Amateur Radio General License Training

Welcome to 2023 Amateur Radio General Class License Training

Amateur Radio General License Training

These presentations are sponsored by:

Mendocino Auxiliary Communications Service (MACS)

Mendocino County Amateur Radio Communications Service (McARCS)

Willits Amateur Radio Society (WARS)

Topics on General Class Exam

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Sub-element G8 – signals and emissions

Topics in G8:

- **Signals and Emissions**
  - Carriers and modulation: AM, FM, and single sideband; modulation envelope; digital modulation; overmodulation; link budgets and link margins
  - Frequency changing; bandwidths of various modes; deviation; intermodulation
  - Digital emission modes
- **One question from each of the three categories on exam**

Review questions:

G7B02

Which of these classes of amplifiers has the highest efficiency?

A. Class A
B. Class B
C. Class AB
D. Class C

Review questions:

G6B07

Which of the following describes a type N connector?

A. A moisture-resistant RF connector useful to 10 GHz
B. A small bayonet connector used for data circuits
C. A low noise figure VHF connector
D. A nickel plated version of the PL-259

Review questions:

G5C11

What is the inductance of a circuit with a 20-millihenry inductor connected in series with a 50-millihenry inductor?

A. 7 millihenries
B. 14.3 millihenries
C. 70 millihenries
D. 1,000 millihenries

Review questions:

G3A01

How does a higher sunspot number affect HF propagation?

A. Higher sunspot numbers generally indicate a greater probability of good propagation at higher frequencies
B. Lower sunspot numbers generally indicate greater probability of sporadic E propagation
C. A zero sunspot number indicates that radio propagation is not possible on any band
D. A zero sunspot number indicates undisturbed conditions

Review questions:

G9B07

How does the feed point impedance of a horizontal 1/2 wave dipole antenna change as the antenna height is reduced to 1/10 wavelength above ground?

A. It steadily increases
B. It steadily decreases
C. It peaks at about 1/8 wavelength above ground
D. It is unaffected by the height above ground

Review questions:

G9A08

If the SWR on an antenna feed line is 5:1, and a matching network at the transmitter end of the feed line is adjusted to present a 1:1 SWR to the transmitter, what is the resulting SWR on the feed line?

A. 1:1
B. 5:1
C. Between 1:1 and 5:1 depending on the characteristic impedance of the line
D. Between 1:1 and 5:1 depending on the reflected power at the transmitter

Review questions:

G3C08

Why are HF scatter signals in the skip zone usually weak?

A. Only a small part of the signal energy is scattered into the skip zone
B. Signals are scattered from the magnetosphere, which is not a good reflector
C. ropagation is via ground waves, which absorb most of the signal energy
D. Propagation is via ducts in the F region, which absorb most of the energy

Radio Communications

Universe is full of electromagnetic energy, including RF

- Most is random, from variety of sources
- The energy simply exists, carries no information
- To use RF to communicate, information must be added/extracted

Sub-element G8 – signals and emissions

What Happens During Radio Communication?

Transmitting:

- Information (voice, data, video, commands, etc.) is converted to electronic form
- The information in electronic form is added to a radio wave
- The radio wave carrying the information radiates from the station antenna

Receiving:

- The radio wave carrying information is intercepted by the receiving antenna
- The receiver extracts the information from the received wave
- The information is converted to a format that can be understood (sound, image, written words, response to a command)

Adding Information - Modulation

Adding information to a radio wave (carrier) = modulation

- Simplest - turn wave on and off (Morse code)
- Encode speech or music
- Digital data

Different modulation techniques alter different properties of the wave to add information

- Amplitude
- Frequency or phase

Sub-element G8 – signals and emissions

Three common ways to add voice information to an RF carrier

- *Amplitude modulation (AM) varies the instantaneous power level of the RF signal*
- *Frequency modulation (FM) changes the instantaneous frequency of an RF wave*
- *Phase modulation (PM) changes the phase angle of an RF signal*
  - PM may be produced by a *reactance modulator connected to a transmitter RF amplifier stage*

Sub-element G8 – signals and emissions

Bandwidth

- Different types of modulation and information results in different signal bandwidths

- *Single sideband (SSB) a type of amplitude modulation that produces phone emissions using narrower bandwidth than FM or PM*

Sub-element G8 – signals and emissions

<u>Modulation envelope</u> of an AM signal

- *The waveform created by connecting the peak values of the modulated signal*

Over modulation is not good

- *Excessive bandwidth*
- *Can produce "flat-topping"*
- *Results in signal distortion*

Digital signals and emissions

RTTY

- *Baudot code, 5-bit code with additional start and stop bits*
- Usually produced by frequency-shift keying (FSK) an RF signal
- *Direct binary FSK modulation generated by changing an oscillator's frequency directly with a digital control signal*
- *Two separate frequencies of FSK signal "mark" and "space" frequencies*
- Lacks error detection/correction

Sub-element G8 – signals and emissions

Digital mode error correction

Automatic Repeat reQuest

ARQ

- Data integrity checked by receiving station
- Send ACK if good, *NAK to repeat*
- *Failure to exchange information* (too many NAK) *= dropped connection*

Forward Error Correction

FEC

- Receiver detects/corrects errors automatically
- Accomplished by transmitting redundant information

Digital signals and emissions

Packet structure

- Data sent in structured format
- Header/payload (data)/trailer
- *Header contains the routing and handling information*

Digital signals and emissions

Common digital modes

- WSPR - *used as a low-power beacon for assessing HF propagation*
- QPSK31
  - *Transmitted using 0-, 90-, 180- and 270-degrees phase shift modulation*
  - *Is sideband sensitive*
  - *Encoding provides error correction*
  - *Bandwidth approximately = to BPSK31 (all of the above)*
- *PSK31*
  - *Varicode used for sending characters*
  - *Upper case letters use longer Varicode, slows down transmission*

Digital signals and emissions

FT8

- Increasingly popular *narrow-band digital mode*
  - *Uses 8-tone frequency shift keying (FSK)*
  - *Can receive signals with very low signal-to-noise ratios*
  - *FT8 signal report +3 means the signal-to-noise ratio = +3 dB in a 2.5 kHz bandwidth*

Digital signals and emissions

Link terminology

Link budget

- *link budget = transmit power + antenna gains - system losses at receiver*

Link margin

- *difference between rx power level & minimum required signal at receiver*

Section questions:

G8A11

What is the modulation envelope of an AM signal?

A. The waveform created by connecting the peak values of the modulated signa
B. The carrier frequency that contains the signal
C. Spurious signals that envelop nearby frequencies
D. The bandwidth of the modulated signal

Section questions:

G8A08

Which of the following is an effect of overmodulation?

A. Insufficient audio
B. Insufficient bandwidth
C. Frequency drift
D. Excessive bandwidth

Section questions:

G8A09

What type of modulation is used by FT8?

A. 8-tone frequency shift keying
B. Vestigial sideband
C. Amplitude compressed AM
D. 8-bit direct sequence spread spectrum

Section questions:

G8C06

What action results from a failure to exchange information due to excessive transmission attempts when using an ARQ mode?

A. The checksum overflows
B. The connection is dropped
C. Packets will be routed incorrectly
D. Encoding reverts to the default character set

Section questions:

G8C04

Which of the following describes Baudot code?

A. A 7-bit code with start, stop, and parity bits
B. A code using error detection and correction
C. A 5-bit code with additional start and stop bits
D. A code using SELCAL and LISTEN

Sub-element G8 – signals and emissions

Hams and WiFi

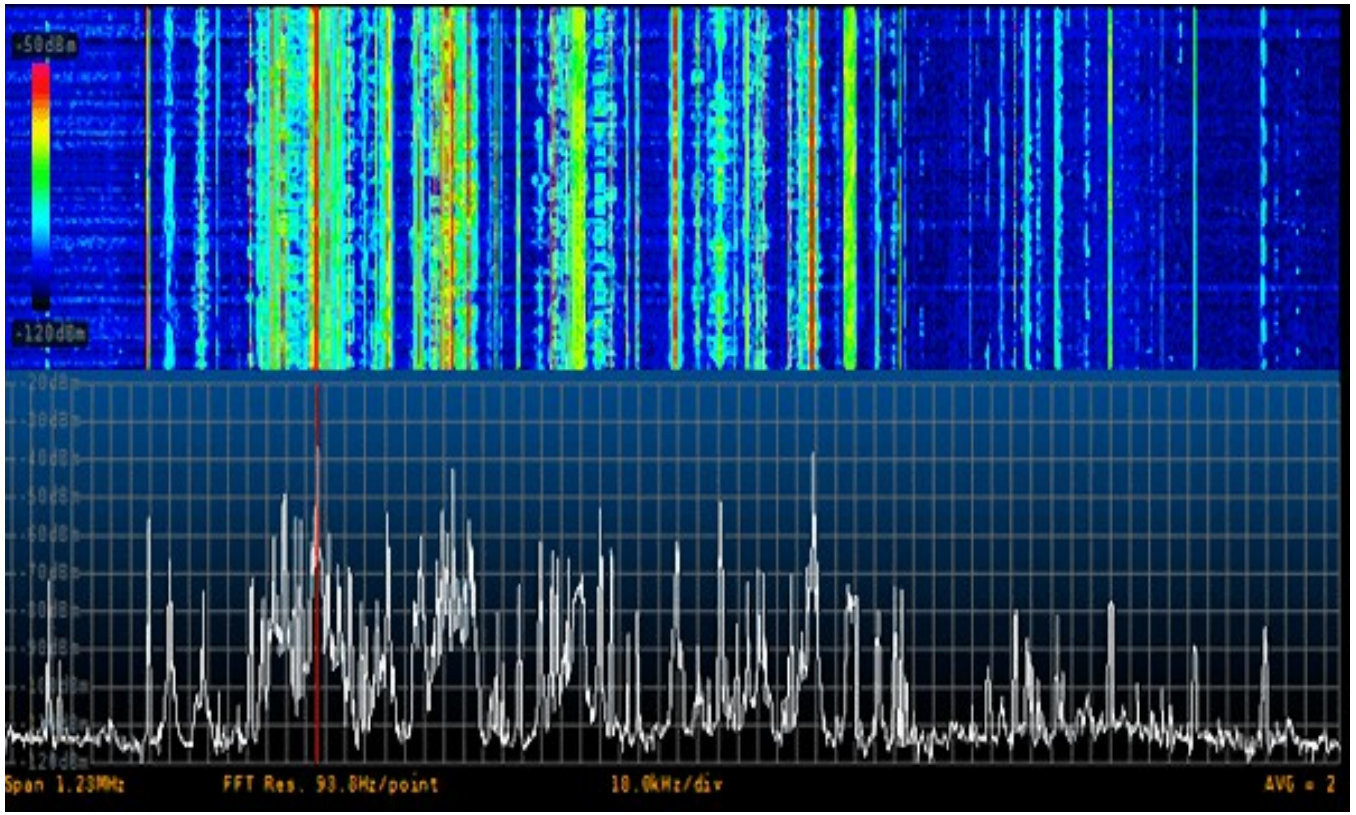
Amateurs share channels with the unlicensed Wi-Fi on 2.4 GHz

Some hams use use commercially available Wi-Fi equipment to build mesh networks

- *Mesh network microwave nodes* provide a robust network as *if one node fails, a packet may still reach its target station via an alternate node*

Sub-element G8 – signals and emissions

Digital tuning aids



Waterfall display

- *frequency is horizontal*
- *time is vertical*
- *signal strength is intensity (color)*
- *One or more vertical lines on either side of a data mode or RTTY signal = Overmodulation*

Sub-element G8 – signals and emissions

Digital voice modes

Voice can be digitized, common systems

- *DMR*
- *D-STAR*
- *SystemFusion*

Sub-element G8 – signals and emissions

Digital mode bandwidth

Relationship between transmitted symbol rate and bandwidth

- *higher symbol rates require wider bandwidth*
- Character (baud) rate limited on HF bands

Match rx bandwidth to bandwidth of operating mode = best signal-to-noise ratio

Two questions about bandwidth and deviation

- *G8B06 Total bandwidth of FM phone transmission having 5 kHz deviation and 3 kHz modulating frequency =* ***16 kHz***
- *G8B07 Frequency deviation for a 12.21 MHz reactance modulated oscillator in a 5 kHz deviation, 146.52 MHz FM phone transmitter =* ***416.7 Hz***
- *See pages 5-10 and 5-11*

Sub-element G8 – signals and emissions

Digital duty cycle

Some modes = high duty cycle

- *Important to know duty cycle of mode you are using when transmitting*
- *Modes with high duty cycles could exceed the transmitter's average power rating*
- Limit transmit time or reduce transmit output power to avoid overheating

Section questions:

G8C16

Which of the following provide digital voice modes?

A. WSPR, MFSK16, and EasyPAL
B. FT8, FT4, and FST4
C. Winlink, PACTOR II, and PACTOR III
D. DMR, D-STAR, and SystemFusion

Section questions:

G3B01

Which of the following describes a waterfall display?

A. Frequency is horizontal, signal strength is vertical, time is intensity
B. Frequency is vertical, signal strength is intensity, time is horizontal
C. Frequency is horizontal, signal strength is intensity, time is vertical
D. Frequency is vertical, signal strength is horizontal, time is intensity

Section questions:

G8B10

What is the relationship between transmitted symbol rate and bandwidth?

A. Symbol rate and bandwidth are not related
B. Higher symbol rates require wider bandwidth
C. Lower symbol rates require wider bandwidth
D. Bandwidth is half the symbol rate

Section questions:

G8B08

Why is it important to know the duty cycle of the mode you are using when transmitting?

A. To aid in tuning your transmitter
B. Some modes have high duty cycles that could exceed the transmitter's average power rating
C. To allow time for the other station to break in during a transmission
D. To prevent overmodulation

Section questions:

G8C09

Which is true of mesh network microwave nodes?

A. Having more nodes increases signal strengths
B. If one node fails, a packet may still reach its target station via an alternate node
C. Links between two nodes in a network may have different frequencies and bandwidths
D. More nodes reduce overall microwave out of band interference

Sub-element G8 – signals and emissions

Practical circuit review

- Oscillators create signals at a desired frequency
- Mixers/multipliers transform frequency from oscillator into different frequencies
- *Combining frequencies from two oscillators in a mixer = heterodyning*

Result of mixing two signals

- *Combination of mixer's Local Oscillator (LO) and RF input frequencies at output = sum and difference of the two frequencies*
- Mix 5 MHz with 21 MHz signal, output of the mixer has two signals, one at 16 MHz (21-5) and one at 26 MHz (21+5).

Sub-element G8 – signals and emissions

Mixers and Multipliers

Use local oscillator (LO) to produce an output at intermediate frequency (IF)

- *Local oscillator input varied/tuned to convert signals to an intermediate frequency (IF)*
- *Interference that occurs from signal 2X desired IF frequency = image response*

Frequency multiplier

- Transforms input frequency to output at a harmonic (integer multiple) of the input
- *Stage in VHF FM transmitter that generates a harmonic of a lower frequency signal to reach desired operating frequency* (49 MHz X 3 = 147 MHz)

Sub-element G8 – signals and emissions

Unwanted mixing and multiplying

<u>Unintentional</u> mixing = intermodulation

- A *process that combines* (mixes) *two signals in a <u>non-linear circuit</u>*
- *Produces <u>unwanted</u> spurious outputs "<u>intermodulation</u>"*
- Two signals that combine in bad electrical connection (non-linear circuit) can produce interference (intermod = headache)

Two other questions in pool relating to intermodulation products

- *G8B05 Which of the following is an odd-order intermodulation product of frequencies F1 and F2?* = **2F1-F2**
- *G8B13 Which intermodulation products are closest to the original signal frequencies?* **Odd-order**

Section questions:

G8B12

What process combines two signals in a non-linear circuit to produce unwanted spurious outputs?

A. Intermodulation
B. Heterodyning
C. Detection
D. Rolloff

Section questions:

G8B05

Which intermodulation products are closest to the original signal frequencies?

A. Second harmonics
B. Even-order
C. Odd-order
D. Intercept point

Section questions:

G8B03

What is another term for the mixing of two RF signals?

A. Heterodyning
B. Synthesizing
C. Frequency inversion
D. Phase inversion

Section questions:

G8B01

Which mixer input is varied or tuned to convert signals of different frequencies to an intermediate frequency (IF)?

A. Image frequency
B. Local oscillator
C. RF input
D. Beat frequency oscillator

Section questions:

G8B11

What combination of a mixer's Local Oscillator (LO) and RF input frequencies is found in the output?

A. The ratio
B. The average
C. The sum and difference
D. The arithmetic product

End of G8 – Signals and Emissions

Presented by
Tim Hanna WB9NJS