Technician License Class

1

Technician Class

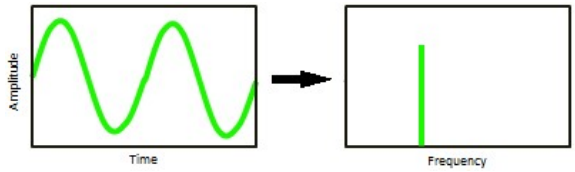
Chapter 5
Amateur Radio Equipment

2

Modulation

Bandwidth.

- A simple sine wave signal occupies only a single frequency in the spectrum.

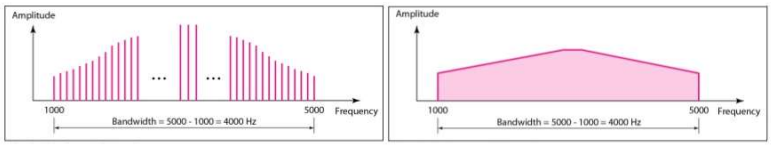


3

Modulation

Bandwidth.

- A signal consisting of multiple sine waves is called a *composite* signal.
  - The individual signals that make up the composite signal are called *components* of the signal.
  - The size of the range of frequencies occupied by a composite signal is called its *bandwidth*.



4

Modulation

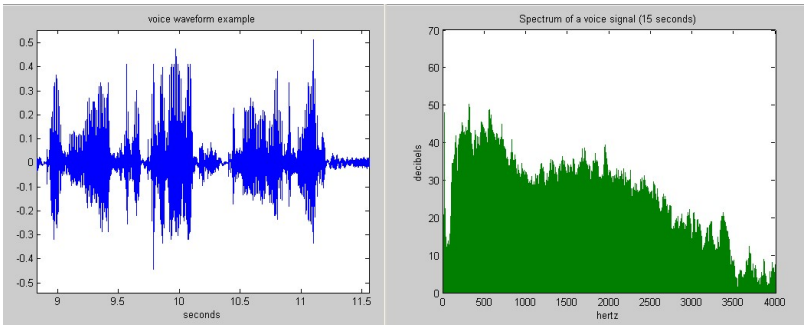
Bandwidth.

- The human voice is a composite signal containing many different frequencies simultaneously.
  - The lowest frequency component of the human voice is approximately 300 Hz.
  - The highest frequency component of the human voice is approximately 3000 Hz.
  - Therefore the bandwidth of the human voice is about 2700 Hz (3000 Hz – 300 Hz).

5

Modulation

Bandwidth.



6

Modulation

Modulation.

- A simple radio signal with a constant amplitude and a constant frequency conveys no information and cannot be used to communicate.
- In order to communicate, we must add some information to the simple radio signal.
  - Adding information to a signal is called *modulation*.
  - Retrieving the information from the signal is called *demodulation* or *detection*.

7

Modulation

Modulation.

- A simple RF radio signal is called a *carrier* or a *carrier wave* because it "carries" the information.
- Modulation converts a carrier into a composite signal, increasing its bandwidth.
  - Bandwidth depends on modulating method and the characteristics of the modulating signal.

8

Modulation

Modulation.

- A carrier can be modulated by changing any of its characteristics:
  - Amplitude = Amplitude Modulation (AM).
  - Frequency = Frequency Modulation (FM).
  - Phase = Phase Modulation (PM).
- Different types of modulation are called *modes*.
  - CW, AM, SSB, FM, PM, etc.

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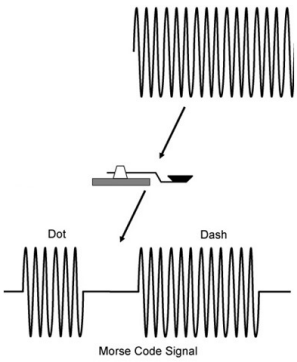
Modulation

Continuous Wave (CW).

- The simplest method of modulation is to merely turn the signal on and off in a particular pattern, such as Morse code.
  - This mode is known as *continuous wave* or *CW*.

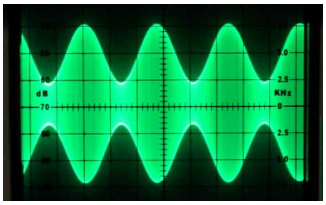


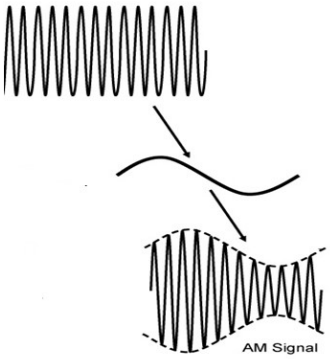
10

Modulation

Amplitude Modulation (AM).

- In AM, the strength of the carrier is changed to match the changes in the strength of the modulating signal.





11

T8D09 -- What is CW?

A. A type of electromagnetic propagation
B. A digital mode used primarily on 2 meter FM
C. A technique for coil winding
D. Another name for a Morse code transmission

12

Modulation

Amplitude Modulation (AM).

- The sound waves that make up your voice are a complex mixture of multiple frequencies.
- When this complex mixture is added to the carrier, two sidebands are created that are mirror images.
  - The width of each sideband equals the bandwidth of the modulating signal.

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Modulation

Amplitude Modulation (AM).

- AM signals consist of three components:
  - Carrier.
  - Lower sideband.
  - Upper sideband.
- Voice bandwidth is from 300 Hz to 3 kHz.
- AM bandwidth is twice the voice bandwidth.

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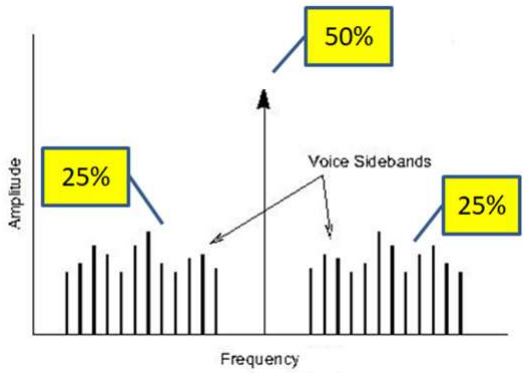
Modulation

Amplitude Modulation (AM).

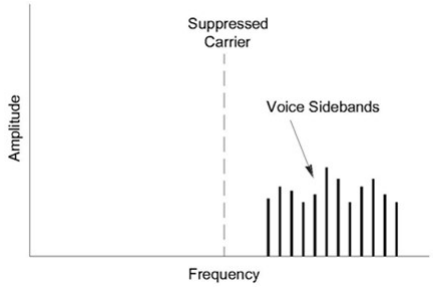


15

Modulation

Single Sideband (SSB).

- We can improve the efficiency of transmission by transmitting only one sideband and then reconstruct the missing sideband & carrier at the receiver.



16

Modulation

Single Sideband (SSB).

- Used for nearly all HF voice communications.
- Used for most HF digital mode transmissions.
- Used for weak-signal VHF & UHF voice communications.
- Frequencies above 14 MHz typically use USB.
- Frequencies below 7.3 MHz typically use LSB.
  - Exception: 5 MHZ must use USB.

17

T8A01 -- Which of the following is a form of amplitude modulation?

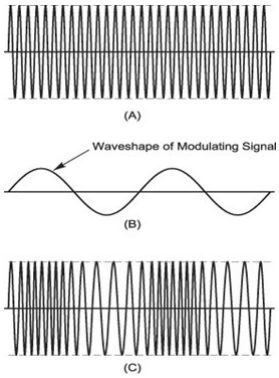
A. Spread spectrum
B. Packet radio
C. Single sideband
D. Phase shift keying (PSK)

18

Modulation

Frequency Modulation (FM)

- If we vary the frequency of the carrier in step with the information waveform, FM is produced.



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Modulation

Frequency Modulation

- FM signals are much more resistant to the effects of noise but require more bandwidth.
- In amateur radio FM transmissions, the bandwidth is typically between 10 and 15 kHz.

20

Modulation

Phase Modulation

- If we vary the phase of the carrier in step with the information waveform, PM is produced.
- PM signals are a lot like FM signals.
- In FM, the amount of deviation is dependent only on the amplitude of the modulating signal.
- In PM, the amount of deviation is dependent on both the amplitude and the frequency of the modulating signal.

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Modulation

Frequency/Phase Modulation

- Most common voice mode on VHF & UHF.
- Used by VHF & UHF voice repeaters.
- Used for VHF & UHF packet operations.
- If multiple signals are preset on the same frequency, only the strongest will be heard.
  - It is possible to hear & understand 2 or more SSB signals on the same frequency.

22

T8A02 -- What type of modulation is commonly used for VHF packet radio transmissions?

A. FM or PM
B. SSB
C. AM
D. PSK

23

T8A04 -- Which type of modulation is most commonly used for VHF and UHF voice repeaters?

A. AM
B. SSB
C. PSK
D. FM or PM

24

T8A12 -- Which of the following is a disadvantage of FM compared with single sideband?

A. Voice quality is poorer
B. Only one signal can be received at a time
C. FM signals are harder to tune
D. All these choices are correct

25

Modulation

Bandwidth of Modulated Signals

Type of Signal	Typical Bandwidth
AM Voice	6 kHz
AM Broadcast	10 kHz
Analog TV	6 MHz
SSB Voice	2 kHz to 3 kHz
SSB Digital	<100 Hz to >1 kHz
CW	150 Hz
FM Voice	10 kHz to 15 kHz
FM Broadcast	180 kHz

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Modulation

Bandwidth of Modulated Signals

- SSB has less bandwidth than AM or FM/PM.
  - Therefore, less noise & better reception of weak signals.
  - Contesters and DX'ers normally use SSB for VHF/UHF voice contacts.

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Modulation

Bandwidth of Modulated Signals

- CW has the narrowest bandwidth & is used for extremely weak signal work.
  - e.g. – EME.
- Some of the newer digital modes were designed for weak signal reception and can outperform CW.
  - e.g. – JT65, FT8, & FT4.

28

T8A03 -- Which type of voice mode is most often used for long-distance (weak signal) contacts on the VHF and UHF bands?

A. FM
B. DRM
C. SSB
D. PM

29

T8A05 -- Which of the following types of signal has the narrowest bandwidth?

A. FM voice
B. SSB voice
C. CW
D. Slow-scan TV

30

T8A06 -- Which sideband is normally used for 10 meter HF, VHF, and UHF single-sideband communications?

A. Upper sideband
B. Lower sideband
C. Suppressed sideband
D. Inverted sideband

31

T8A07 -- What is a characteristic of single sideband (SSB) compared to FM?

A. SSB signals are easier to tune in correctly
B. SSB signals are less susceptible to interference
C. SSB signals have narrower bandwidth
D. All these choices are correct

32

T8A08 -- What is the approximate bandwidth of a typical single sideband (SSB) voice signal?

A. 1 kHz
B. 3 kHz
C. 6 kHz
D. 15 kHz

33

T8A09 -- What is the approximate bandwidth of a VHF repeater FM phone signal?

A. Less than 500 Hz
B. About 150 kHz
C. Between 10 and 15 kHz
D. Between 50 and 125 kHz

34

T8A10 -- What is the approximate bandwidth of AM fast-scan TV transmissions?

A. More than 10 MHz
B. About 6 MHz
C. About 3 MHz
D. About 1 MHz

35

T8A11 -- What is the approximate bandwidth required to transmit a CW signal?

A. 2.4 kHz
B. 150 Hz
C. 1000 Hz
D. 15 kHz

36

Transmitters and Receivers

Selecting Band, Frequency and Mode.

- Stations in most radio services are assigned one or more specific frequencies that they must operate on.
- Stations in the Amateur Radio Service may operate anywhere they wish within specified ranges of frequencies.
  - The 60m band is the only exception.

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Transmitters and Receivers

Selecting Band, Frequency and Mode.

- The ranges of frequencies that amateurs radio stations are allowed to operate on are called “bands”.
- Bands are usually referred to by their approximate wavelength.

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Transmitters and Receivers

Selecting Band, Frequency and Mode.

Frequency (MHz)	Wavelength (m or cm)
1.800 to 2.000	160m
3.500 to 4.000	80m
7.000 to 7.300	40m
10.100 to 10.150	30m
14.000 to 14.350	20m
18.068 to 18.168	17m
21.000 to 21.450	15m
24.890 to 24.990	12m
28.000 to 29.700	10m

Frequency (MHz)	Wavelength (m or cm)
50 to 54	6m
144 to 148	2m
222 to 225	1.25m
420 to 450	70cm
902 to 928	33m
1240 to 1300	23m
2300 to 2310 2390 to 2450	13m

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Transmitters and Receivers

Selecting Band, Frequency and Mode.

- Selecting the band.
  - Most radios have one or more buttons to select the band.
    - Several buttons labeled in frequency (MHz), or
    - Several buttons labeled in wavelength (m or cm), or
    - 2 buttons (Band Up & Band Down).
    - 1 button (Band).
      - Each push of the button advances to the next band.
  - Older radios had a switch instead of buttons.

40

Transmitters and Receivers

Selecting Band, Frequency and Mode.

- Selecting the frequency.
  - Tuning knob.
    - Select frequency.
      - VFO (variable-frequency oscillator).
      - Dial-in any frequency within the range of the radio.
    - Select memory channel.
      - Most rigs have memory channels you can use to rapidly select your favorite frequencies.

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Transmitters and Receivers

Selecting Band, Frequency and Mode.

- Selecting the frequency.
  - Keypad.
    - Many radios have a keypad to allow direct entry of a frequency or memory channel.
    - Sometimes the keypad is built into the microphone.

42

Transmitters and Receivers

Selecting Band, Frequency and Mode.

- Selecting the mode.
  - Usually several buttons to select the desired mode.
    - Occasionally one button that cycles through all of the modes.
      - Compact radios designed for mobile use.
  - Often modes are “paired”.
    - LSB – USB.
    - AM – FM.
    - CW – RTTY.

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Transmitters and Receivers

Selecting Band, Frequency and Mode.

- **Watch that band edge!**
  - **All** transceiver VFOs have some calibration error.
  - **All** transceiver VFOs can drift in frequency.
  - **All** transmitted signals have components that extend above and/or below the carrier frequency.
    - These components are called *sidebands*.

44

Transmitters and Receivers

Selecting Band, Frequency and Mode.

- **Watch that band edge!**
  - Your **ENTIRE** signal must be within the band.
  - **DO NOT** set your transmit frequency exactly on the band edge or your sidebands may fall outside of the band.

45

T1B092 -- Why should you not set your transmit frequency to be exactly at the edge of an amateur band or sub-band?

A. To allow for calibration error in the transmitter frequency display
B. So that modulation sidebands do not extend beyond the band edge
C. To allow for transmitter frequency drift
D. All these choices are correct

46

T4B02 -- Which of the following can be used to enter a transceiver's operating frequency?

A. The keypad or VFO knob
B. The CTCSS or DTMF encoder
C. The Automatic Frequency Control
D. All of these choices are correct

47

T4B04 -- What is a way to enable quick access to a favorite frequency on your transceiver?

A. Enable the frequency offset
B. Store it in a memory channel
C. Enable the VOX
D. Use the scan mode to select the desired frequency

48

Transmitters and Receivers

Transmitter Functions.

- Output power level.
  - Most SSB/CW transceivers have a continuously-variable control.
    - Knob or menu setting.
  - Most VHF/UHF FM transceivers have 2, 3, or 4 pre-set levels.
    - Button or menu setting.

49

Transmitters and Receivers

Transmitter Functions.

- Switching transceiver from receive to transmit.
  - Normally done manually using a push-to-talk switch referred to as the *PTT* switch.
    - Push button on hand microphone.
    - Foot switch.
    - Hand switch.

50

Transmitters and Receivers

Transmitter Functions.

- Switching transceiver from receive to transmit.
  - Can be done automatically using a voice operated circuit referred to as *VOX*.
    - Built into most HF transceivers.
    - Not normally found in FM transceivers.

51

Transmitters and Receivers

Transmitter Functions.

- Microphone gain.
- Speech processor.
  - Increases average transmitter power output by compressing the modulating signal.
    - Without compression, average SSB power is about 25% of PEP.
    - With compression, average SSB power is about 40% of PEP.
  - Common on most SSB transceivers.
  - Not used on FM transmitters.

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Transmitters and Receivers

Transmitter Functions.

- Microphones.
  - Hand microphone.
    - Usually supplied with transceiver.
    - Normally has PTT switch.
    - May have power for auxiliary functions.
      - Keypad, frequency control, etc.

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Transmitters and Receivers

Transmitter Functions.

- Microphones.
  - Desk microphone.
    - PTT switch on base and/or post.
  - Headset.
    - Use hand switch, foot switch, or VOX for PTT.

54

Transmitters and Receivers

Transmitter Functions.

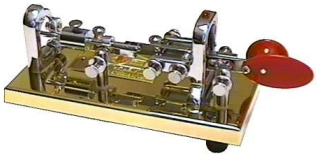
- CW key.
  - When operating CW, the transceiver automatically switches to transmit when the key contacts are closed.
  - The dots (dits) and dashes (dahs) that form the Morse code characters are called *elements*.
    - When the operator forms the elements of the code manually, it is called *hand keying*.
    - The operator can be assisted in forming the elements by using special types of keys.

55

Transmitters and Receivers

Transmitter Functions.

- CW keys.
  - Straight key.
  - Semi-automatic key.
    - "Bug".



56

Transmitters and Receivers

Transmitter Functions.

- CW keys.
  - Automatic key.
    - Paddles.
    - Electronic keyer.
      - Automatically forms both dits & dahs.
        - Pressing one paddle generates a string of dits.
        - Pressing the other paddle generates a string of dahs.
      - Built into most HF transceivers.

57

Transmitters and Receivers

Transmitter Functions.

- CW keys.
  - Automatic key.
    - A set of “paddles” along with a device called an “electronic keyer” allow you to automatically generate a string of dits or a string of dahs.

58

Transmitters and Receivers

Transmitter Functions.

- CW keys.
  - Automatic key.
    - Single-Paddle Key.
      - A single lever attached to 2 sets of contacts.
      - Moving the lever one direction closes one set of contacts.
      - Moving the lever the other direction closes the other set of contacts.

59

Transmitters and Receivers

Transmitter Functions.

- CW keys.
  - Automatic key.
    - Dual-Paddle Key.
      - Two lever, each attached to a set of contacts.
      - Pressing one lever closes one set of contacts.
      - Pressing the other lever closes the other set of contacts.

60

Transmitters and Receivers

Transmitter Functions.

- CW keys.
  - Automatic key.
    - Electronic Keyer.
      - A circuit that allows you to automatically generate a string of dits and/or dahs.
      - Built into most HF transceivers.

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Transmitters and Receivers

Transmitter Functions.

- CW keys.
  - Keyboard.

62

Transmitters and Receivers

Transmitter Functions.

- Dummy load.
  - A *dummy load* is a non-radiating replacement for your antenna. Used while tuning or testing your transmitter to avoid interfering with other stations.
    - 50Ω non-inductive resistor mounted in some sort of container to dissipate heat.



63

T4A12 -- What is an electronic keyer?

A. A device for switching antennas from transmit to receive

B. A device for voice activated switching from receive to transmit

C. A device that assists in manual sending of Morse code

D. An interlock to prevent unauthorized use of a radio

64

T7A07 -- What is the function of a transceiver's PTT input?

A. Input for a key used to send CW
B. Switches transceiver from receive to transmit when grounded
C. Provides a transmit tuning tone when grounded
D. Input for a preamplifier tuning tone

65

T7C01 -- What is the primary purpose of a dummy load?

A. To prevent transmitting signals over the air when making tests
B. To prevent over-modulation of a transmitter
C. To improve the efficiency of an antenna
D. To improve the signal-to-noise ratio of a receiver

66

T7C12 -- What does a dummy load consist of?

A. A high-gain amplifier and a TR switch
B. A non-inductive resistor mounted on a heat sink
C. A low-voltage power supply and a DC relay
D. A 50-ohm reactance used to terminate a transmission line

67

Transmitters and Receivers

Spurious Signals.

- If a transmitter is not set up properly, or is not operated correctly, it can cause interference to other communications, both amateur and non-amateur.
- This interference is normally caused by what are called “spurious emissions”.

68

Transmitters and Receivers

Spurious Signals.

§97.3(a)(43) Spurious emission. *An emission, or frequencies outside the necessary bandwidth of a transmission, the level of which may be reduced without affecting the information being transmitted.*

69

Transmitters and Receivers

Spurious Signals.

- Spurious emissions are most commonly caused by overmodulating the transmitter.
  - Overmodulation causes distortion of the signal.
  - Distortion causes spurious signals to be created.

70

Transmitters and Receivers

Spurious Signals.

- Overmodulation.
  - SSB & AM.
    - Too high a microphone gain setting or speaking to loudly or to close to the microphone causes distortion.
      - Distortion results in strong signals outside of the normal 3kHz voice bandwidth.
        - a.k.a. – Splatter.

71

Transmitters and Receivers

Spurious Signals.

- Overmodulation.
  - SSB & AM.
    - An ALC circuit helps prevent splatter.
      - Reduces the peak amplitude of the voice signal.
      - Digital signals are distorted when ALC activates.

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Transmitters and Receivers

Spurious Signals.

- Overmodulation.
  - FM.
    - Similar to overmodulation of SSB & AM signals.
    - Causes excessive bandwidth.
    - Can cause complete loss of received signal under certain conditions.

73

Transmitters and Receivers

Spurious Signals.

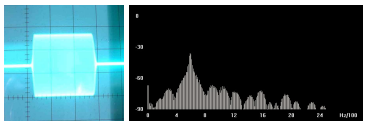
- RF Feedback.
  - Can cause spurious signals that sound similar to overmodulation.

74

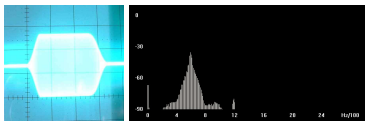
Transmitters and Receivers

Spurious Signals.

- CW key clicks.
  - Clicking sounds heard at some distance above and below the transmit frequency.
  - Caused by too rapid rise & fall times when carrier is turned on and off.



2 ms Rise/Fall Times



8 ms Rise/Fall Times

75

T2B05 -- What would cause your FM transmission audio to be distorted on voice peaks?

A. Your repeater offset is inverted
B. You need to talk louder
C. You are talking too loudly
D. Your transmit power is too high

76

T4B01 -- What is the effect of excessive microphone gain on SSB transmissions?

A. Frequency instability
B. Distorted transmitted audio
C. Increased SWR
D. All these choices are correct

77

T7B01 -- What can you do if you are told your FM handheld or mobile transceiver is over-deviating?

A. Talk louder into the microphone
B. Let the transceiver cool off
C. Change to a higher power level
D. Talk farther away from the microphone

78

Transmitters and Receivers

Receiver Functions.

- Receivers have several controls to adjust their operation.
  - Not all receivers will have all of the controls we are going to discuss.
  - Some receivers will have controls that we are not going to discuss.

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Transmitters and Receivers

Receiver Functions.

- AF gain.
  - a.k.a – Audio gain or volume control.

80

Transmitters and Receivers

Receiver Functions.

- Automatic gain control (AGC).
  - Not really a control, but rather an internal circuit that functions like a control.
  - Due to propagation changes, the received strength of a signal will vary up and down.
  - For AM modes, as the signal strength varies, the audio output volume will vary accordingly.

81

Transmitters and Receivers

Receiver Functions.

- Automatic gain control (AGC).
  - An AGC circuit automatically adjusts the RF gain of the receiver in an attempt to keep the audio output relatively constant.
    - A voltage is created based on signal strength to control gain.
    - Often, the S-meter reading is derived from the AGC voltage.
  - Different modes require different AGC response speeds.
    - CW & data requires faster response speed.
    - Voice signals require slower response speed.

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Transmitters and Receivers

Receiver Functions.

- RF gain.
  - Adjusts the gain of the receiver, usually by changing the AGC voltage.
    - Because the S-Meter reading is usually derived from the AGC voltage, turning the RF gain down will result in a higher S-meter reading.

83

Transmitters and Receivers

Receiver Functions.

- Pre-amplifier.
  - A pre-amp may be needed on the higher-frequency bands.
  - A pre-amp may do more harm than good on the lower-frequency bands.
  - Sometimes there is a switch to turn the pre-amp on/off or to add attenuation.

84

Transmitters and Receivers

Receiver Functions.

- Squelch.
  - A squelch circuit mutes the receiver audio when no signal is present.
    - Allows the operator to monitor a frequency without hearing constant noise when no signal is being received.
    - Always used in FM/PM receivers.
    - Seldom used in AM/SSB/CW receivers.

85

Transmitters and Receivers

Receiver Functions.

- Squelch.
  - Carrier squelch.
    - Unmutes the audio based on the presence of an RF signal.
    - The squelch control is adjusted until the audio remains silent when no signal is present.
      - Too “loose” of a squelch and bursts of noise will be heard.
      - Too “tight” of a squelch and even very strong signals will not be heard.
      - Adjusting the squelch so that you hear noise all of the time may allow you to hear a weak signal.

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Transmitters and Receivers

Receiver Functions.

- Squelch.
  - Tone squelch.
    - Unmutes the audio based on the presence of a sub-audible tone.
      - Continuous tone coded squelch system (CTCSS).
        - a.k.a. – PL (Private Line®) tone.
    - Commonly used on VHF or UHF FM repeaters.

87

T2B13 -- What is the purpose of a squelch function?

A. Reduce a CW transmitter's key clicks
B. Mute the receiver audio when a signal is not present
C. Eliminate parasitic oscillations in an RF amplifier
D. Reduce interference from impulse noise

88

T4B03 -- How is squelch adjusted so that a weak FM signal can be heard?

A. Set the squelch threshold so that receiver output audio is on all the time
B. Turn up the audio level until it overcomes the squelch threshold
C. Turn on the anti-squelch function
D. Enable squelch enhancement

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Transmitters and Receivers

Receiver Functions.

- Receiver performance is primarily determined by 3 main characteristics:
  - Sensitivity.
  - Dynamic range.
  - Selectivity.

90

Transmitters and Receivers

Receiver Functions.

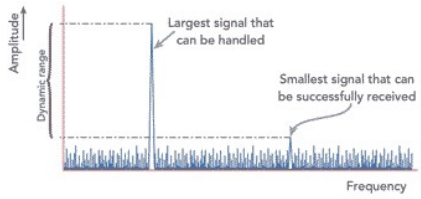
- Sensitivity and Selectivity.
  - *Sensitivity* is a measure of how weak a signal the receiver can receive.
    - Sensitivity may be improved by installing a pre-amplifier (pre-amp) between the antenna and the receiver.
      - Often built into the receiver.

91

Transmitters and Receivers

Receiver Functions.

- Sensitivity and Selectivity.
  - Combined with the sensitivity, the *dynamic range* determines how strong a signal the receiver can receive without distortion.

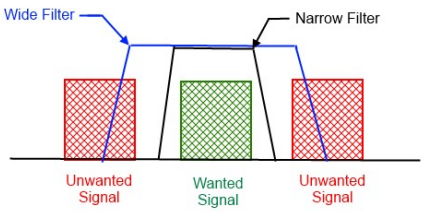


92

Transmitters and Receivers

Receiver Functions.

- Sensitivity and Selectivity.
  - *Selectivity* is a measure of how well the receiver rejects signals near the desired frequency.
    - Determined by the receiver filters.



93

T7A01 -- Which term describes the ability of a receiver to detect the presence of a signal?

A. Linearity
B. Sensitivity
C. Selectivity
D. Total Harmonic Distortion

94

T7A04 -- Which term describes the ability of a receiver to discriminate between multiple signals?

A. Discrimination ratio
B. Sensitivity
C. Selectivity
D. Harmonic distortion

95

T7A11 -- Where is an RF preamplifier installed?

A. Between the antenna and receiver
B. At the output of the transmitter power amplifier
C. Between the transmitter and the antenna tuner
D. At the output of the receiver audio amplifier

96

Transmitters and Receivers

Receiver Functions.

- Filtering and tuning.
  - Receivers reject unwanted nearby signals by using band-pass filters.
    - Want to match filter width to bandwidth of signal.
      - Reduces interference from nearby signals.
      - Reduces noise level.

Mode	Typical Filter Width	Mode	Typical Filter Width
CW	500 Hz or less	RTTY	500 Hz
SSB	2.4 kHz to 3.0 kHz	Digital	3 kHz to 4 kHz
AM	6 kHz to 8 kHz	FM	15 kHz

97

Transmitters and Receivers

Receiver Functions.

- Filtering and tuning.
  - The effect of tuning slightly off of the correct frequency when receiving a signal depends on the mode:
    - CW – The pitch of the received tone will vary.
    - SSB – The pitch of the voice will be too high or too low and will not sound natural.
    - FM/PM – The received audio my become distorted.

98

Transmitters and Receivers

Receiver Functions.

- Filtering and tuning.
  - On most multi-mode transceivers, there is a control to assist in tuning the receiver so that the other station's signal sounds natural
  - Receiver incremental tuning (RIT).
    - a.k.a. – Clarifier.
    - Allows small changes in receive frequency without changing transmit frequency.

99

Transmitters and Receivers

Receiver Functions.

- Filtering and tuning.
  - There usually is a corresponding control for the transmit frequency.
  - Transmitter incremental tuning (XIT).
    - Allows small changes in transmit frequency without changing receive frequency.

100

Transmitters and Receivers

Receiver Functions.

- Noise blanker.
  - Most multi-mode transceivers have a function called a “Noise Blanker” which detects presence of a noise pulse & turns off (blanks) the receiver audio during the pulse.
  - Especially effective on repetitive pulse-type noise.
    - Ignition noise.
    - Electric motors.
    - Fluorescent lamps.

101

Transmitters and Receivers

Receiver Functions.

- Noise limiter.
  - Clamps the receiver audio at a maximum level.
    - Prevents a strong noise burst from damaging your hearing.
- Notch filter.
  - A very narrow band reject filter used to eliminate an interfering steady signal, such as a carrier.
    - Do **NOT** use with CW or data.

102

Transmitters and Receivers

Receiver Functions.

- Signal Strength.
  - Most receivers have a method of displaying signal strength.
    - Analog Meter.
    - LCD display.
    - Often derived from AGC voltage & not well calibrated.

103

Transmitters and Receivers

Receiver Functions.

- Signal Strength.
  - S-Units
    - Numbered S1 (weakest) to S9 (strongest).
    - 1 S-unit = 6 dB.
    - S9 is defined as 50µV (-73dBm) at the antenna terminals.
    - Extremely strong signals are reported as the number of dB greater than S9.
      - e.g. – "Your signal is 10 dB over S9."

104

T4B06 -- Which of the following controls could be used if the voice pitch of a single-sideband signal returning to your CQ call seems too high or low?

A. The AGC or limiter
B. The bandwidth selection
C. The tone squelch
D. The receiver RIT or clarifier

105

T4B08 -- What is the advantage of having multiple receive bandwidth choices on a multimode transceiver?

A. Permits monitoring several modes at once by selecting a separate filter for each mode
B. Permits noise or interference reduction by selecting a bandwidth matching the mode
C. Increases the number of frequencies that can be stored in memory
D. Increases the amount of offset between receive and transmit frequencies

106

T4B10 -- Which of the following receiver filter bandwidths provides the best signal-to-noise ratio for SSB reception?

A. 500 Hz
B. 1000 Hz
C. 2400 Hz
D. 5000 Hz

107

T4B12 -- What is the result of tuning an FM receiver above or below a signal's frequency?

A. Change in audio pitch
B. Sideband inversion
C. Generation of a heterodyne tone
D. Distortion of the signal's audio

108

Break

109

Transmitters and Receivers

VHF/UHF Power Amplifiers.

- Hand-held FM transceivers are very popular, but relatively low power.
  - Typically 8 watts or less.
- You can use an external power amplifier to increase the transmitter power output.

110

Transmitters and Receivers

VHF/UHF Power Amplifiers.

- Multi-mode amplifiers need to operate slightly differently depending on mode and include an SSB/CW-FM switch.
  - SSB position.
    - Required for SSB operations.
    - Best linearity, but less efficient.
  - CW-FM position.
    - Used for CW & FM operations.
    - Best efficiency, but poorer linearity.

111

T7A09 -- What is the function of the SSB/CW-FM switch on a VHF power amplifier?

A. Change the mode of the transmitted signal
B. Set the amplifier for proper operation in the selected mode
C. Change the frequency range of the amplifier to operate in the proper portion of the band
D. Reduce the received signal noise

112

T7A10 -- What device increases the transmitted output power from a transceiver?

A. A voltage divider
B. An RF power amplifier
C. An impedance network
D. All of these choices are correct

113

Transmitters and Receivers

Transverters.

- Some HF transceivers include the 6m band.
- A few HF transceivers also include the 2m and/or 70cm bands.
- None include any bands above 70cm.
- To operate on bands not directly covered by your transceiver, you use a device called a “transverter”.

114

Transmitters and Receivers

Transverters.

- A transverter converts a transceiver's transmit & receive frequency range to an entirely new band.
  - Transverters use mixers to:
    - Shift low-power transmit signals to the new band.
    - Allow received signals on the new band to be heard.
  - A band covered by the transceiver is used as an IF for the desired VHF/UHF/Microwave band.
    - Usually 10m.

115

T7A06 -- What device converts the RF input and output of a transceiver to another band?

A. High-pass filter
B. Low-pass filter
C. Transverter
D. Phase converter

116

Digital Communications

Most HF & some VHF/UHF stations include a computer to:

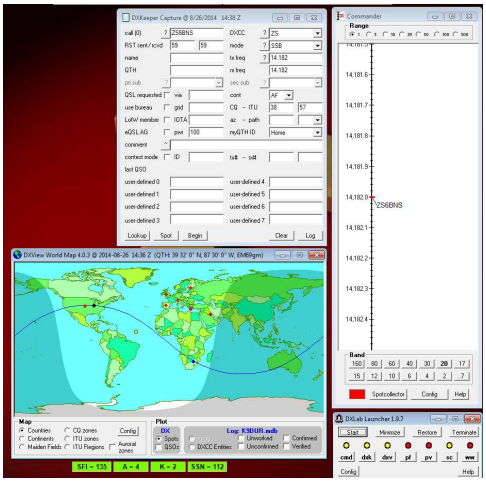
- Automate many functions.
  - Frequency & mode control.
  - Sending/receiving CW.
    - International Morse Code.
  - Logging, award tracking, & QSL'ing.
- Allow types of operation not otherwise possible.
  - Digital modes.

117

Digital Communications

DXLabs Suite

- Radio control.
- Logging.
  - QSL'ing.
  - Award tracking.
- DX spots.
- Propagation prediction.
- CW, RTTY, & PSK31.



118

Digital Communications

Amateur Digital Modes.

- Amateur transceivers designed for voice transmission can be used to send digital information (data) as a series of tones.
- Data modes consist of:
  - Modulation method.
    - How tones are added to RF signal.
  - Protocol.
    - Rules governing how data is converted to tones.

119

Digital Communications

Amateur Digital Modes.

- Many digital modes have error detection and correction features built into the protocol.
  - Forward Error Correction (FEC).
    - Sends extra information so that the data can be reconstructed.
      - e.g. - MFSK16, MT63.
  - Automatic Repeat Request (ARQ).
    - If an erroris detected, the receiving station asks the sending station to retransmit the data.
      - e.g. – Packet, Winmor

120

Digital Communications

Data Modes.

- CW.
  - CW is actually a “digital” mode.
    - Amplitude modulation (AM).
  - International Morse Code.
    - Letters A-Z
      - No lower case.
    - Numerals 0-9.
    - Some punctuation.
    - Some special characters.

Morse Code Alphabet

The International morse code characters:

A	.-	N	-.	0	-----
B	-...	O	---	1	.----
C	-.-.	P	.--.	2	..---
D	-..	Q	--.-	3	...--
E	.	R	.-.	4	....-
F	..-.	S	...	5	.....
G	--.	T	-	6	-....
H	....	U	..-	7	--...
I	..	V	...-	8	---..
J	.---	W	.--	9	----.
K	-.-	X	-..-	Fullstop	.-.-.-
L	.-..	Y	-.--	Comma	--..--
M	--	Z	--..	Query	..--..

121

Digital Communications

Amateur Digital Modes.

- Radioteletype (RTTY).
  - Oldest digital mode.
  - Adapted from land-line teletype system.
    - Frequency shift keying (FSK).
    - Audio frequency shift keying (AFSK).
  - 5-bit Baudot code.
    - Letters A-Z
      - No lower case.
    - Numbers 0-9.
    - Some punctuation.

122

Digital Communications

Amateur Digital Modes.

- Packet.
  - American Standard Code for Information Interchange (ASCII) code.
    - Start bit.
    - 7 data bits.
    - Parity bit (may be 8th data bit).
    - 1, 1.5, or 2 stop bits.
    - Upper & lower case letters.
    - Numerals 0-9.
    - Punctuation & control codes.

123

Digital Communications

Amateur Digital Modes.

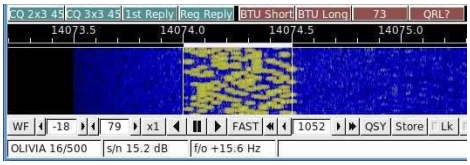
- MFSK.
  - Multi-tone frequency shift keying.
  - Forward error correction (FEC).
    - Extra information is sent to allow reconstruction of the original data if errors are detected.

124

Digital Communications

Amateur Digital Modes.

- Olivia.
  - Variation of MFSK.
  - Very effective at poor signal-to-noise levels.
    - S/N = -14 dB.
  - Relatively slow but robust.



125

Digital Communications

Amateur Digital Modes.

- AMTOR.
  - Variation of RTTY.
    - 170 Hz FSK.
    - 100 baud.
    - Special code.
    - Adds ARQ error correction.
  - Rarely used anymore.
    - Replaced by more modern modes.

126

Digital Communications

Amateur Digital Modes.

- PACTOR.
  - Developed by Special Communications Systems GmBH.
    - Combination of AMTOR & Packet.
  - PACTOR I.
    - Open technology → Relatively inexpensive modems.
      - $50.00 to $150.00.
  - PACTOR II, PACTOR III, & PACTOR IV.
    - Proprietary technology → Very expensive modems.
      - $1000.00 to >$1600.00.
  - Used in NTS digital message handling system.

127

Digital Communications

Amateur Digital Modes.

- WINMOR.
  - Similar to PACTOR.
    - Developed as inexpensive alternate to PACTOR.
  - Uses ARQ error correction.
  - Only a simple soundcard interface is required.
  - Intended for handling the HF portion of the WinLink system.

128

Digital Communications

Amateur Digital Modes.

- The WSJT Modes.
  - A family of modes designed for different types of weak-signal communications.
  - Written by Dr. Joseph Taylor Jr, K1JT.
    - Professor Emeritus at Princeton University.
    - Winner of Nobel Prize for Physics in 1993.
  - First WSJT program released in 2001.

129

Digital Communications

Amateur Digital Modes.

- The WSJT Modes.
  - FSK441 – Meteor scatter (2m & 70cm).
  - JT6M – Meteor scatter (6m).
  - JT65 – VHF & UHF moonbounce or earth-moon-earth (EME).
    - JT65-HF – HF weak signals many dB below the noise.

130

Digital Communications

Amateur Digital Modes.

- The WSJT Modes.
  - JT9 – MF & HF weak signals.
  - FT8 – MF, HF, & VHF weak signals.
    - 15-second transmit/receive intervals.
  - FT4 – MF, HF, & VHF weak signals.
    - 7.5-second transmit/receive intervals.
    - FT8 modified for contest & DX operations.

131

Digital Communications

Amateur Digital Modes.

- Wi-Fi and Broadband-Hamnet™.
  - Wi-fi (IEEE 802.11) shares frequencies with the Amateur Radio Service in the 2.4GHz & 5.6GHz bands.
  - Amateurs have modified the firmware of some commercial wi-fi modems to automatically connect forming a local network.
    - Broadband-Hamnet™.
    - High Speed Multi-Media Network (HSMM).
  - Useful in public service & emergency communications.

132

T8D01 -- Which of the following is a digital communications mode?

A. Packet radio
B. IEEE 802.11
C. FT8
D. All these choices are correct

133

T8D10 -- Which of the following operating activities is supported by digital mode software in the WSJT suite?

A. Earth-Moon-Earth
B. Weak signal propagation beacons
C. Meteor scatter
D. All these choices are correct

134

T8D12 -- Which of the following best describes an amateur radio mesh network?

A. An amateur-radio based data network using commercial Wi-Fi equipment with modified firmware
B. A wide-bandwidth digital voice mode employing DMR protocols
C. A satellite communications network using modified commercial satellite TV hardware
D. An internet linking protocol used to network repeaters

135

T8D13 -- What is FT8?

A. A wideband FM voice mode
B. A digital mode capable of low signal-to-noise operation
C. An eight channel multiplex mode for FM repeaters
D. A digital slow-scan TV mode with forward error correction and automatic color compensation

136

Digital Communications

Amateur Digital Modes.

- Packet and Packet Networks.
  - Oldest of the "modern" digital modes.
    - Development started in the 1970's.
    - Became widely popular in the 1980's.
    - Still popular on VHF & UHF.
      - 1200-9600 baud on 2m.
    - Not practical on HF.
      - Limited to 300 baud.
      - Very slow when band conditions are noisy.

137

Digital Communications

Amateur Digital Modes.

- Packet and Packet Networks.
  - Data is sent in groups of characters called *packets*.
    - AX.25 protocol.
  - Each packet has 5 parts, in this order:
    1. Start of packet flag character.
    2. Header (address & control information).
    3. Data (1 to 256 characters).
    4. Checksum.
    5. End of packet flag character.

138

Digital Communications

Amateur Digital Modes.

- Packet and Packet Networks.
  - The checksum is used to detect errors in the received message.
  - If an error is detected, the receiving station requests the transmitting station to send the packet again.
    - This is called *Automatic Repeat Request (ARQ)*.
    - Message will either be received error-free or not at all.

139

Digital Communications

Amateur Digital Modes.

- Packet and Packet Networks.
  - A hardware device called a *Terminal Node Controller (TNC)* handles all details of the protocol.
    - Transmit
      - The computer sends data to TNC.
      - TNC sends properly formatted packets to the radio.
    - Receive
      - The radio sends packets to the TNC.
      - TNC sends data to the computer.
    - A TNC can be emulated in software.

140

Digital Communications

Amateur Digital Modes.

- Packet and Packet Networks.
  - A TNC can be set up to act as a *digipeater*.
    - Analogous to a voice repeater but not real-time.
    - Uses a store-and-forward technique.
      - A packet is received and then immediately re-transmitted.

141

T8D08 -- Which of the following is included in packet radio transmissions?

A. A check sum that permits error detection
B. A header that contains the call sign of the station to which the information is being sent
C. Automatic repeat request in case of error
D. All these choices are correct

142

T8D11 -- What is an ARQ transmission system?

A. A special transmission format limited to video signals

B. A system used to encrypt command signals to an amateur radio satellite

C. An error correction method in which the receiving station detects errors and sends a request for retransmission

D. A method of compressing data using autonomous reiterative Q codes prior to final encoding

143

Digital Communications

Amateur Digital Modes.

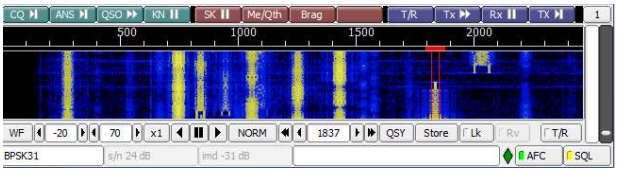
- Keyboard-to-Keyboard.
  - Modes designed for real-time, person-to-person communications are called *keyboard-to-keyboard* modes.
    - Not for sending data or files.
    - Nearly all digital modes can be used.
    - The most popular keyboard-to-keyboard mode today is PSK31.

144

Digital Communications

Amateur Digital Modes.

- PSK31.
  - PSK = Phase shift keying.
  - 31 = 31.25 baud.
  - Narrowest bandwidth of any mode, including CW.
  - Very effective in noisy conditions.



145

T8D06 -- What does the abbreviation "PSK" mean?

A. Pulse Shift Keying
B. Phase Shift Keying
C. Packet Short Keying
D. Phased Slide Keying

146

Digital Communications

Amateur Digital Modes.

- APRS.
  - APRS stands for “Automatic Packet Reporting System“.
    - Developed by Bob Bruninga, WB4APR.
    - Uses packet radio (144.390 MHz in North America).
    - Often connected to a GPS receiver for position tracking.
    - Also can be used for messaging.

147

Digital Communications

Amateur Digital Modes.

- APRS.
  - Digipeaters are used to relay RF signals to or from an internet gateway.
    - An internet gateway transfers packets between RF & the internet.
  - Non-radio uses.
    - Often personal weather stations are connected to the APRS network on the internet for automated weather data gathering.

148

Digital Communications

Amateur Digital Modes.

- APRS.

149

T8D03 -- What kind of data can be transmitted by APRS?

A. GPS position data
B. Text messages
C. Weather data
D. All these choices are correct

150

T8D05 -- Which of the following is an application of APRS?

A. Providing real-time tactical digital communications in conjunction with a map showing the locations of stations
B. Showing automatically the number of packets transmitted via PACTOR during a specific time interval
C. Providing voice over internet connection between repeaters
D. Providing information on the number of stations signed into a repeater

151

Digital Communications

Setting Up for Digital Modes.

- Need some way to:
  - Convert data to tones.
  - Feed tones to radio.
  - Key the radio.
  - Receive tones from radio.
  - Convert tones to data.
- Can use:
  - External modulator-demodulator (modem).
  - Soundcard software.

152

Digital Communications

Setting Up for Digital Modes.

- Modulator-demodulator (modem).
  - External device to convert data to tones for transmission and to convert tones to data for reception.
    - Connects between computer serial port and radio.
  - Packet Terminal Node Controller (TNC).
  - Multi-mode controller.
    - Limited to just a few modes.

153

Digital Communications

Setting Up for Digital Modes.

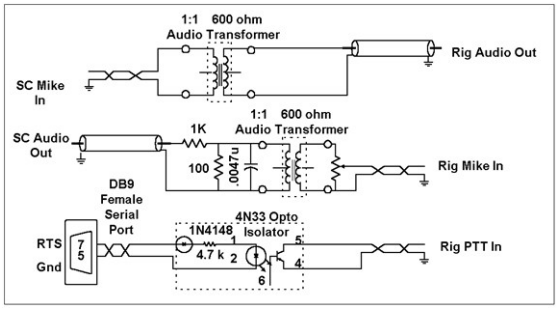
- Soundcard software.
  - Computer program that uses the computer soundcard to send/receive the tones.
    - Requires a hardware interface to connect the computer soundcard to the radio microphone & speaker connections, and to connect the serial port to PTT.
      - Some radios have a data connector which makes connections easier.
    - Allows operating all of the various digital modes.

154

Digital Communications

Setting Up for Digital Modes.

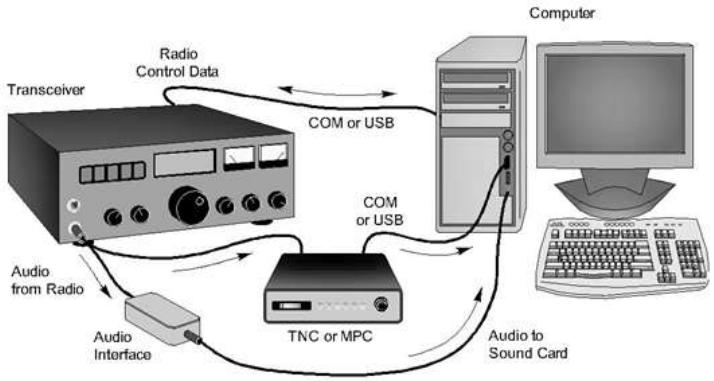
- Soundcard interface.



155

Digital Communications

Setting Up for Digital Modes.



156

T4A04 -- How are the transceiver audio input and output connected in a station configured to operate using FT8?

A. To a computer running a terminal program and connected to a terminal node controller unit
B. To the audio input and output of a computer running WSJT-X software
C. To an FT8 conversion unit, a keyboard, and a computer monitor
D. To a computer connected to the FT8converter.com website

157

T4A06 -- What signals are used in a computer-radio interface for digital mode operation?

A. Receive and transmit mode, status, and location
B. Antenna and RF power
C. Receive audio, transmit audio, and transmitter keying
D. NMEA GPS location and DC power

158

T4A07 -- Which of the following connections is made between a computer and a transceiver to use computer software when operating digital modes?

A. Computer “line out” to transceiver push-to-talk
B. Computer “line in” to transceiver push-to-talk
C. Computer “line in” to transceiver speaker connector
D. Computer “line out” to transceiver speaker connector

159

Digital Communications

Gateways.

- Provide connections between data transmitted via amateur radio & the internet.
  - Message forwarding.
  - Packet bulletin boards.
  - WinLink remote message service (RMS) stations.
  - D-Star repeaters.

CAUTION: All regulations concerning message content & appropriateness apply to messages sent via internet gateways.

160

T8C11 -- What is an amateur radio station that connects other amateur stations to the internet?

A. A gateway
B. A repeater
C. A digipeater
D. A beacon

161

Power Supplies and Batteries

Power Supplies.

- House power is 120 VAC, 60 Hz.
- Most modern radios require +12 VDC.
  - Actually +13.8 VDC.
- A power supply is a device that converts 120 VAC power to the desired DC voltage or voltages.

162

Power Supplies and Batteries

Power Supplies.

- Unregulated supply.
  - Simple circuit.
  - Voltage can vary over a wide range with changing load current.
    - Not good for solid-state radios.

163

Power Supplies and Batteries

Power Supplies.

- Regulated supply.
  - More complex circuit.
    - Adds a circuit called a *voltage regulator* to an unregulated supply.
  - Voltage is nearly constant with changing load.
  - Radios work best with a regulated power supply.

164

Power Supplies and Batteries

Power Supplies.

- Ratings:
  - Output voltage.
  - Continuous current.
    - How much current can be supplied over the long term.
  - Intermittent current.
    - a.k.a. – Surge current or peak current.
    - How much current can be supplied over the short term.
  - Voltage regulation.
    - How well the power supply can handle rapid current changes.

165

Power Supplies and Batteries

Power Supplies.

- Regulated Power Supplies.
  - Linear.
    - Large & heavy.
    - Inefficient.
      - Generate heat.
    - Easy to repair.
    - Less expensive.

166

Power Supplies and Batteries

Power Supplies.

- Regulated Power Supplies.
  - Switching.
    - Small & lightweight.
    - Very efficient.
    - More difficult to repair.
    - More expensive.
    - May generate RF noise.

167

Power Supplies and Batteries

Power Supplies.

- Wire Size and Power Sources.
  - Transceivers can draw large amounts of current while transmitting.
    - >20A for a 100W HF transceiver.
    - >10A for a 50W FM transceiver.

168

Power Supplies and Batteries

Power Supplies.

- Wire Size and Power Sources.
  - Large wire sizes must be used to prevent voltage drop in the wiring.
    - Higher current → larger wire.
    - Longer length → larger wire.

169

T4A01 -- Which of the following is an appropriate power supply rating for a typical 50 watt output mobile FM transceiver?

A. 24.0 volts at 4 amperes
B. 13.8 volts at 4 amperes
C. 24.0 volts at 12 amperes
D. 13.8 volts at 12 amperes

170

T4A03 -- Why are short, heavy-gauge wires used for a transceiver's DC power connection?

A. To minimize voltage drop when transmitting
B. To provide a good counterpoise for the antenna
C. To avoid RF interference
D. All these choices are correct

171

T6D05 -- What type of circuit controls the amount of voltage from a power supply?

A. Regulator
B. Oscillator
C. Filter
D. Phase inverter

172

Power Supplies and Batteries

Mobile Power Wiring.

- Fuse **BOTH** positive & negative leads close to the power connection.
- Connect negative lead to negative (-) battery terminal or to battery ground connection.
- Use grommets or sleeves to protect wires where they pass through firewall.
- Do **NOT** assume that all metal body parts are grounded.

173

Power Supplies and Batteries

Mobile Power Wiring.

- Mobile installations are susceptible to interference from noise sources not present in home stations.
  - Ignition noise.
    - Present on received signal.
    - Reduced or eliminated by turning on the noise blanker.
  - Alternator whine.
    - High-pitched whine that varies in frequency with engine speed.
    - Present on either received or transmitted signal or both.
    - Eliminated by adding a filter to the DC wiring at the radio.

174

T4A11 -- Where should the negative power return of a mobile transceiver be connected in a vehicle?

A. At the 12 volt battery chassis ground
B. At the antenna mount
C. To any metal part of the vehicle
D. Through the transceiver's mounting bracket

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Power Supplies and Batteries

Batteries.

- Battery cells create electrical energy through a chemical reaction.
  - Primary cell.
    - Chemical reaction is not reversible.
    - Cannot be recharged.
  - Secondary cell.
    - Chemical reaction is reversible.
    - Can be recharged.

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Power Supplies and Batteries

Batteries.

- Batteries are one or more battery cells connected in series.


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Power Supplies and Batteries

Batteries.

- Battery capacity is rated in ampere-hours (AH) or milliampere-hours (mAH).
  - A 500 mAH battery will provide:
    - 500 mA for 1 hour.
    - 50 mA for 10 hours.
    - 25 mA for 20 hours.
    - 5 mA for 100 hours.
    - etc.

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Power Supplies and Batteries

Batteries.

- The individual cell voltage depends on the materials used to construct the cell.

Chemistry	Cell Voltage	Type
Lead-Acid	2.1V	Rechargeable
Carbon-Zinc (obsolete)	1.5V	Disposable
Alkaline	1.5V	Disposable*
Nickel-Cadmium (NiCad)	1.2V	Rechargeable
Nickel-Metal-Hydride (NiMH)	1.2V	Rechargeable
Lithium Ion (LI-Ion)	3.6V	Rechargeable

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Power Supplies and Batteries

Batteries.

- Lead-Acid.
  - Secondary cell.
  - Approximately 2.12 Volts per cell.
  - "12V" battery = 6 cells in series.
    - Open-Circuit at full charge: 12.6 V to 12.8 V
    - Open-circuit at full discharge: 11.8 V to 12.0 V
    - Loaded at full discharge: 10.5 V
    - Float Charge: 13.8 V
    - Daily Charge: 14.2 V to 14.5 V

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Power Supplies and Batteries

Batteries.

- Lead-Acid.
  - If overcharged a lead-acid battery will release hydrogen gas.
    - **Remember the Hindenberg!**
    - **ALWAYS** use in a well-ventilated area!
    - Gassing threshold ~14.4 V.

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Power Supplies and Batteries

Batteries.

- Sealed lead-acid (SLA).
  - a.k.a. – Gel-Cell.
  - Electrolyte is in a gel form rather then liquid.
  - Sealed so does not vent hydrogen gas.
  - Avoid over charging to prevent build up of internal pressure.

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Power Supplies and Batteries

Batteries.

- Battery Charging.
  - Some batteries can be recharged, some cannot.
  - Use the proper charger for the battery being charged.
  - Batteries will wear out over time.
  - Best if batteries are maintained fully charged.
  - Over-charging will cause heating and could damage the battery.

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Power Supplies and Batteries

Batteries.

- Batteries for Handheld Radios.
  - Handheld transceivers usually use battery packs
    - Packages of several individual batteries connected together.
    - Most are rechargeable.
      - NiCd (nickel-cadmium).
      - NiMH (nickel-metal hydride).
      - Li-ion (lithium-ion).
  - For emergencies, a battery pack that can use disposable batteries (usually AA size) is useful.

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T4A09 -- How can you determine the length of time that equipment can be powered from a battery?

A. Divide the watt-hour rating of the battery by the peak power consumption of the equipment
B. Divide the battery ampere-hour rating by the average current draw of the equipment
C. Multiply the watts per hour consumed by the equipment by the battery power rating
D. Multiply the square of the current rating of the battery by the input resistance of the equipment

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T6A10 -- Which of the following battery chemistries is rechargeable?

A. Nickel-metal hydride
B. Lithium-ion
C. Lead-acid
D. All of these choices are correct

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T6A11 -- Which of the following battery chemistries is not rechargeable?

A. Nickel-cadmium
B. Carbon-zinc
C. Lead-acid
D. Lithium-ion

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T0A10 -- What hazard is caused by charging or discharging a battery too quickly?

A. Overheating or out-gassing
B. Excess output ripple
C. Half-wave rectification
D. Inverse memory effect

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Questions?

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Technician Class

Next Week

Chapter 6

Communicating with Other Hams

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