Amateur Radio Service Technician Class

Exam Preparation Class June 2019 Session 3 Roland K. Smith K7OJL Phone: (435) 849-1946 Email: <u>rolandksmith@gmail.com</u> These slides will be uploaded to my website

https://k7ojl.com/technician-class-materials/

just before class each week.

Depending on how the class goes, they may get updated after the class.

Class Overview

- Questions?
- Review from Last Session
- Digital Communications
- Modes
- Interference
- Volts, Ohms, Amperes, and Farads
- Components
- Decibels



If At First You Don't Succeed...



Last Session

- Nets and Net Operations
- Propagation
 - D, E and F Layers
 - Sunspots
 - Solar Flux Index
- Antennas and Feedlines
 - Dipole ... formula for length in feet: 468/frequency in Megahertz
 - Vertical Antennas
 - Directional Antennas
- Space Stations
 - Station repeater mode: U/V; V/U

A Satellite Contact Video

 <u>https://</u> <u>www.youtube.com/</u> <u>watch?</u> <u>v=pj0VqsYzGVA&t=393s</u>



SO-50





Although there aren't any test questions about HF bands, Technicians have CW privileges on the 80 meter, 40 meter, and 15 meter bands.





In wireless telecommunications, multipath is the propagation phenomenon that results in radio signals reaching the receiving antenna by two or more paths. ... Multipath causes multipath interference, including constructive and destructive interference, and phase shifting of the signal.

Automatic Packet Reporting System

- APRS is an application capable of providing real-time tactical digital communications together with a map showing the location of stations
 - Requires a GPS receiver to provide position information to the transmitting application
- Popular mobile text messaging application
- Many amateur weather stations use APRS to send their weather information to various weather data systems
- <u>https://aprs.fi/#!</u> addr=salt%20lake%20city%2C% 20ut



There is an app for Android and IOS that will send APRS information from the phone. Some HT's and base stations have APRS functionality built in.

APRS is particularly useful in tracking people and vehicles supporting an event, such as a bicycle race.

Other RF Digital Modes

- Digital Mobile Radio (DMR)
 - Two "time multiplexed" conversations on a 12.5 kHz channel
 - Users connect to "talkgroups" which are conference rooms for like interests
 - Inexpensive cost to play
- D-Star
 - Developed in Japan, supported by ICOM, Kenwood, and Elecraft
 - Has very fast data transfer capability
- System Fusion
 - Developed by Yaesu and proprietary to Yaesu
 - Growing in popularity
- DMR, D-Star, and System Fusion are all incompatible with each other

Mesh Networking

- Commercial WIFI gear (part 90 equipment) repurposed to work on amateur frequencies (part 97)
 - Several WIFI channels are within amateur radio bands
- Makes a self-healing, multi-path routing, highspeed data network
- Amateur Radio Emergency Data Network (<u>AREDN</u>) is where the firmware and additional information is available

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Some Other Digital Mode Information

- <u>PSK</u> (phase shift keying) is a very popular keyboard to keyboard protocol as well as the ability to transfer files
- <u>IRLP</u> (internet radio linking project) is a technique to connect amateur radio systems, such as repeaters, using Voice Over Internet Protocol (VOIP). A popular IRLP repeater in our area is the WA7GIE machine on 449.425(-, 100.0 ctcss) connected to the Western Reflector
 - <u>DTMF</u> (dual-tone multi-frequency tones, similar to the touch tones on a phone) tones are used to connect and disconnect reflectors
- <u>Echolink</u> is another VOIP system. There are Echolink applications that can run on your laptop or smart phone. Registration is required before using Echolink to prove you are a licensed amateur.
- There are online services, printed directories, and subscription services to find repeaters and VOIP services

IRLP "reflectors" are conference bridges linking a number of IRLP nodes together. These are similar to DMR's "talkgroups", Fusions's "rooms", and D-Star's "gateways".

Echolink and Allstar (a new VOIP system that will likely be included on the next revision of the Technician Class question pool) offer similar functionality by allowing various "nodes" to connect with each other.



There are two amateur TV repeaters in the Salt Lake area. Both have inputs in the 2.4GHz frequencies and outputs in the 1.2GHz frequency band.



Common Transmission Modes

- Continuous Wave (CW)
 - Mode to carry morse code and several digital capabilities
- Amplitude Modulation (AM)
 - Radio stations on the AM band, for example
- Frequency Modulation (FM)
 - Radio stations on the FM band, for example
- Single Side Band
 - A type of amplitude modulation
 - Either upper or lower sideband

Continuous Wave

- An oscillator generates the signal
- Transmitter is either on or off ... no modulation of the carrier
- Some digital modes, such as RTTY, alternate between higher amplitudes and lower amplitudes
- Very narrow bandwidth
- CW Morse code is 150 Hz (use a 500 Hz filter)
- Other CW modes are only slightly wider



Signal to Noise Ratio: One way to improve the SNR is to narrow the bandwidth of the received signal. A CW signal carrying morse code is about 150 Hz wide. If the receiver is receiving a bandwidth of 6 kHz (the width of an AM broadcast signal), there is a lot of unwanted noise surrounding the CW signal. Most modern transceivers have a set of filters of various widths that can be switched in to narrow the received bandwidth thus making the desired signal more prominent.

Amplitude Modulation

- A microphone or similar generates a modulating signal
- An Oscillator generates a carrier signal
- A mixer combines the modulating signal and the carrier
- The amplitude of the resulting wave form varies in time with the modulating signal
- AM signals are about 6 kHz wide and have a center carrier with an upper and a lower sideband



Frequency Modulation

- An oscillator generates a carrier
- A microphone or similar creates a modulating wave
- A modulator varies the carrier frequency over time with the modulating wave
- FM voice signals have a bandwidth up to 25 kHz
- When using a repeater, the strongest FM signal wins



Frequency deviation is used in FM radio to describe the maximum difference between an FM modulated frequency and the nominal carrier frequency. The width of an FM signal varies as the carrier is modulated. The amount of variation in the width is call "deviation". If the fully modulated signal "deviates" more that 25 kHz, it is over deviating. Usually that is caused by talking too loudly into the microphone or holding the microphone too close to the mouth.

If someone receiving your HT signal says you are "over deviating", move the microphone away from your mouth.

Some multi-function transceivers have a microphone gain setting. If you are over-deviating also check the mike gain setting.





When SSB was beginning to be implemented, the circuitry to filter out the unwanted sideband made it fairly easy to generate a lower sideband signal for transmitted signals below 50 meters and to easily generate an upper sideband signal for transmitted signals above 50 meters. In today's solid-state transmitters, that's no longer the case, but the convention remained.

Note that digital communications are usually upper sideband (except for RTTY), regardless of the frequency band.

Multi-mode Transceiver

- A transmitter and receiver in the same box with a method to switch the receiver out of the circuit when the transmitter is operating
 - Multiple bands and modes
 - Switching modes switches in the proper filter
- Most include a Receiver
 Incremental Tuning (RIT) control to
 manage the pitch of a SSB signal
- Usually have multiple bandwidth choices to reduce noise or interference
- The ability of the receiver to pull out weak signals is the receiver's <u>sensitivity</u>
- The <u>selectivity</u> of the receiver is its ability to discriminate between multiple signals



Some Important Definitions

- <u>Oscillator</u>: a circuit that generates a signal at a specific frequency
- <u>Mixer</u>: a non-linear device that takes two radio signals and creates the sum and difference frequencies of the two input frequencies
- <u>Automatic Gain Control</u> (AGC): Used to (somewhat) level out the huge variations in signal strength making the audio relatively constant. The AGC speed can often be set
- <u>Transverter</u>: A device that converts the RF input and output of a transceiver to another band. Often used for microwave and very low frequency systems
- <u>RF Preamplifier</u>: If needed (and rarely is needed) is placed between the antenna and the receiver to boost weak signals
- <u>Modulation</u>: the process of combining speech with an RF carrier

Transverter is a combination of the words "transmitter" and "converter". Since there is no commercial equipment available to amateurs in the gigahertz frequencies, enterprising hams build home-brew transverters to take emissions in the 2 meter band and "up" them to the desired gigahertz frequency and conversely receive on the desired gigahertz frequency and "down" the signal to a frequency in the 2 meter band.



The FCC Rules

The FCC regulates any device that emits radio frequency emissions. Commercial radio equipment is regulated under Part 90 and amateur radio equipment under Part 97. Everything else is regulated under Part 15.

Part 15 devices are either "unintentional emitters" such as computers or TV receivers (they may generate RF signals as part of their operation but they aren't intended to transmit them) or "low power intentional emitters" such as garage door openers, cordless phones, wireless microphones, etc. which must transmit / receive RF signals to function.

Part 15 devices must not interfere with Part 90 and Part 97 devices and must accept normal emissions from those devices.

If your neighbor feels his TV is being interfered with by your transmissions from a certified Part 97 device, the FCC says it's your neighbor's TV that's the problem....

The FCC relies on the manufacturer of Part 15 devices to do the required testing and submit the results as part of the application for Part 15 certification. Some foreign manufactories are less than comprehensive with their testing and compliance. Particular offenders for amateur radio are grow lights, LED lights, and wall-wart power supplies. Cheap TVs from Asia are emitter offenders and often don't include the filtering needed to accept normal interference from Part 90 / 97 devices.



High-pass filter: allows high frequencies to pass, attenuates frequencies below the cut-off frequency.

Low-pass filter: allows low frequencies to pass, attenuates frequencies above the cut-off frequency

There are also "bandpass filters" (attenuates frequencies above and below a specific bandwidth) and "band-reject filters" (attenuates frequencies in a specific bandwidth, such as the FM band)

I'm Being Interfered With!

- Check for local noise sources such as wall-warts, LED lights, USB chargers, etc.
- If it's coming from a neighbor?
 - Work with the neighbor to identify the source
 - Inform the neighbor of the relevant FCC regulations (you're licensed, their device is not)
 - Make sure your station meets good practice standards
- Use shielded ethernet cables to reduce propensity to couple
- Ferrite cores on cables where applicable

How About Mobile Interference?

- Connect power directly to battery and battery ground. Fuse both leads close to the battery
 - The cigarette lighter is a poor power source
- Alternator whine? Turn on the mobile radio's noise blanker. Employ DC / AC filters on the positive lead
- Poor audio reports?
 - Right frequency?
 - Sufficient voltage?
 - Bad location?



Volts, Ohms, Amperes, Henries, and Farads? Oh My!

Electromotive Force

- The force behind electron flow
- Symbol is 'E'
- Measured in Volts, 'v'
- Measured by a voltmeter
- Measurement is made in parallel with the circuit
- May also be called "electric potential'

Current ... The Flow of Electrons

- The symbol for current is 'I'
- The amount of current flowing is measured in 'Amperes', denoted by an 'A'
- Current is measured by an 'ammeter'
- · Measurement is made in series with the circuit
- Current flowing in one direction is called "direct current"
- Current flowing in one direction and then the other is called "alternating current"

Resistors Oppose the Flow

- Resistance is measured in 'ohms'
- The symbol for ohms is the Greek letter 'Ω'
- Resistance is measured by an 'ohmmeter'
- The resistance in a circuit usually cannot be directly measured, but can be calculated
- The current that doesn't pass is dissipated as heat



















Current flows from the anode to the cathode. Diodes have a threshold voltage value and current will flow when the threshold is exceeded.

While they will normally only allow current to flow in one direction, a very high voltage applied to the cathode can cause the diode to break down and allow current to flow in the reverse direction.



One farad is a rather large amount of power stored in a capacitor. Capacitors capable of being charged to one or more farads are massive and found in places like the large Hadron collider in Cern, Switzerland.

The capacitors used in most electrical circuits have fractions of a farad capacity, usually measured in microfarads (1/1,000 of a farad), nanofarad (1/1,000,000 of a farad), and picofarads (1/1,000,000,000 of a farad).



Light-Emitting Diode



LED's are a special type of diode. They allow current to flow in one direction, but convert some of the energy into light.

The positive (anode) lead will be the longer lead and have a flat edge on the outer casing.

Diodes have very low resistance and will short a circuit if not coupled with a resistor to limit the current flow through the LED.



The outer two pins have a fixed amount of resistance between them.

When a potentiometer is turned all the way to the left, the center conductor (also called the "wiper") has zero resistance. Turned all the way to the right, the center conductor has the full resistance.



The Schottky Diode is distinguished from "normal" diodes by the "curly" cathode indicator. Note that in a Schottky Diode, the current flows from the cathode to the anode whereas in normal diodes, current flows from the anode to the cathode (compare #5 to #10)



The only thing this circuit does is turn on a lamp if some other part of the circuit (which isn't shown) draws current.



When input voltage applied to Base/Emitter, it changes the resistance between the Collector and Emitter. That then affects how much current can flow between the Collector and Emitter

Amplification is called "gain" and is measured in "dBm"



This circuit actually works, whereas the other two circuits are pretty much nonsense. This circuit is a trans match to make the transmitter think it's seeing a 50 ohm impedance.



One henry is a very large amount of power. Most of the inductors in today's electrical circuits are measured in milli henries and micro henries.

Inductance vs Capacitance

Inductors

Capacitors

- Stores energy in the form of a magnetic field
- A current can pass through an inductor but will create a magnetic field as it does so
- As a property of the magnetic field, when the current suddenly increases or decreases, the current within the magnetic field will change in the opposite direction. This resists, or impedes, the change in current across the circuit. The inductor inhibits the current from changing instantly.
- Stores energy in the form of an electrical field
- As a current is applied to the circuit, charges accumulate on the plates of the capacitor. Therefore, voltage cannot change instantly across a capacitor
- When the current decreases the capacitor will release the charge

Some Add'l Component Info

- A transistor is made up of three layers of semiconductor material
- A transistor is used to amplify signals
- The three pins on a transistor, whether it is an NPN or a PNP transistor are Emitter, Base, and Collector
- However, the three pins on a Field Effect Transistor are Source, Gate, and Drain
- A <u>Rectifier</u> is used to convert alternating current to direct current. A rectifier is a component of a <u>Power</u> <u>Supply</u>. A <u>Regulator</u> governs the amount voltage from a power supply

And Even More...

- A <u>dummy load</u> is non-inductive resistor (usually about 50 ohms) and a heat sink to dissipate the heat
- Dummy loads are used to prevent transmission of signals while testing the equipment
- Rosin core solder is used for electronic circuits. A good solder joint will be bright and shiny
- When measuring resistance with a ohmmeter which shows increasing resistance over time, there is a capacitor in the circuit being measured



Good Things to Know

- Some battery types are rechargeable. <u>Carbon-zinc</u> batteries are not
- Copper, gold, aluminum are a good <u>conductors</u> of electricity. Wood, glass, and rubber are good <u>insulators</u>
- Copper wire has some resistance, meaning that the voltage will drop as the length of the wire increases. Heavier wire has less resistance. Shorter lengths have less loss
- Opposition to the flow of AC current is called impedance and is also measured in ohms

If a battery is rechargeable, it will say so

Most power supplies (as well as the automotive charging system) deliver 13.7 volts which will draw down to 12.5 volts when transmitting

How Much Power Does a Transceiver Need?

- Modern transceivers require at least 12 volts of power
 - Most power supplies, as well as the automotive charging system, deliver 13.7 volts which will drop to about 12.5 volts when transmitting
- The amount of current needed is determined by:
 - The efficiency of the transmitter at full power
 - The receiver and control circuit requirements
 - The efficiency (regulation) of the power supply
 - The amount of heat dissipation
- A 100 watt transmitter will required about 20-25 watts on transmit and 1-5 watts on receive



The decibel (dB) is used to measure sound level, but it is also widely used in electronics, signals and communication. <u>The dB is a logarithmic way of describing a ratio</u>. The ratio may be power, sound pressure, voltage, or intensity or several other things.

Decibe	I Table
dB	Power Change
3 dB	2x Power Change
6 dB	4x Power Change
9 dB	8x Power Change
10 dB	10x Power Change
20 dB	100x Power Change
30 dB	1000x Power Change
40 dB	10,000 x Power Change

Amount of change in dB of a power increase from 20 watts to 200 watts? 10 dB Amount of change in dB of a power increase from 5 watts to 10 watts? 3 dB

Going the Other Way

dB	Power Change
-3 dB	1/2 Power Change
-6 dB	1/4 Power Change
-9 dB	1/8 Power Change
-10 dB	1/10 Power Change
-20 dB	1/100 Power Change
-30 dB	1/1000 Power Change
-40 dB	1/10,000 Power Change



