supporting Emergency Operations

• One of the pivotal reasons for the existence of Amateur Radio
• You will be licensed communicators
  • Get involved and use what you have learned
• Know where you fit in the overall emergency management team

EMCOMM Tips

• Don’t become part of the problem
• You are a communicator, not a decision or policy maker
• Don’t give out unauthorized information
• Know your abilities and limitations—keep yourself safe
• Follow radio discipline and net procedures
• Protect personal information—ham radio communications is a “party line”

EMCOMM Training

• If you are going to participate in EMCOMM: get training
• Take EMCOMM courses
  • ARRL EMCOMM Courses 1, 2, and 3
  • NIMS and FEMA courses
### EMCOMM

- Actively participate in EMCOMM activities
  - Nets
  - Public service activities
  - Attend community meetings and get involved in your community

### EMCOMM Organizations

- **Radio Amateur Civil Emergency Service (RACES)**
  - Supports civil emergencies
  - National in scope

### EMCOMM Organizations

- **Amateur Radio Emergency Service (ARES)**
  - Local and regional in scope
  - Supports non-governmental agencies supported
  - ARRL sponsored
Emergency Declarations
- FCC may declare a Temporary State of Communications Emergency
- Includes details of conditions and rules to be followed
- Specifics communicated through web sites and ARRL bulletins, the NTS, and on-the-air
- Avoid operating on restricted frequencies unless engaged in relief efforts

Making and Answering Distress Calls
- Rule #1 – speak in plain language!
- Mayday (voice); SOS (Morse code)
- Identify
- Give location
- State the situation
- Describe assistance required
- Provide other important information

Tactical Communications
- Tactical Call Signs
  “Fire Command”, “Main Street School Shelter”, “Incident Commander”
- Facilitate communications
- Location or function specific
- Transcends operator changes
- FCC ID rules still apply
  Your FCC Call Sign - every 10 minutes and at end
Emergency Equipment

- “Go-kits”
  - Portable ham radio equipment
  - Emergency power sources
  - Personal survival supplies and equipment

Questions?

Chapter 6
Communicating with other hams
Special Modes and Techniques

6-29
Awards

• DXCC
  • Contacting 100 different countries and/or entities
• WAS
  • Contacting 50 states
• VUCC
  • Contacting 100 grid squares on VHF/UHF

Special Events

• Special Event stations are set up to commemorate some significant local event
• Usually stations are demonstration stations set up for public display
• Commemorative certificates are awarded for contacting the stations

Special Events

• Call Signs = 1 by 1 W1J K3D
Which type of call sign has a single letter in both its prefix and suffix?
A. Vanity
B. Sequential
C. Special event
D. In-memoriam
Contests

- Field Day - June
- Sweepstakes - November
- QSO Parties
- CQ DX Contest
- Contest Corral (a list in QST)

Amateur Satellites

- OSCAR
  - Orbiting Satellites Carrying Amateur Radio
- Modes
  - FM
  - Analog (SSB and CW)
  - Digital
- International Space Station 6-30

What satellite contacts sound like

- FM contact
- SSB contact
  - Very loud
- ISS contact
Digital Techniques

- Radio Teletype (RTTY)
  - Single letters sent as they are typed
- AMTOR and PACTOR
  - Small grouping of letters sent with error correction
- Packet and Packet Networks
  - Groups (packets) of collected data sent with error correction and automatic forwarding
- PSK31
  - Different modulation technique

What Digital sounds like

- RTTY
- AMTOR
- PACTOR
- PACKET
- PSK31

Digital Mode Modulation Techniques

- Digital means two states: ON and OFF
  - Digital code is a sequence of ON and OFF states or 1’s and 0’s
  - The letter “A” is 0100 0001 (41 hexadecimal or 65 decimal)
- When two audio tones are used to represent the ON and OFF states it is called Frequency Shift Keying (FSK)
- When changing phase states are used to represent ON and OFF states it is called Phase Shift Keying (PSK)
Communicating Digitally

- Keyboard-to-keyboard
  - Live exchange using computer keyboards
  - Digipeaters extend range

Store and forward networks

- Packet networks, bulletin boards
  - Digipeaters make up the backbone of packet networks
- Internet-Radio connections
  - WinLink
  - Radio connections are Internet Gateways
APRS
• Automatic Position Reporting System (APRS)
• Packet based Global Positioning System (GPS) position reporting
  ▪ Uses a packet-like digipeater system to create an APRS network (also Internet connected)

Video
Slow Scan TV (SSTV)
  Sending snap-shot pictures
Amateur TV (ATV)
  Similar to commercial TV
• What SSTV sounds like
Other Special Modes

- Meteor Scatter
  - Reflecting radio signals off of the ionized trail left by meteors
- Moonbounce
  - Reflecting radio signals off the surface of the moon

Other Special Modes

- Radio Control (RC)
  - Telecommand
  - 50 MHz band

Questions?
Chapter 7.1 Licensing Regulations

Licensing Terms

Working with the FCC
Bands and Privileges
International Rules
Call Signs

Definitions

- Amateur Service – non pecuniary interest (private and personal, non-commercial)
- Amateur Operator – the person holding authorization (license) to operate an amateur radio station
- Amateur Station – equipment capable of transmitting on frequencies authorized for Amateur Service

License Term and Renewal

- The license is free
- The license is good for 10 years
  - Renewable within 90 days of expiration
- Personal identification information is required
  - Federal Registration Number or
  - Tax ID (social security number)
  - Current Mailing Address
The Amateur License
- No age limit or citizenship restrictions
  - One exception – no foreign representatives
- License actually contains two parts
  - Operator License
  - Station License (the Call Sign)
- Three classes of operator privileges: Tech, General, Extra

Examinations
- Preparation
  - Study the content
  - Question Pool
- Taking the exam
  - Proctored exam
  - Multiple choice
- Volunteer Examiners (VEs)
- Volunteer Examiner Coordinators

Responsibilities of Licensure
- Prevent unauthorized operation of your station
- Provide personal information as required – keep a current mailing address on file
- Make your station available for FCC inspection upon request
What can you do with a Technician Class License?
- Use the minimum power required to communicate
- Up to 1500 Watts Peak Envelope Power (PEP)
  - Will generally require an external amplifier
  - Some special cases where power is restricted

Chapter 7.2
Licensing Regulations
Licensing Terms
Working with the FCC
Bands and Privileges
International Rules
Call Signs

Licensing Authority
- Federal Communications Commission
  - Located in Gettysburg, PA
FCC ULS Web Site

- www.wireless.fcc.gov/uls
- Register for on-line access to your license information
- Make changes to your address and other information
- Renew your license
- Search for other station information

Chapter 7.3
Licensing Regulations

- Licensing Terms
- Working with the FCC
- Bands and Privileges
- International Rules
- Call Signs

What can you do with a Technician Class License?

- Frequency Privileges
- Given one we can calculate the other:
  \[
  Band = \frac{300}{Freq(MHz)}
  \]

Band in meters, Freq in MHz
• Emission Privileges

Amateur Emission Types

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CW</td>
<td>Morse code telegraphy</td>
</tr>
<tr>
<td>Data</td>
<td></td>
</tr>
<tr>
<td>Image</td>
<td>Television that uses one or more visual and acoustic or textual</td>
</tr>
<tr>
<td>MCW</td>
<td>Tone modulated CW, Morse code generated by using an audio tone</td>
</tr>
<tr>
<td>Phone</td>
<td>Speech or voice communications</td>
</tr>
<tr>
<td>Pulse</td>
<td>Communications using a sequence of pulses whose characteristics are modulated in order to carry information</td>
</tr>
<tr>
<td>RTTY</td>
<td>Narrowband direct-printing telegraphy operated by automatic equipment, such as a computer or computer system</td>
</tr>
<tr>
<td>SS</td>
<td>Spread-spectrum communications in which the signal is spread out over a wide band of frequencies</td>
</tr>
<tr>
<td>Test</td>
<td>Transmissions containing no information</td>
</tr>
</tbody>
</table>

Emission Privileges

- CW
- Pulse
- Data
- RTTY
- Image
- SS
- MCW
- Test
- Phone
Primary & Secondary Allocations

- Some authorized amateur frequencies are shared
  - Primary Users
  - Secondary Users
- Navigation, Research ...

Band Plans

- Good Practice
- Voluntary
- Different frequencies for different activities
- Don't use CW in the Phone segment

Repeater Coordination

- Frequency Coordinator
  - Fixed Repeater Input frequencies
  - Fixed Repeater Output frequencies
  - Access control tones
  - Distance separation
Chapter 7.4
Licensing Regulations
Licensing Terms
Working with the FCC
Bands and Privileges
International Rules
Call Signs

International Rules
- The ITU
- Regions
- Reciprocal Operating Authority
- IARP (N and S America)
- CEPT (most of Europe)

Amateur Radio - Internationally
- International Telecommunications Union (ITU)
  - Regions 1, 2, and 3
- CONUS hams are in Region 2
- Reciprocal Operating Authorization
- There are times when there are restrictions on certain countries that we can contact
ITU Regions

Third Party Rules
- We will discuss these shortly -- operating regulations
- There are different station identification requirements for third party communications

Chapter 7.5
Licensing Regulations
- Licensing Terms
- Working with the FCC
- Bands and Privileges
- International Rules
- Call Signs
### Call Signs

- **US call signs**
  - begin with: K, N, W, and A
  - districts: 0-9
- Other nations have different prefixes

### US Amateur Radio Call Signs

- **Other Radio Services** have different formats
- **Prefix, Number, Suffix**
  - W 3 BSA
  - WA 4 USB
  - K 4 BSA
  - KG 4 RKE
US Amateur Radio Call Signs

- Are unique in the world
  - Australia AX, VH–VN, and VZ
  - Canada CF–CK, CY–CZ, VA–VG, VO (Newfoundland and Labrador), VX–VY, XJ–XO
  - China B, XS, 3H–3U
  - Indonesia JZ, PK–PO, YB–YH, 7A–7I, 8A–8I
  - Japan JA–JS, 7J–7N, 8J–8N
  - Mexico XA–XI, 4A–4C, 6D–6J
  - Russia R, UA–UI
  - Sweden SA–SM, 7S, 8S
  - United Kingdom G, M, VS, ZB–ZJ, ZN–ZO, ZQ, 2
  - United States K, W, N, AA–AL.

Not on the test

You may hear this on the air
Call Signs

- Portable – operating away from primary station location
- If in the different call sign district add:
  - “portable 6” if voice
  - /6 if Morse code or digital
  - Not required just nice to do
- If recent up-grade add “AG” or “AE”
Special Call Signs

• Club
• Special Event (1x1)
  W1J October 20, 2000 to October 22, 2000 PIONEER VALLEY BSA JOTA
• Vanity Call Signs
  There is a FCC fee every 10 years

Chapter 8.1
Operating Regulations

Control Operators
Identification
Interference
Third-Party Communications
Remote and Automatic Operation
Prohibited transmissions
Control Operator Responsibilities

The FCC's primary concern is that transmissions are made only under the control of a licensed operator.

- Control Operator – the licensed amateur responsible for making sure transmissions comply with FCC rules.

Control Operator

- Must have a valid FCC issued amateur radio license.
- Station must operate within the authorization of the control operator's license.
- Control operator must be present at the control point of the station (the on-off switch) or remotely connected by a control link.

Guest Operations

- Unlicensed people can use ham radio but only when a control operator is present.
- The control operator is solely responsible for station operation.
- Licensed guests can use the ham radio.
- Both the control operator and the guest ham are responsible for station operation.
Chapter 8.2
Operating Regulations

Control Operators
Identification
Interference
Third-Party Communications
Remote and Automatic Operation
Prohibited transmissions

8-3

Station Identification

- Normal ID
  - Say your call sign every ten minutes during and at the end of the contact
- Use of Tactical Call Signs
  Does not substitute for proper station ID

Every 10 minutes during communications **and at the end of each communication** (not each transmission)

ID is **not required** at each over or at the beginning
Be aware of 3rd party rules
Station Identification

- Ham Guests
  - If higher license class and use higher class privileges
  - Guest's call followed by owner's call
    - "This is K4AB KG4XYZ"
    Extra, General

Repeating, Satellites, ISS

- Repeaters must ID using the same 10 minute rule
  - Can be voice or CW (at 20 WPM or less)
  - Satellites and ISS have special rules

Repeating, Satellites, ISS

- Special event calls (ex. W4J)
  - Normal club call or control operator call given once per hour
Chapter 8.3
Operating Regulations

Control Operators
Identification

Interference
Third-party Communications
Remote and Automatic Operation
Prohibited Transmissions

Types of Interference

- QRN
  - Natural interference (thunderstorms)
  - Man-made (appliances and power lines)
- QRM
  - Interference from nearby signals
  - Other hams or other users of the frequencies

Prevent Interference

Control operators should prevent interfering with other users of the frequencies
Preventing Interference

- Use common sense and courtesy
- Keep equipment in proper operating order
- No one owns a frequency, be a good neighbor and share
- Yield to special operations and special circumstances

Interference

- Harmful
  - Interference that is disruptive but not intentional
  - Deal with it as best you can and help others avoid harmful interference

Willful Interference

Intentionally causing interference
- This becomes a legal and law enforcement issue
- This is rare and there are procedures to deal with this (ARRL Official Observers can help)
**Chapter 8.4**
**Operating Regulations**

- Control Operators
- Identification
- Interference
- **Third-Party Communications**
- Remote and Automatic Operation
- Prohibited transmissions

---

**Third-party Communications**

- Third-party means that a non-ham is involved in communication via ham radio
  - Could be actually speaking on the air
  - Could be passing a message on behalf of the non-ham

---

**Third-party Communications**

- Two situations - with different rules
  1. Within the US
  2. Communication that crosses international borders
Third-party within US

- No special rules
- Make sure the message is non-commercial in nature

Third-party Across Borders

- Make sure that third-party agreement exists
  - Check for current third-party agreements from FCC sources if in doubt
  - You might be surprised at the countries that we do not have third-party agreements with

Third-party Across Borders

- During station identification say both station’s call signs
  “DL2XYZ this is K4US”
Remote and Automatic Control

- Some stations, repeaters and beacons operate without the control operator physically present at the control point
- These stations must still comply with control operator stipulations
  - Local
  - Remote
  - Automatic
**Prohibited Transmissions**

- **Unidentified** transmissions (not giving your call sign)
- **False or deceptive** signals (using someone else’s call sign)
- **False distress** or emergency signals (fake calls for help)
- **Obscene or indecent** speech (up to interpretation)
- **Music**

**No Business Communications**

- You can not **make a profit** through the use of transmissions made via ham radio
- The exceptions are teachers using ham radio in their classrooms and certain emergency drills

**No Encrypted Transmissions**

- Encryption involves encoding information for transmission that must be decoded upon reception to interpret the information
- Encryption is okay if:
  - Coding is open source
  - Intention is not to hide the message or deceive
No Broadcasting

• Broadcasting is sending one-way transmissions with no expectation of getting a response
  • News, Music

Exceptions

• Code practice
• Ham radio related bulletins
• Re-transmission of shuttle communications

Special Circumstances

• Ham communication is generally intended for hams
• Emergencies and critical situations create special circumstances
• Special commemorative events may qualify as special circumstances
• Normal rules return when the situation returns to normal

Questions?
• Avoiding contact is the most effective way of practicing electrical safety.
• Most modern radio equipment uses currents that are not as dangerous as older equipment but precautions still must be taken.

Electrical Injuries
• Shocks
• Burns
• Even small currents can cause problems.
Mitigating Electrical Hazards

- TURN OFF power when working on equipment (inside the case)
- Make sure the equipment is PROPERLY GROUNDED and the circuit is protected by a fuse, breaker, etc.

- If power is required:
  - Remove jewelry
  - Avoid unintentional touching of circuitry
  - Never bypass safety interlocks
  - Capacitors hold a charge even when power is off
  - Storage batteries are dangerous when shorted
Mitigating Electrical Hazards

- Use only one hand so your body does not complete a circuit
- Leather shoes, dry floor

Respond to Electrical Injury

- REMOVE POWER!
  - Have ON/OFF switches and circuit breakers clearly marked
  - Call for help
  - Learn CPR and first aid

Electrical Grounding and Circuit Protection

- This is in your best interest
- In the home
- In the car
**In the home**
- Make sure your home is “up to code”
- Most ham equipment does not require special wiring or circuits
  - Use 3-wire power cords
  - Use circuit breakers, circuit breaker outlets, or Ground Fault Interrupter (GFI) breakers
  - Use proper size fuse or circuit breaker
- Don’t overload outlets

**In the car**
- **Car batteries hold lots of energy** – shorting a battery could cause a fire
- **There are many good ways to do it safely**

**Do it SAFELY in the car**
- Fuse positive **and** negative leads
- Connect radio’s **negative** lead to **where** the battery ground connection is made – **not to the battery**
- Use grommets or sleeves to prevent chafing
- All **metal** in the car is **not grounded**, cars are as much plastic as metal
**RF Exposure**

- **Proper Grounding**
  - **Important for protection of**
    - Equipment
    - People
  - Wires connected to the radio become part of the antenna - can radiate RF – RF can burn you

**Lightening Safety**

- Antennas are not struck more frequently than trees or tall structures
- Ground all antennas
- Use lightening arrestors
- Disconnect antenna cables and power cords during storms
- Disconnect telephone lines from computer modems
RF Exposure
- Exposure to high levels of RF can cause problems
- If equipment is operated properly, RF exposure is minimal and not dangerous
- RF energy can heat body tissues
  - Heating depends on the RF intensity and frequency

RF Intensity
- Power Density
  - Transmitter power
  - Antenna gain and proximity
  - Mode and duty cycle

RF Intensity
- Power Density
  - Actual transmitter power
  - Higher power is higher risk
RF Intensity
- Power Density
  - Antenna gain and proximity
  - Beam antennas focus available energy
  - Being physically close or standing in the beam direction increases risk
- Mode and duty cycle
  - The more time the power output is at a high level, the higher the risk
  - CW, Voice, RTTY

We are concerned about
- Where the antenna is located
- How close can people get to the antenna
  - Controlled Environment
  - Uncontrolled Environment
Antenna Proximity

• **Controlled Environment**
  ▪ You know where people are standing in relation to your antenna and you can do something about it
  ▪ More power is allowed because you can make adjustments if needed

• **Uncontrolled Environment**
  ▪ You have no idea or control of people near your antenna
  ▪ Less power is allowed because you have to assume the worse case scenario

Mode and Duty Cycle

• The more time the transmitted power is at high levels, the greater the duty cycle, and the greater the exposure risk
**Mode and Duty Cycle**

Operating Duty Cycle of Modes Commonly Used by Amateurs

<table>
<thead>
<tr>
<th>Mode</th>
<th>Duty Cycle</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversational SSB</td>
<td>20%</td>
<td>1</td>
</tr>
<tr>
<td>Conversational SSB</td>
<td>40%</td>
<td>2</td>
</tr>
<tr>
<td>SSB &amp; PSK</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Voice AM, 100% modulation</td>
<td>25%</td>
<td>3</td>
</tr>
<tr>
<td>Voice AM, 100% modulation</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Voice FM</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Uplink firecall</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>40m, video portion, image</td>
<td>60%</td>
<td></td>
</tr>
<tr>
<td>40m, video portion, black screen</td>
<td>80%</td>
<td></td>
</tr>
<tr>
<td>Conversational CW</td>
<td>40%</td>
<td></td>
</tr>
<tr>
<td>Carrier</td>
<td>100%</td>
<td>4</td>
</tr>
<tr>
<td>Digital (PSK1, RTTY)</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

Note 1: Includes voice characteristics and symbolic duty cycle. No speech processing.
Note 2: Includes voice characteristics and symbolic duty cycle. Heavy speech processor employed.
Note 3: Full carrier, double-sideband modulation, referenced to 100% typical for voice speech. Can range from 25% to 100%, depending on modulation.

**RF Exposure and Frequency**

- Body parts are like antennas - absorb RF energy at certain frequencies (wavelengths) more efficiently
- RF exposure risk varies with frequency
  - More caution is required at some frequencies than others
Physical Safety

- Mobile Installations
  - Secure all equipment
  - Location, location, location
- Antenna installation
  - Clear of trees and power lines
  - If it falls it won’t hit anyone or cross power lines
- Tower climbing considerations

Questions?

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Practice Exams

• On Line
• CD based
• How did you do?
• What are you going to do this week?

February 14 Exam

• Please bring the following:
  • 1) Picture ID or a DMV “child’s ID” which looks like a drivers license.
    OR a parent with the same last name and address AND info that only a parent would have such as a birth certificate - parent ID IS NOT the preferred ID
  • 2) SSN

Please let me know if need to have the exam read to you and allow extra time
Must have SSN (card is not required) or FRN
Must have Picture ID - Government, Student, or parent with same last name - School ID with picture will work
Forms must be done in black or blue ink (we will have pens)
February 14 Exam

- If you hold any FCC license and have a FRN please bring that also
- Such as GMRS