# General License Class

1

# General Class

## Chapter 2

## Procedures & Practices

2

# HF Operating Techniques

- Good Practices
  - Most of the good operating practices and rules of courtesy learned on the VHF/UHF bands carry over to the HF bands.
  - HF operating is similar to “weak signal” operating on VHF & UHF.
  - The use of the NATO phonetic alphabet is considered the best practice.

3

# HF Operating Techniques

**NATO Phonetic Alphabet**

| | | | |
|---|---|---|---|
| A - Alpha | H - Hotel | O – Oscar | V - Victor |
| B - Bravo | I – India | P - Papa | W - Whiskey |
| C - Charlie | J – Juliet | Q - Quebec | X - X-ray |
| D - Delta | K – Kilo | R - Romeo | Y - Yankee |
| E - Echo | L – Lima | S - Sierra | Z - Zulu |
| F - Foxtrot | M – Mike | T - Tango | |
| G - Golf | N- November | U - Uniform | |

4

# HF Operating Techniques

## Selecting a Frequency

- There are several ways of selecting an operating frequency.
- Factors to consider are:
  - Proximity to band edges.
  - License class privileges.
  - Proximity to other stations.
  - Propagation conditions.

5

# HF Operating Techniques

## Selecting a Frequency

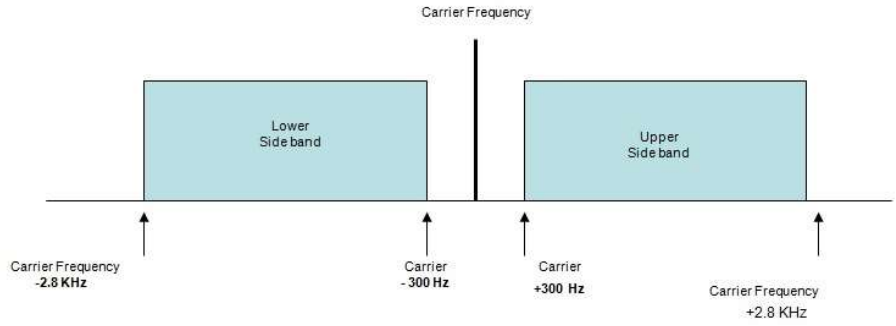
- Proximity to band edges.
  - Your entire transmitted signal, including any sidebands, must be contained entirely within the range of frequencies authorized to the Amateur Radio Service and to your class of license.
    - **ALL** modulated signals, including CW, have sidebands.

6

# HF Operating Techniques

## Selecting a Frequency

**Be aware of the band edges!**




7

# HF Operating Techniques

## Selecting a Frequency

- Proximity to other stations.
  - You need to allow for a “guard band” between your signal and others so that your signal does not cause interference to nearby signals.
  - The size of this guard band will vary by mode.

8

# HF Operating Techniques

## Selecting a Frequency

- Recommended minimum signal separation for various modes:

| Mode | Separation |
|---|---|
| CW | 150-500 Hz |
| SSB | Approx 2-3 kHz |
| RTTY | 250-500 Hz |
| PSK31 | 150-500 Hz |

9

# HF Operating Techniques

## Selecting a Frequency

- Except for emergencies, a single operator or group of operators **NEVER** has priority on a given frequency.
- If a conflict arises, move to a different frequency.
  - Changes in propagation can cause a conflict.
  - **Courtesy Rules!**

10

# HF Operating Techniques

## Selecting a Frequency

- **ALWAYS** ask if a frequency is in use before using it.
  - Depending on the propagation conditions, you may not be able to hear both sides of a conversation.
  - Say “Is this frequency in use?” followed by your call sign on phone.
  - Send “QRL?” followed by your call sign on CW.

11

# HF Operating Techniques

## Selecting a Frequency

- Band Plans.
  - Band plans are voluntary agreements that specify what segments of a band are used for what mode or type of operation.
    - Band plans are **NOT** regulations but are guidelines.
      - However, the FCC considers following the band plans to be “good amateur practice”.

12

# HF Operating Techniques

## Selecting a Frequency

- Band Plans.
  - The ARRL website provides a list of the current band plans for each amateur radio band.

http://arrl.org/band-plan

13

# HF Operating Techniques

## Selecting a Frequency

- Nets.
  - Nets are regularly scheduled gatherings of amateur radio operators on the air for a specific purpose.
  - Nets normally have some form of formal structure.
    - Net Control Station (NCS).

14

# HF Operating Techniques

## Selecting a Frequency

- Nets.
  - There are several different types of nets depending on their purpose:
    - Traffic Nets.
    - Service Nets.
    - Social Nets.
    - Emergency Nets.
      - Obviously unscheduled.

15

# HF Operating Techniques

## Selecting a Frequency

- Dual channel or “split” operation.
  - Transmitting on one frequency while listening on another.
  - Popular stations, such as DX stations, may have many stations trying to call them at the same time.
    - Operating split helps to manage the pile-up.

16

# HF Operating Techniques

## Selecting a Frequency

- In summary:
  - Make certain that the frequency is authorized to General Class licensees.
    - **Be aware of the band edges!**
  - If possible, follow the band plan.
  - Maintain separation from nearby signals.
  - Be prepared to change frequencies if conditions change.
  - **Listen before transmitting!**

17

**G2B01 -- Which of the following is true concerning access to frequencies?**

A. Nets have priority
B. QSOs in process have priority
C. Except during emergencies, no amateur station has priority access to any frequency
D. Contest operations should yield to non-contest use of frequencies

18

**G2B03 – What is good amateur practice if propagation changes during a contact creating interference from other stations using the frequency?**

A. Advise the interfering stations that you are on the frequency and that you have priority
B. Decrease power and continue to transmit
C. Attempt to resolve the interference problem with the other stations in a mutually acceptable manner
D. Switch to the opposite sideband

19

**G2B04 -- When selecting a CW transmitting frequency, what minimum separation should be used to minimize interference to stations on adjacent frequencies?**

A. 5 Hz to 50 Hz
B. 150 Hz to 500 Hz
C. 1 kHz to 3 kHz
D. 3 kHz to 6 kHz

20

**G2B05 – When selecting an SSB transmitting frequency, what minimum separation should be used to minimize interference to stations on adjacent frequencies?**

A. 5 Hz to 50 Hz
B. 150 Hz to 500 Hz
C. 2 kHz to 3 kHz
D. Approximately 6 kHz

21

**G2B06 -- How can you avoid harmful interference on an apparently clear frequency before calling CQ on CW or phone?**

A. Send “QRL?” on CW, followed by your call sign; or, if using phone, ask if the frequency is in use, followed by your call sign
B. Listen for 2 minutes before calling CQ
C. Send the letter “V” in Morse code several times and listen for a response, or say “test” several times and listen for a response
D. Send “QSY” on CW or if using phone, announce “the frequency is in use,” then give your call sign and listen for a response

22

**G2B07 -- Which of the following complies with commonly accepted amateur practice when choosing a frequency on which to initiate a call?**

A. Listen on the frequency for at least two minutes to be sure it is clear
B. Identify your station by transmitting your call sign at least 3 times
C. Follow the voluntary band plan
D. All these choices are correct

23

**G2C04 -- What does the Q signal "QRL?" mean?**

A. "Will you keep the frequency clear?"
B. "Are you operating full break-in?" or "Can you operate full break-in?“
C. "Are you listening only for a specific station?"
D. "Are you busy?" or "Is this frequency in use?"

24

**G2D07 -- Which of the following are examples of the NATO Phonetic Alphabet?**

A. Able, Baker, Charlie, Dog
B. Adam, Boy, Charles, David
C. America, Boston, Canada, Denmark
D. Alpha, Bravo, Charlie, Delta

25

**G4A12 – Which of the following is a common use for the dual-VFO feature on a transceiver?**

A. To allow transmitting on two frequencies at once
B. To permit full duplex operation -- that is, transmitting and receiving at the same time
C. To transmit on one frequency and listen on another
D. To improve frequency accuracy by allowing variable frequency output (VFO) operation

26

# HF Operating Techniques

## Making Contacts

- CQ – General call to any station.
  - General CQs.
    - Any station may answer.
  - Restricted CQs.
    - Only specific stations or groups of stations should answer.
      - By location -- CQ DX, CQ Europe, CQ Texas, etc.
      - Other – CQ Contest, CQ Field Day, etc.

27

# HF Operating Techniques

## Making Contacts

- Calling CQ is rare on the VHF/UHF FM channels.
  - Stations are listening on specific frequencies (channels) for contacts.
- Calling CQ is common on HF and for CW & SSB contacts on VHF/UHF.
  - Stations can be anywhere within the band.

28

# HF Operating Techniques

## Making Contacts

- Making a voice contact
  - Calling CQ on phone:

    **CQ CQ CQ this is *<your call> <your call> <your call>* over**
  - Answering a CQ on phone:

    ***<his call>* this *is <your call> <your call> <your call>* over**
  - Answering a CQ on CW or digital modes:

    ***<his call>* this *is <your call> <your call> <your call>* K**
  - Use the NATO Phonetic Alphabet to send your call.

29

# HF Operating Techniques

## Making Contacts

- Making a voice contact
  - Breaking into an existing conversation:
    - Send your call sign using the NATO Phonetic Alphabet during a break between transmissions.
  - Making contacts during a contest.
    - Send only your call sign using the NATO Phonetic Alphabet to answer a station.

30

# HF Operating Techniques

## Making Contacts

- Making a CW or digital mode contact
  - Calling CQ on CW or digital modes:

    **CQ CQ CQ DE *<your call> <your call> <your call>* K**
  - Answering a CQ on CW or digital modes:

    ***<his call>* this *is <your call> <your call> <your call>* K**
  - Breaking into an existing conversation:
    - Send **BK *<your call>*** during a break between transmissions.
    - Do not break in if stations are sending KN.

31

# HF Operating Techniques

## Making Contacts

- The band plans for several bands have a portion designated as a "DX window".
  - e.g. – On 6m, the DX window is 50.1 to 50.125 MHz.
- Stations should only make contact with stations located in a different country or DXCC entity.
  - NOTE: Alaska & Hawaii are different DXCC entities than the contiguous 48 states.

32

# HF Operating Techniques

Making Contacts

- Logs.
  - Record of station operation.
  - Originally, logs were kept on paper.
  - Most amateurs now use computer logging software.

33

# HF Operating Techniques

Making Contacts

- Logs
  - Not required by FCC, but useful if FCC makes inquiries about station operation.
  - Necessary for exchanging QSL cards.
  - Necessary for award tracking.
  - Necessary for contests.

34

# HF Operating Techniques

## Making Contacts

- Logs
  - Normally contain:
    - Date & time of contact.
    - Band or frequency of contact.
    - Mode used.
    - Call sign of station worked.

35

# HF Operating Techniques

## Making Contacts

- Logs
  - May contain any other desired information.
    - Signal reports sent/received.
    - QTH of station contacted.
    - Name of operator of station contacted.
    - Equipment used.
    - etc.

36

## HF Operating Techniques

Making Contacts

- Logs
  - Should contain name & call sign of any guest operators at your station.
  - If operating on 60m with an antenna other than a dipole, the station records must contain a record of the gain of the antenna used.

37

## HF Operating Techniques

- Managing Interference
  - Types of Interference
    - Incidental interference
      - Propagation changes
      - Not maintaining proper frequency separation
    - Harmful interference
      - Prohibited by FCC Rules & Regulations
    - Malicious (intentional) interference
      - Prohibited by FCC Rules & Regulations

38

## HF Operating Techniques

- Managing Interference
  - Avoiding Interference
    - Be smart.
    - Know band conditions.
      - Propagation
      - Busy times
    - Use directional antenna.

39

## HF Operating Techniques

- Managing Interference
  - Reacting to Interference.
    - Change frequency or antenna.
      - Nets should have a back-up frequency.
    - Have a back-up plan.
    - **Keep cool!!!**

40

**G1C04 – Which of the following is required by the FCC rules when operating in the 60-meter band?**

A. If you are using an antenna other than a dipole, you must keep a record of the gain of your antenna
B. You must keep a record of the date, time, frequency, power level, and stations worked
C. You must keep a record of all third-party traffic
D. You must keep a record of the manufacturer of your equipment and the antenna used

41

**G2A08 -- What is the recommended way to break into a phone contact?**

A. Say “QRZ” several times, followed by your call sign
B. Say your call sign once
C. Say “Breaker Breaker”
D. Say “CQ” followed by the call sign of either station

42

**G2A11 – Generally, who should respond to a station in the contiguous 48 states calling "CQ DX"?**

A. Any caller is welcome to respond
B. Only stations in Germany
C. Any stations outside the lower 48 states
D. Only contest stations

43

**G2B08 – What is the voluntary band plan restriction for US stations transmitting within the 48 contiguous states in the 50.1 MHz to 50.125 MHz band segment?**

A. Only contacts with stations not within the 48 contiguous states
B. Only contacts with other stations within the 48 contiguous states
C. Only digital contacts
D. Only SSTV contacts

44

**G2B10 – Which of the following is good amateur practice for net management?**

A. Always use multiple sets of phonetics during check-in
B. Have a backup frequency in case of interference or poor conditions
C. Transmit the full net roster at the beginning of every session
D. All these choices are correct

45

**G2D05 – Which of the following indicates that you are looking for an HF contact with any station?**

A. Sign your call sign once, followed by the words "listening for a call" -- if no answer, change frequency and repeat
B. Say "QTC" followed by "this is" and your call sign -- if no answer, change frequency and repeat
C. Repeat "CQ" a few times, followed by "this is," then your call sign a few times, then pause to listen, repeat as necessary
D. Transmit an unmodulated carried for approximately 10 seconds, followed by "this is" and your call sign, and pause to listen -- repeat as

46

## G2D08 -- Why do many amateurs keep a station log?

A. The FCC requires a log of all international contacts
B. The FCC requires a log of all international third-party traffic
C. The log provides evidence of operation needed to renew a license without retest
➡ D. To help with a reply if the FCC requests information about your station

47

## G2D09 – Which of the following is required when participating in a contest on HF frequencies?

A. Submit a log to the contest sponsor
B. Send a QSL card to the stations worked, or QSL via Logbook of The World
➡ C. Identify your station according to normal FCC regulations
D. All these choices are correct

48

# HF Operating Techniques

Modes

- CW (Continuous wave).
  - a.k.a. –Morse Code.
  - Best mode for weak-signal conditions.
    - Some digital modes can outperform CW on weak signals.

49

# HF Operating Techniques

Modes

- CW -- Continuous wave.
  - Permitted on ANY amateur frequency.
  - Courteous operators stay in segments specified for CW in the band plan.
    - Normally, in the lower end of the band in the segments restricted to CW & data transmissions

50

# HF Operating Techniques

Modes

- AM and SSB Phone.
  - An AM signal consists of a carrier and 2 sidebands located above and below the carrier.
    - Typically, an AM signal is approximately 6 kHz wide.
  - An SSB signal is an AM signal with the carrier and one sideband suppressed.
    - Typically, an SSB signal is approximately 3 kHz wide.

51

# HF Operating Techniques

Modes

- AM and SSB Phone.
  - In an AM signal, the carrier contains no information and the 2 sidebands contain identical information.
  - Therefore, the carrier and one sideband can be removed without any loss of information.

52

## HF Operating Techniques

Modes

- AM and SSB Phone.
  - In an AM signal, the carrier accounts for 50% of the total transmitted power, and the sidebands account for 25% each.
  - Therefore, SSB allows increasing the effective power by a factor of 4 without increasing the transmitter power.

53

## HF Operating Techniques

Modes

- AM and SSB Phone.
  - SSB is the most common mode on HF.
  - SSB has a narrower bandwidth than AM.
  - SSB is more power efficient than AM.
  - AM has higher fidelity than SSB.

54

# HF Operating Techniques

Modes

- AM and SSB Phone
  - SSB – Which sideband?
    - 60m -- USB only (FCC Regulation)
    - On all other bands, sideband is dictated by convention, not by regulation.

55

# HF Operating Techniques

**Conventional Sideband Usage**

| Band | Sideband |
|---|---|
| 160m | LSB |
| 80m | LSB |
| 40m | LSB |
| 20m | USB |
| 17m | USB |
| 15m | USB |
| 12m | USB |
| 10m | USB |
| VHF/UHF | USB |

56

# HF Operating Techniques

## Modes

- Digital Voice.
  - Digital voice modes are beginning to appear on the HF bands.
    - Fidelity similar to SSB.
    - Less noise in recovered audio.
    - More immune to fading.
    - FreeDV.

57

# HF Operating Techniques

## Modes

- Digital Modes
  - SSB transceivers are used to send/receive digital signals.
    - Digital data is transmitted as a series of tones.
    - A hardware interface connects the computer's soundcard to the transceiver's microphone & headphone connectors.
      - Some transceivers have a special data jack for this purpose.

58

# HF Operating Techniques

## Modes

- Digital Modes
  - Many different modes are available:
    - RTTY – Oldest digital mode.
    - FT8 – Most popular mode today.
    - PSK31 – Popular keyboard-to-keyboard mode.
    - PACTOR – Used for transferring large files.
    - Olivia – Good weak-signal performance.
    - Many, many more!

59

# HF Operating Techniques

## Modes

- Image Modes:
  - Slow-Scan Television (SSTV)
    - Bandwidth ≤ 3 kHz
    - Allowed in phone segments of HF bands.
  - Fast-Scan Television (ATV)
    - Bandwidth 6 MHz or greater.
    - Restricted to 432 MHz band and above.

60

**G2A01 -- Which mode is most commonly used for voice communications on frequencies of 14 MHz or higher?**

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

61

**G2A02 -- Which mode is most commonly used for voice communications on the 160-, 75-, and 40-meter bands?**

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

62

**G2A03 -- Which mode is most commonly used for SSB voice communications in the VHF and UHF bands?**

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

63

**G2A04 -- Which mode is most commonly used for voice communications on the 17- and 12-meter bands?**

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

64

**G2A05 -- Which mode of voice communication is most commonly used on the HF amateur bands?**

A. Frequency modulation
B. Double sideband
C. Single sideband
D. Single phase modulation

65

**G2A06 -- Which of the following is an advantage of using single sideband, as compared to other analog voice modes on the HF amateur bands?**

A. Very high fidelity voice modulation
B. Less subject to interference from atmospheric static crashes
C. Ease of tuning on receive and immunity to impulse noise
D. Less bandwidth used and greater power efficiency

66

**G2A07 -- Which of the following statements is true of single sideband (SSB)?**

A. Only one sideband and the carrier are transmitted; the other sideband is suppressed

B. Only one sideband is transmitted; the other sideband and carrier are suppressed

C. SSB is the only voice mode authorized on the 20-, 15-, and 10-meter amateur bands

D. SSB is the only voice mode authorized on the 160-, 75-, and 40-meter amateur bands

67

**G2A09 -- Why do most amateur stations use lower sideband on the 160-, 75-, and 40-meter bands?**

A. Lower sideband is more efficient than upper sideband at these frequencies

B. Lower sideband is the only sideband legal on these frequency bands

C. Because it is fully compatible with an AM detector

D. It is commonly accepted amateur practice

68

# HF Operating Techniques

HF Receiving

- FM receivers normally only have volume, squelch, & frequency (channel) controls.
- SSB/CW receivers have MANY more controls to adjust operation.

69

# HF Operating Techniques

HF Receiving

- Selectivity
  - The ability to reject strong signals close to the desired frequency.
  - More important than sensitivity.
    - Primary noise source is the atmosphere rather than the receiver circuitry.
      - Atmospheric noise is referred to as “QRN”.

70

# HF Operating Techniques

## Signal Reports

- Most QSOs include reports of how each station hears the other.
  - Strength of signal.
  - Quality of signal.
- Signal reports allow stations to adapt their operating techniques to existing conditions.

71

# HF Operating Techniques

## Signal Reports

- The most common system of signal reports is the Readability, Strength, Tone (RST) system.
  - 3 numbers.
  - Each number quantifies one aspect of the signal.

72

# HF Operating Techniques

## Signal Reports

| Readability | |
|---|---|
| 1 | Unreadable |
| 2 | Barely readable, occasional words distinguishable |
| 3 | Readable with considerable difficulty |
| 4 | Readable with practically no difficulty |
| 5 | Perfectly readable |

73

# HF Operating Techniques

## Signal Reports

- The S-Meter on a radio is an attempt to quantify signal strength readings.
- "S9" is defined as a 50µV signal at the antenna terminals.

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

74

# HF Operating Techniques

## Signal Reports

| | Tone |
|---|---|
| 1 | 60Hz 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 |

75

# HF Operating Techniques

## Signal Reports

- Tone is omitted on phone.
- “C” at end indicates unstable tone or “chirp”.
- “K” at end indicates key clicks.
- Sometimes “cut” numbers are used on CW.
  - “599” is sent as “5NN”.

76

# HF Operating Techniques

HF Receiving

- Receiver Incremental Tuning (RIT)
  - Tunes receiver slightly off of transmit frequency.
- Transmitter Incremental Tuning (XIT)
  - Tunes transmitter slightly off of receive frequency.

77

**G2C07 -- When sending CW, what does a "C" mean when added to the RST report?**

A. Chirpy or unstable signal
B. Report was read from S meter reading rather than estimated
C. 100 percent copy
D. Key clicks

78

## G2C10 -- What does the Q signal “QRN” mean?

A. Send more slowly
B. Stop sending
C. Zero beat my signal
D. I am troubled by static

79

## G2D11 -- Why are signal reports typically exchanged at the beginning of an HF contact?

A. To allow each station to operate according to conditions
B. To be sure the contact will count for award programs
C. To follow standard radiogram structure
D. To allow each station to calibrate their frequency display

80

# HF Operating Techniques

HF Transmitting

- Phone.
  - Several methods can be used to switch the transceiver from receive to transmit.
  - The two most common methods are:
    - Push-to-Talk (PTT).
    - Voice-Operated Transmit (VOX).

81

# HF Operating Techniques

HF Transmitting

- Phone.
  - PTT.
    - Button on microphone.
    - Hand switch.
    - Foot switch.
    - Best for noisy environments.

82

# HF Operating Techniques

HF Transmitting

- Phone.
  - VOX.
    - Allows “hands-free” operation.
      - Convenient for long periods of operation.
      - Allows mobile operators to keep both hands on the wheel.
    - 3 Controls:
      - VOX Gain
      - VOX Delay
      - Anti-VOX

83

# HF Operating Techniques

HF Transmitting

- CW.
  - The very first amateur radio contacts over 100 years ago used CW.
  - CW more common on HF than on VHF/UHF.

84

# HF Operating Techniques

HF Transmitting

- CW.
  - When operating CW you do not have to be on the same frequency as the other station.
    - The term “zero-beat” indicates that you have exactly matched your frequency to that of the other station.

85

# HF Operating Techniques

HF Transmitting

- CW.
  - Several different types of “keys” are used to send CW:
    - Straight key.
    - Semi-automatic key or “bug”.
    - Single-lever paddles.
    - Dual-lever paddles.
    - Keyboard.

86

# HF Operating Techniques

HF Transmitting

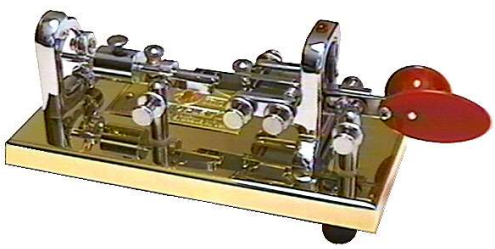
- CW.
  - Straight Key.
    - First method used by most CW operators.

87

# HF Operating Techniques

HF Transmitting

- CW.
  - Semi-Automatic Key or “Bug”.
    - Invented in 1905 by Vibroflex.
    - Manually forms “dahs”.
    - Automatically forms “dits”.
    - Unique rhythm.

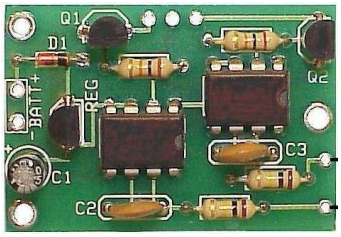


88

# HF Operating Techniques

HF Transmitting

- CW
  - Electronic Keyer
    - Automatically creates strings of “dits” & “dahs”.
    - Requires special type of key called “paddles”.
    - Built into most modern transceivers.


89

# HF Operating Techniques

HF Transmitting

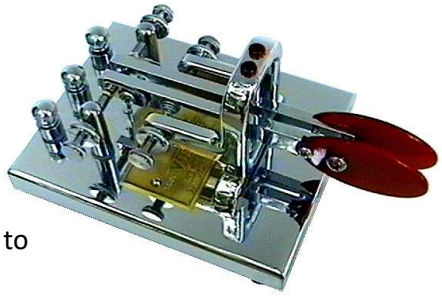
- CW.
  - Single-Paddle Key.
    - Move paddle one direction to send a string of “dits”.
    - Move paddle the other direction to send a string of “dahs”.

90

# HF Operating Techniques

HF Transmitting

- CW.
  - Dual-Paddle Key.
    - Press one paddle to send a string of “dits”.
    - Press the other paddle to send a string of “dahs”.
    - Press both paddles at the same time to send a string of alternating “dits” & “dahs”.



91

# HF Operating Techniques

HF Transmitting

- CW.
  - Keyboard.
    - Popular in the 1970s before personal computers became available.

92

# HF Operating Techniques

HF Transmitting

- CW.
  - T-R Switching.
    - MOX.
      - Manually put radio in transmit mode before sending.
      - Rarely used anymore.
        - Most modern transceivers have some form of QSK operation.

93

# HF Operating Techniques

HF Transmitting

- CW.
  - T-R Switching.
    - Semi Break-In (Semi QSK).
      - Pressing key puts radio in transmit mode.
      - Cannot receive between characters.
    - Full Break-In (Full QSK).
      - Pressing key puts radio in transmit mode.
      - Can receive between characters.

94

# HF Operating Techniques

HF Transmitting

- CW Procedures
  - Abbreviations are used to shorten common words.
  - Prosigns are procedural signals consisting of 2 letters send as a single character.
  - Q-signals are 3-letter groups beginning with the letter “Q” that represent entire sentences or phrases.

95

# HF Operating Techniques

HF Transmitting

- CW Procedures
  - Some common abbreviations are:

| | |
|---|---|
| RX = Receive | FER = For |
| XMT = Transmit | CUL = See You Later |
| WX = Weather | AGN = Again |
| TX = Transmit | K = Go Ahead |
| DE = This Is | KN = Go Ahead (Only) |
| ES = And | R = Acknowledged (“Roger”) |
| FB = Fine Business (OK) | |

96

# HF Operating Techniques

## HF Transmitting

- CW Procedures & Abbreviations
  - Some common prosigns are:

| | |
|---|---|
| $\overline{AR}$ = End of Message | $\overline{BT}$ = Pause or Separator |
| $\overline{AS}$ = Wait | $\overline{SK}$ = End of Contact |
| $\overline{BK}$ = Break in Transmission | $\overline{SOS}$ = Distress Signal |

  - Prosigns are sent as a single character with no space between the letters.

97

# HF Operating Techniques

## HF Transmitting

- CW Procedures & Abbreviations
  - Q-Signals replace an entire sentence or phrase with a group of 3 letters beginning with “Q”.
    - Originally developed for the commercial radiotelegraph service. (circa 1909)
    - Add a “?” to change the statement to a question.

98

# HF Operating Techniques

| Q-Signal | Definition |
|---|---|
| QRL / QRL? | I am busy. / Are you busy?<br>This frequency is in use. / Is this frequency in use? |
| QRM / QRM? | I have interference. / Do you have interference? |
| QRN / QRN? | I am troubled by static. / Are you troubled by static? |
| QRO / QRO? | Increase power. / Shall I increase power? |
| QRP / QRP? | Decrease power. / Shall I decrease power? |
| QRQ / QRQ? | Send faster. / Shall I send faster? (Can add speed in wpm) |
| QRS / QRS? | Send more slowly.<br>Shall I send more slowly? (Can add speed in wpm) |
| QRT / QRT? | Stop sending. / Shall I stop sending? |
| QRV / QRV? | I am ready. / Are you ready? |

99

# HF Operating Techniques

| Q-Signal | Definition |
|---|---|
| QRX / QRX? | I will call you again at <time> on <freq>.<br>Shall I call you again at <time> on <freq>?<br>Also: Stand-By or Wait. |
| QRZ / QRZ? | <call> is calling you on <freq>. / Who is calling me? |
| QSB / QSB? | Your signals are fading. / Are my signals fading? |
| QSK / QSK? | I can hear you between my signals.<br>Can you hear me between your signals? |
| QSL / QSL? | I am acknowledging receipt. / Can you acknowledge receipt? |
| QST | Here is a broadcast message for all amateurs. |
| QSY / QSY? | Change frequency. / Shall I change frequency?<br>(Can add frequency or frequency offset.) |
| QTH / QTH? | My location is <location>. / What is your location? |

100

# HF Operating Techniques

HF Transmitting

- Phone Procedures
  - Similar to prosigns in CW, phone operators use prowords as procedural signals.
  - Some common prowords are:
    - Over – End of transmission and a reply is expected.
    - Out – End of transmission and no reply is expected.
    - Roger – I received your transmission correctly.

101

# HF Operating Techniques

HF Transmitting

- Phone Procedures.
  - Although intended for CW operation, the use of Q-signals is common in phone operations.
    - Purists will say that using Q-signals on phone is bad form, but the practice is now considered acceptable.
  - "10-Codes" should never be used in amateur radio operations.

102

**G2A10 -- Which of the following statements is true of voice VOX operation versus PTT operation?**

A. The received signal is more natural sounding
B. It allows "hands free" operation
C. It occupies less bandwidth
D. It provides more power output

103

**G2C01 -- Which of the following describes full break-in CW operation (QSK)?**

A. Breaking stations send the Morse code prosign “BK”
B. Automatic keyers, instead of hand keys, are used to send Morse code
C. An operator must activate a manual send/receive switch before and after every transmission
D. Transmitting stations can receive between code characters and elements

104

**G2C02 -- What should you do if a CW station sends "QRS"?**

A. Send slower
B. Change frequency
C. Increase your power
D. Repeat everything twice

105

**G2C03 -- What does it mean when a CW operator sends "KN" at the end of a transmission?**

A. No US stations should call
B. Operating full break-in
C. Listening only for a specific station or stations
D. Closing station now

106

**G2C05 -- What is the best speed to use answering a CQ in Morse Code?**

A. The fastest speed at which you are comfortable copying, but no slower than the CQ
B. The fastest speed at which you are comfortable copying, but no faster than the CQ
C. At the standard calling speed of 10 wpm
D. At the standard calling speed of 5 wpm

107

**G2C06 -- What does the term "zero beat" mean in CW operation?**

A. Matching the speed of the transmitting station
B. Operating split to avoid interference on frequency
C. Sending without error
D. Matching your transmit frequency to the frequency of a received signal.

108

**G2C08 -- What prosign is sent to indicate the end of a formal message when using CW?**

A. SK
B. BK
C. AR
D. KN

109

**G2C09 -- What does the Q signal "QSL" mean?**

A. Send slower
B. We have already confirmed the contact
C. I have received and understood
D. We have worked before

110

## G2C11 -- What does the Q signal “QRV” mean?

A. You are sending too fast
B. There is interference on the frequency
C. I am quitting for the day
D. I am ready to receive

111

## G4A10 -- What is the function of an electronic keyer?

A. Automatic transmit/receive switching
B. Automatic generation of dots and dashes for CW operation
C. To allow time for switching the antenna from the receiver to the transmitter
D. Computer interface for PSK and RTTY operation

112

# Emergency Operation

Overview

- Emergency operations are one of the basic purposes of the Amateur Radio Service.
- The ability to assist with emergencies is the primary reason that many individuals get their license.
- All amateurs should be prepared to respond properly if an emergency arises.

113

# Emergency Operation

ARES & RACES



114

# Emergency Operation

ARES & RACES

- Amateur Radio Emergency Service (ARES)
  - An organization of amateur operators who train to operate effectively during emergencies.
    - Part of the ARRL field organization.
  - Open to any amateur radio operator regardless of ARRL membership.
  - No official recognition in FCC rules.

115

# Emergency Operation

ARES & RACES

- Radio Amateur Civil Emergency Service (RACES)
  - A radio service which provides communications to government agencies for civil defense or disaster relief purposes.
    - Defined in section §97.407 of the FCC Rules.
    - Supports FEMA, SEMA, & local EMA.

116

# Emergency Operation

ARES & RACES

- Radio Amateur Civil Emergency Service (RACES)
  - RACES is not an organization.
  - Stations may only operate in RACES if authorized by EMA.
  - May be the only amateur radio operations permitted if the President's War Powers Act is invoked.

117

# Emergency Operation

ARES & RACES

- Radio Amateur Civil Emergency Service (RACES)
  - RACES tests or drills are necessary to assure systems are all working properly.
    - Tests or drills shall not exceed 1 hour per week unless special authorization is granted.
    - If authorized, tests may be conducted not more than twice per year for a total of 72 hours.

118

# Emergency Operation

Distress Calls

- Responding to a Distress Call.
  - Make certain that you are the station who can best handle the traffic.
  - Immediately acknowledge calling station.
  - Accurately copy information.
  - Notify proper authorities.
  - Stay in contact with calling station until help arrives.

119

# Emergency Operation

Distress Calls

- Placing a Distress Call.
  - Send the distress call proword or prosign 3 times.
    - Phone proword = MAYDAY
    - CW Prosign = SOS
  - Send your callsign 3 times.
    - On phone, use the ICAO phonetic alphabet.
  - Send the location & nature of the emergency.
  - End with the appropriate proword or prosign.
    - Phone proword = Over
    - CW prosign = K

120

# Emergency Operation

Distress Calls

- Placing a Distress Call.
  - During the existence of the emergency, you may use ANY frequency available without regard to radio service or license class.
  - During the existence of the emergency, you may contact ANY station without regard to radio service.

121

# Emergency Operation

Distress Calls

- Do what is necessary to accomplish communication & ask forgiveness later.
  - ANY frequency (not just amateur).
  - Contact ANY station (not just amateur).

122

**G2B02 -- What is the first thing you should do if you are communicating with another amateur station and hear a station in distress break in?**

A. Inform your local emergency coordinator
B. Acknowledge the station in distress and determine what assistance may be needed
C. Immediately decrease power to avoid interfering with the station in distress
D. Immediately cease all transmissions

123

**G2B09 -- Who may be the control operator of an amateur station transmitting in RACES to assist relief operations during a disaster?**

A. Only a person holding an FCC-issued amateur operator license
B. Only a RACES net control operator
C. A person holding an FCC-issued amateur operator license or an appropriate government official
D. Any control operator when normal communication systems are operational

124

**G2B11 -- How often may RACES training drills and tests be routinely conducted without special authorization?**

A. No more than 1 hour per month
B. No more than 2 hours per month
C. No more than 1 hour per week
D. No more than 2 hours per week

125

# Break

126

# General Class

# Chapter 6
# Digital Modes

127

## Basics of Digital Modes

Overview

- Exchange digital data via radio between two computing systems.
  - E-mail, files, keyboard-to-keyboard, messages, etc.
- New modes being developed all the time.
- More and more amateurs are using digital modes.

128

# Basics of Digital Modes

Overview

- Maximum data rates determined by FCC regulations.
- If you create your own digital code, you must make the protocol public.

129

# Basics of Digital Modes

Digital Voice & Image Modes

- Digital voice systems are considered voice modes by the FCC.
  - DMR, FreeDV, D-Star, SystemFusion, WinDRM, etc.
  - Operations in voice/image sections of the band.
- SSTV operations are converting from current analog systems to digital file transfers, but are still considered image modes.

130

# Basics of Digital Modes

Where to Find Digital Activity

- Restricted to CW/data segments of each band.
- Usually close to the top end of the CW segment, but check the band plan.
  - 160m -- bottom end of band.
  - 60m – center of each channel.
  - 10m – middle of CW segment.

131

# Basics of Digital Modes

| Band | Digital Mode Frequencies |
|---|---|
| 160m | 1.800 MHz to 1.810 MHz |
| 80m | 3.570 MHz to 3.600 MHz |
| 60m | Center of each channel. |
| 40m | 7.035 MHz to 7.045 MHz (ITU Regions 1 & 3)<br>7.080 MHz to 7.125 MHz (ITU Region 2) |
| 20m | 14.070 MHz to 14.0995 MHz (14.070 MHz = PSK31)<br>14.1005 MHz to 14.112 MHz |
| 17m | 18.100 MHz to 18.110 MHz |
| 15m | 21.070 MHz to 21.110 MHz |
| 12m | 24.920 MHz to 24.930 MHz |
| 10m | 28.070 MHz to 28.150 MHz |

132

# Basics of Digital Modes

Definitions

- Air link – That part of the system that transmits & receives digital signals.
- Bit – The fundamental unit of data.
  - 0 or 1
  - True or false.
  - Yes or no,
  - etc.

133

# Basics of Digital Modes

Definitions

- Bit rate – The number of bits sent per second.
- Baud – The number of symbols sent per second.
  - a.k.a. - Symbol rate.
- Duty cycle – The percentage of time that the transmitter is transmitting.

134

# Basics of Digital Modes

Definitions

- Protocol – A set of rules determining how the data is converted to audio tones for transmission.
- Mode – The combination of a protocol with a modulation method.
- MODEM – A device (or software algorithm) that converts data to tones & tones back to data.
  - Short for “modulator-demodulator”.

135

# Basics of Digital Modes

Bit Rate vs. Symbol Rate (baud)

- There is a lot of confusion between the terms bit rate and symbol rate.

136

## Basics of Digital Modes

Bit Rate vs. Symbol Rate (Baud)

- In simple coding methods there is 1 bit in each symbol.
  - Bit rate = symbol rate.
  - Baudot (RTTY), ASCII, etc.

137

## Basics of Digital Modes

Bit Rate vs. Symbol Rate (Baud)

- In more complex coding methods there are multiple bits in each symbol.
  - Bit rate > symbol rate.
  - MFSK16.
    - 4 bits per symbol.
    - Bit rate = 4 x symbol rate.

138

# Basics of Digital Modes

Frequency Shift Keying (FSK)

- Individual bits are assigned to different frequencies.
- The frequencies in 2-tone FSK are called “mark” and “space”.

139

# Basics of Digital Modes

Frequency Shift Keying (FSK)

- There are 2 main methods for generating an FSK signal:
  - FSK.
  - AFSK
    - Audio Frequency Shift Keying.

140

# Basics of Digital Modes

Frequency Shift Keying (FSK)

- FSK – The frequency of a transmitter's oscillator is changed to send the data.
- AFSK – The frequency of a tone modulating an SSB transmitter is changed to send the data.
  - If the SSB transmitter is properly adjusted, AFSK cannot be distinguished from FSK on the air.

141

# Basics of Digital Modes

Frequency Shift Keying (FSK)

- MFSK – More than 2 tones are used to send the data.
  - Must use AFSK if more than 2 tones.

142

# Basics of Digital Modes

## Frequency Shift Keying (FSK)

- Multiple frequency shift keying (MFSK).

| Mode | Number of Tones | Bandwidth |
|---|---|---|
| MFSK-32 | 32 | 500 Hz |
| MFSK-64 | 64 | 1 kHz |
| MT63-1KL | 64 | 1 kHz |
| MT63-2KL | 64 | 2 kHz |
| Olivia | 4 to 64 | 250 Hz to 2 kHz |

143

# Basics of Digital Modes

## Phase Shift Keying (PSK)

- A change in the phase of a tone or tones is used to send the data.
  - Most common type is inversion (180° phase shift).
  - Phase shift can be referenced to same signal at earlier point in time or to another tone.
  - Sounds like a raspy buzz or noise.

144

**G2E08 -- In what segment of the 20-meter band are most digital mode operations commonly found?**

A. At the bottom of the slow-scan TV segment, near 14.230 MHz
B. At the top of the SSB phone segment, near 14.325 MHz
C. In the middle of the CW segment, near 14.100 MHz
D. Between 14.070 MHz and 14.100 MHz

145

**G8A01 -- How is direct binary FSK modulation generated?**

A. By keying an FM transmitter with a sub-audible tone
B. By changing an oscillator's frequency directly with a digital control signal
C. By using a transceiver's computer data interface protocol to change frequencies
D. By reconfiguring the CW keying input to act as a tone generator

146

**G8C11 -- How are the two separate frequencies of a Frequency Shift Keyed (FSK) signal identified?**

A. Dot and Dash
B. On and Off
C. High and Low
D. Mark and Space

147

**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

148

# Character-Based Modes

Overview

- The simplest way method of sending digital information is one character at a time.
  - The transmitting operator types a character onto his computer's keyboard.
  - The receiving operator reads the character off of his computer's screen.

149

# Character-Based Modes

Overview

- The most popular character-based digital modes are:
  - Radioteletype (RTTY).
  - PSK31.

150

# Character-Based Modes

Radioteletype (RTTY)

- Oldest digital mode.
- Adapted from land-line teletype system (TELEX).
  - Frequency shift keying (FSK).
  - Audio frequency shift keying (AFSK).

151

# Character-Based Modes

Radioteletype (RTTY)

- 5-bit Baudot code.
  - Letters A-Z (no lower case).
  - Numbers 0-9.
  - Some punctuation.
  - Only 32 different codes (characters) possible.
    - Special FIGS & LTRS codes are used to switch between 2 sets of characters to allow 62 different characters.

152

# Character-Based Modes

Radioteletype (RTTY)

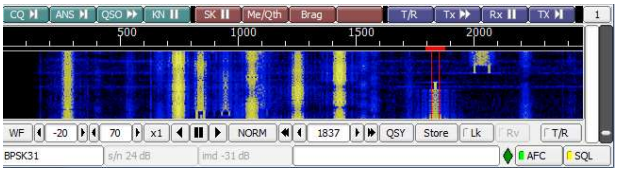
- The most common specifications used for amateur radio RTTY operations are:
  - Speed = 60 wpm (45.45 baud).
  - Frequency shift = 170 Hz.
    - The mark frequency is considered to be the operating frequency and is 170 Hz higher than the space frequency.
      - e.g. – If operating on 3590 kHz (mark frequency), then the space frequency is 3589.830 kHz

153

# Character-Based Modes

PSK31

- Phase shift keying.
- 31.25 baud.
- Narrowest bandwidth of any mode.
- Very effective in noisy conditions.




154

# Character-Based Modes

PSK31

- Special code.
  - Not all characters have the same number of bits (varicode).
  - More common characters have fewer numbers of bits.
  - Upper-case letters have more bits than lower-case.
    - Operators often type only in lower case.

155

# Character-Based Modes

PSK31

- Sideband sensitive.
  - Must select the correct sideband.
    - USB.

156

# Character-Based Modes

PSK31

- A variation of PSK31 is QPSK31.
  - Uses quadrature phase shift keying.
  - Two audio ones instead of one.
    - Four possible phase-shift variations.
    - Provides error correction.
  - Approximately the same bandwidth as PSK31

157

**G2E06 -- What is the most common frequency shift for RTTY emissions in the amateur HF bands?**

A. 85 Hz
B. 170 Hz
C. 425 Hz
D. 850 Hz

158

**G8A06 -- Which of the following is characteristic of QPSK31?**

A. It is sideband sensitive
B. Its encoding provides error correction
C. Its bandwidth is approximately the same as BPSK31
D. All these choices are correct

159

**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

160

**G8C08 -- Which of the following statements is true about PSK31?**

A. Upper case letters make the signal stronger
B. Upper case letters use longer Varicode signals and thus slow down transmission
C. Error Correction is used to ensure accurate message reception
D. Higher power is needed as compared to RTTY for similar error rates

161

**G8C12 -- Which type of code is used for sending characters in a PSK31 signal?**

A. Varicode
B. Viterbi
C. Volumetric
D. Binary

162

# Packet-Based Modes and Systems

Overview

- Character-based modes are prone to errors.
  - If an error occurs in a character, you may not know it, & it is lost forever.

163

# Packet-Based Modes and Systems

Overview

- Packet-based modes were developed to overcome this problem.
  - Groups of characters are organized into packets called “frames” before being transmitted.
  - Each packet contains extra information for error detection and/or correction.

164

# Packet-Based Modes and Systems

Overview

- Most packet-based modes are based on the same protocol used for sending data over the internet.
- As digital modes became more sophisticated, more processing power was required in the computer used to send/receive the data.

165

# Packet-Based Modes and Systems

Packet Basics

- All packet-based modes use the same basic structure for each frame which consists of the following 3 parts:
  - Header.
  - Data.
  - Trailer.

166

# Packet-Based Modes and Systems

Packet Basics

- Header.
  - The packet header contains the following information:
    - Synchronization bits.
      - Used to synchronize the receiving system with the data being transmitted.
    - Control & routing information.
    - Error detection/correction information.
      - Only some protocols.

167

# Packet-Based Modes and Systems

Packet Basics

- Data.
  - The data section contains the actual data being transmitted.
    - Typically a group of 128 or 256 ASCII characters.
    - May be compressed for efficiency.

168

# Packet-Based Modes and Systems

Packet Basics

- Trailer.
  - The trailer contains the following information:
    - Additional control & routing information.
    - Error detection/correction information.
      - Only some protocols.

169

# Packet-Based Modes and Systems

Packet Basics

- Error detection is usually accomplished by the use of a cyclic redundancy check (CRC).
  - The CRC is a value that is calculated on the rest of the data in the packet.
  - The receiving system performs the same calculation. If the results do not match, an error is known to have occurred.

170

# Packet-Based Modes and Systems

Packet Basics

- Error correction is accomplished by one of two methods:
  - Automatic Repeat Request (ARQ).
  - Forward Error Correction (FEC).

171

# Packet-Based Modes and Systems

Packet Basics

- ARQ.
  - If an error is detected, the receiving system asks the sending system to send the packet again.

172

# Packet-Based Modes and Systems

Packet Basics

- ARQ.
  - ARQ systems are designed to exchange information between 2 stations.
    - The receiving station has to acknowledge that each packet was received correctly.
    - Only one station can send the acknowledgement.
    - Cannot “break in” to QSO between stations using ARQ.

173

# Packet-Based Modes and Systems

Packet Basics

- ARQ.
  - Other stations can use monitor mode (MON) to “listen in” without having the benefits of error detection.
  - ARQ systems provide a “broadcast” or “unconnected” mode so that a station can announce its presence (call “CQ”).
    - APRS consists entirely of unconnected packets.

174

# Packet-Based Modes and Systems

Packet Basics

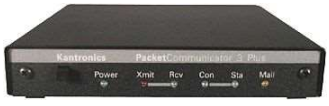
- FEC.
  - Additional information is sent in each packet which may allow the receiving system to re-construct the data if an error occurs.

175

# Packet-Based Modes and Systems

Packet Radio

- Oldest of “modern” digital modes.
  - Became widely popular in 1980’s.
  - Still popular on VHF.
    - 1200-9600 baud on 2m.
  - Not practical on HF.
    - Limited to 300 baud.
    - Very slow when band is busy, or conditions are noisy.





176

# Packet-Based Modes and Systems

Packet Radio

- Uses the AX.25 protocol.
  - Based on the ITU X.25 protocol used by the internet.

177

# Packet-Based Modes and Systems

Packet Radio

- Uses ARQ method of error correction.
  - Only works if the two stations are “connected”.
  - If an error is detected, the receiving station asks the transmitting station to send the packet again.
    - If too many attempts to receive the same packet fail, the connection is terminated.

178

## Packet-Based Modes and Systems

PACTOR

- RTTY was previously used in message handling but had no error handling capabilities.
- Teletype Over Radio (TOR) systems, such as AMTOR, were developed to overcome this shortcoming.
  - Short bursts of data are sent with error detection & correction data.

179

## Packet-Based Modes and Systems

PACTOR

- AMTOR was more reliable than RTTY but was slow.
- PACTOR (packet over radio), WINMOR, & VARA are faster than AMTOR and are used in the NTS digital message handling system.

180

# Packet-Based Modes and Systems

PACTOR

- Developed by Special Communications Systems GmBH.
- PACTOR I.
  - Uses FSK modulation.
  - Open technology → Relatively inexpensive modems.
    - $50.00 to $150.00.

181

# Packet-Based Modes and Systems

PACTOR

- PACTOR II, PACTOR III, & PACTOR IV.
  - Uses PSK modulation.
  - Proprietary technology → Very expensive modems.
    - $1000.00 to >$2000.00.
  - FCC regulations currently prohibit the use of PACTOR IV in the United States.

182

## Packet-Based Modes and Systems

PACTOR

- PACTOR requires the use of an external hardware modem.
- VARA uses the computer's soundcard & does not require a modem.
- PACTOR and VARA are the preferred modes for transferring large amounts of data over amateur radio and for the WINLINK system.
- Both use ARQ for error detection/correction.

183

## Packet-Based Modes and Systems

The Winlink System

- A world-wide system that uses gateways to connect to the internet for passing messages.
  - Radio-based e-mail.
  - File transfers.
  - The Winlink Express software can be used without an internet connection as a stand-alone mailbox for emergency operations.

184

# Packet-Based Modes and Systems

FT8 and WSPR

- The WSJT software suite provides several digital modes designed for weak signal communications.
  - FSK441 & JT6M – Meteor scatter.
  - JT65 – Earth-Moon-Earth (moonbounce).
  - FT8 & FT4 – Weak signal HF.
  - WSPR – Propagation experimentation.

185

# Packet-Based Modes and Systems

FT8 and WSPR

- Both FT8 and WSPR:
  - Use timed send/receive sequences.
    - The computer's internal clock must have an error of less than 1 second.
  - Use 8-tone FSK modulation.
  - Can decode signals 30 dB below the noise level.

186

# Packet-Based Modes and Systems

FT8 and WSPR

- FT8.
  - Sends & receives messages at specific times.
    - Maximum message length = 75 bits.
    - Messages are sent every 15 seconds at 0, 15, 30, & 45 seconds after the start of the minute.

187

# Packet-Based Modes and Systems

FT8 and WSPR

- FT8.
  - Messages normally limited to call sign, signal report, & grid locator.
  - FT8 signal reports are in signal-to-noise ratio instead of signal strength.
    - e.g. - A report of +3 indicates that the signal is 3dB over the noise in a 2.5 kHz bandwidth.

188

# Packet-Based Modes and Systems

## FT8 and WSPR

- FT8.
  - Common FT8 frequencies are:

| Band | Frequency | Band | Frequency |
|---|---|---|---|
| 160m | 1.840-1.847 MHz | 17m | 18.100-18.103 MHz |
| 80m | 3.573-3.576 MHz | 15m | 21.074-21.077 MHz |
| 40m | 7.074-7.077 MHz | 12m | 24.915-24.918 MHz |
| 30m | 10.136-10.139 MHz | 10m | 28.074-28.077 MHz |
| 20m | 14.074-14.077 MHz | 6m | 50.313-50.316 MHz |

189

# Packet-Based Modes and Systems

## FT8 and WSPR

- FT4.
  - A variation of FT8 developed for contesting & Dxpeditions.
    - Messages are sent every 7.5 seconds at 0, 7.5, 15, 22.6, 30, 37.5, 45, & 52.5 seconds after the start of the minute.

190

# Packet-Based Modes and Systems

FT8 and WSPR

- WSPR.
  - Used for propagation research & experimentation at very low signal-to-noise levels.
  - Does not support 2-way communications.
    - Essentially, a weak-signal beacon.
    - Receiving stations report back via a website.

191

# Packet-Based Modes and Systems

Amateur Wireless Networks

- Several WiFi frequencies overlap with amateur bands.
  - Amateurs have modified the firmware in commercial WiFi routers to create mesh networks.
    - Mesh networks have the advantage that if one node fails an alternative path may be found to transmit the data.

192

# Packet-Based Modes and Systems

AREDN (Amateur Radio Emergency Data Networks)

- Mesh networks are often used to support emergency operations or public service events.

193

## G2E02 -- What is VARA?

A. A low signal-to-noise digital mode used for EME (moonbounce)

B. A digital protocol used with Winlink

C. A radio direction finding system used on VHF and UHF

D. A DX spotting system using a network of software defined radios

194

**G2E04 -- Which of the following is good practice when choosing a transmitting frequency to answer a station calling CQ using FT8?**

A. Always call on the station's frequency
B. Call on any frequency in the waterfall except the station's frequency
C. Find a clear frequency during the same time slot as the calling station
D. Find a clear frequency during the alternate time slot to the calling station

195

**G2E07 -- Which of the following is required when using FT8?**

A. A special hardware modem
B. Computer time accurate to within approximately 1 second
C. Receiver attenuator set to -12 dB
D. A vertically polarized antenna

196

**G2E09 -- How do you join a contact between two stations using the PACTOR protocol?**

A. Send broadcast packets containing your call sign while in MONITOR mode
B. Transmit a steady carrier until the PACTOR protocol times out and disconnects
C. Joining an existing contact is not possible, PACTOR connections are limited to two stations
D. Send a NAK code

197

**G2E11 -- What is the primary purpose of an Amateur Radio Emergency Data Network (AREDN) mesh network?**

A. To provide FM repeater coverage in remote areas
B. To provide real time propagation data by monitoring amateur radio transmissions worldwide
C. To provide high-speed data services during an emergency or community event
D. To provide DX spotting reports to aid contesters and DXers

198

**G2E12 -- Which of the following describes Winlink?**

A. An amateur radio wireless network to send and receive email on the internet
B. A form of Packet Radio
C. A wireless network capable of both VHF and HF band operation
D. All of the above

199

**G2E13 -- What is another name for a Winlink Remote Message Server?**

A. Terminal Node Controller
B. Gateway
C. RJ-45
D. Printer/Server

200

**G2E15 -- Which of the following is a common location for FT8?**

A. Anywhere in the voice portion of the band
B. Anywhere in the CW portion of the band
C. Approximately 14.074 MHz to 14.077 MHz
D. Approximately 14.110 MHz to 14.113 MHz

201

**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

202

## G8A12 -- What is QPSK modulation?

A. Modulation using quasi-parallel to serial conversion to reduce bandwidth
B. Modulation using quadra-pole sideband keying to generate spread spectrum signals
C. Modulation using Fast Fourier Transforms to generate frequencies at the first, second, third, and fourth harmonics of the carrier frequency to improve noise immunity
D. Modulation in which digital data is transmitted using 0-, 90-, 180- and 270-degrees phase shift to represent pairs of bits

203

## G8C02 -- Which digital mode is used as a low-power beacon for assessing HF propagation?

A. WSPR
B. MFSK16
C. PSK31
D. SSB-SC

204

**G8C03 -- What part of a packet radio frame contains the routing and handling information?**

A. Directory
B. Preamble
C. Header
D. Trailer

205

**G8C05 -- In an ARQ mode, what is meant by a NAK response to a transmitted packet**

A. Request retransmission of the packet
B. Packet was received without error
C. Receiving station connected and ready for transmissions
D. Entire file received correctly

206

**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

207

**G8C07 -- Which of the following narrow-band digital modes can receive signals with very low signal-to-noise ratios?**

A. MSK144
B. FT8
C. AMTOR
D. MFSK32

208

## 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

209

## G8C10 -- How does forward error correction (FEC) allow the receiver to correct data errors?

A. By controlling transmitter output power for optimum signal strength
B. By using the Varicode character set
C. By transmitting redundant information with the data
D. By using a parity bit with each character

210

**G8C15 -- What does an FT8 signal report of +3 mean?**

A. The signal is 3 times the noise level of an equivalent SSB signal
B. The signal is S3 (weak signals)
C. The signal-to-noise ratio is equivalent to +3dB in a 2.5 kHz bandwidth
D. The signal is 3 dB over S9

211


## Receiving and Transmitting Digital Modes

Overview

- All digital modes except for RTTY are transmitted as USB signals.
  - When RTTY is sent using AFSK, it is transmitted as an LSB signal.
  - If you select the wrong sideband, select the wrong baud, or have the tones reversed, you will not be able to decode the transmission.

212

## Receiving and Transmitting Digital Modes

### Bandwidth of Digital Modes

- The FCC defines the bandwidth of digital signals the same as for any other mode.
- Bandwidth depends on symbol rate.
  - Higher symbol rate ➔ Wider bandwidth.
  - Some protocols can adjust symbol rate & bandwidth during a contact as conditions change.

213

## Receiving and Transmitting Digital Modes

### Bandwidth of Digital Modes

- Currently, the FCC rules limit symbol rate rather than bandwidth.
  - The maximum symbol rate on frequencies below 28 MHz is 300 baud.
  - The FCC is considering changes to this regulation.

214

# Receiving and Transmitting Digital Modes

## Bandwidth of Digital Modes

| Mode | Bandwidth |
|---|---|
| PSK31 | 50 Hz |
| FT8 | 50 Hz |
| RTTY | 200 Hz |
| MFSK16 | 300 Hz |
| JT65 | 350 Hz |
| DominoEX | 524 Hz |

| Mode | Bandwidth |
|---|---|
| Olivia | 1000 Hz |
| WINMOR | 1600 |
| MT63 | 2000 Hz |
| PACTOR-III | 2300 Hz |
| PACTOR-4 | 2300 Hz |

215

# Receiving and Transmitting Digital Modes

- Bandwidth of Digital Modes
  - Be aware of the band edges!
    - If running RTTY using AFSK, keep the VFO frequency at least 2.3 kHz above the lower limit of the data segment or band.
    - For other modes, keep VFO frequency below the upper limit of the data segment or band by an amount greater than the highest frequency being transmitted.
      - $< f_C + f_{BW}$

216

## Receiving and Transmitting Digital Modes

### Transmitter Duty Cycle

- Average power output of a transmitter depends on the duty cycle of the mode.
  - CW ≈ 40%
  - SSB ≈ 25-40%
  - AM ≈ 50%
  - FM = 100%
  - RTTY & Digital = 100%

217

## Receiving and Transmitting Digital Modes

### Transmitter Duty Cycle

- Most HF amateur transceivers are rated for Intermittent Commercial and Amateur Service (ICAS).
  - Cannot run at full power output for long transmissions without overheating.
  - Output power should be reduced to about 50% of rated output when operating RTTY or other digital modes to prevent damage.

218

## Receiving and Transmitting Digital Modes

### Digital Mode Signal Quality

- Same concerns as with SSB or CW for interfering with other nearby QSO's.
- Too much signal from soundcard to transmitter microphone input causes distortion.
  - Splatter & other spurious emissions.
  - Receiving station cannot decode signal.
  - Shows up as additional lines on receiving station's waterfall display.

219

## Receiving and Transmitting Digital Modes

### ALC and Digital Modes

- By design, ALC distorts the signal to avoid excessive power output.
  - Added distortion is an acceptable compromise for voice.
  - Added distortion is not acceptable for digital signals.
    - Signals are difficult to decode.
    - Generates spurious signals.
- Disable ALC or lower microphone gain so that ALC never activates.

220

**G2E01 -- Which mode is normally used when sending an RTTY signal via AFSK with an SSB transmitter?**

A. USB
B. DSB
C. CW
D. LSB

221

**G2E05 -- What is the standard sideband for JT65, JT9, FT4, or FT8 digital signal when using AFSK?**

A. LSB
B. USB
C. DSB
D. SSB

222

**G2E14 -- What could be wrong if you cannot decode an RTTY or other FSK signal even though it is apparently tuned in properly?**

A. The mark and space frequencies may be reversed
B. You may have selected the wrong baud rate
C. You may be listening on the wrong sideband
D. All these choices are correct

223

**G4A11 -- Why should the ALC system be inactive when transmitting AFSK data signals?**

A. ALC will invert the modulation of the AFSK mode
B. The ALC action distorts the signal
C. When using digital modes, too much ALC activity can cause the transmitter to overheat
D. All these choices are correct

224

**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

225

**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

226

**G8C13 -- What is indicated on a waterfall display by one or more vertical lines on either side of a data mode or RTTY signal?**

A. Long Path propagation
B. Backscatter propagation
C. Insufficient modulation
D. Overmodulation

227

# Digital Operating Procedures

Listen First

- Just like all other modes, listen first to make certain that the frequency is clear.
  - Look for signals on waterfall.

228

# Digital Operating Procedures

Initiating and Terminating Digital Contacts

- Terminating a contact in a key-to-keyboard QSO is essentially the same as a CW contact.
- Digital mode QSO's use the same procedures, prosigns, & Q-signals as CW contacts.

229

# Digital Operating Procedures

Initiating and Terminating Digital Contacts

- Calling CQ:
  - CQ CQ CQ de K9DUR K9DUR K9DUR
    CQ CQ CQ de K9DUR K9DUR K9DUR k
- Answering a CQ:
  - W9GWC W9GWC de K9DUR K9DUR K9DUR k

230

# Digital Operating Procedures

## Initiating and Terminating Digital Contacts

- Some digital modes are “connected” modes.
  - Packet, PACTOR, WINMOR, etc.
  - A specific “connect” message is sent to establish a connection between 2 stations.
  - A specific “disconnect” message is sent to end the contact & close the connection.
    - Connection may be closed automatically if excessive transmission attempts or timeout occurs.

231

# Digital Operating Procedures

## Initiating and Terminating Digital Contacts

- Gateway and mailbox stations.
  - An automatic message-handling system has been established to pass messages from origin to destination by automatic relay.
    - A gateway station transfers messages to or from the internet.
    - A mailbox station stores messages for pick up by the recipients at a later time.

232

# Digital Operating Procedures

## Initiating and Terminating Digital Contacts

- Gateway and mailbox stations.
  - A gateway or mailbox station listens until a station attempts to connect to it.
    - Contacts with automatically-controlled stations are initiated by sending a “CONNECT” message.
  - Most digital messaging stations are unmanned & operate under automatic control.

233

# Digital Operating Procedures

## Initiating and Terminating Digital Contacts

- Gateway and mailbox stations.
  - In the US, automatically-controlled digital stations are allowed on 6m or higher bands but are restricted to certain band segments on HF.
  - Your station may communicate with an automatically-controlled non-US station operating outside of the specified band segments, but your station must be under local or remote control.

234

# Digital Operating Procedures

During the Contact

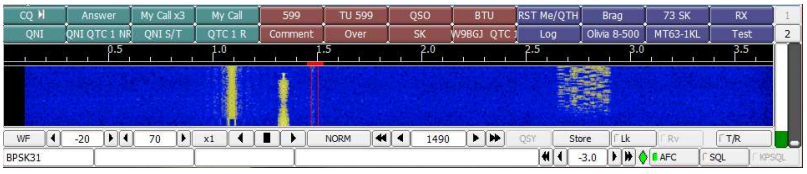
- Operating Displays.
  - Waterfall display.
    - A portion of the received RF spectrum is displayed as a horizontal line. The color and/or brightness of the line indicates the signal strength.
    - As each line is drawn, the previous line(s) are pushed down on the screen & the new line added at the top, giving the impression of a waterfall as the signals flow from top to bottom in the display.

235

# Digital Operating Procedures

During the Contact

- Waterfall Display




236

# Digital Operating Procedures

During the Contact

- Operating Displays.
  - Crossed ellipse display.
    - A more accurate display for RTTY signals.
      - When the two ellipses are at right angles to each other (vertical & horizontal), then signal is tuned in properly.
        - Size of ellipses indicates signal strength.
        - Unequal sizes indicates selective fading is occurring.

237

# Digital Operating Procedures

During the Contact

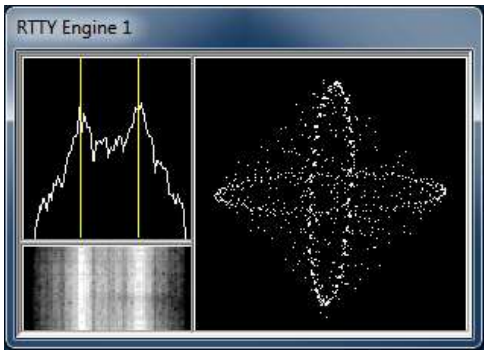
- Operating Displays.
  - Crossed ellipse display.
    - Many software programs provide the crossed-ellipse display in addition to the normal waterfall display.
      - Sometimes called “scope” (short for oscilloscope).

238

# Digital Operating Procedures

During the Contact

- RTTY Display




239

# Digital Operating Procedures

During the Contact

- Third-Party Traffic.
  - Same rules apply to digital messages as for voice or CW.
    - International messages only if third-party agreement exists.
  - Use of gateways must be carefully limited.

240

# Digital Operating Procedures

During the Contact

- Interfering Signals.
  - Like voice or CW signals, digital signals are subject to interference.
    - Human brain can recover CW or voice signals in presence of interference.
    - Digital software may not be able to decode the desired signal.

241

# Digital Operating Procedures

During the Contact

- Interfering Signals.
  - When using unconnected keyboard-to-keyboard modes, the user may be able to “fill in the blanks” in the received signal.
  - When using connected modes, the signal must get through in its entirety or the transmission fails.
    - Cannot establish a connection.
    - Frequent retries with resulting delays.
    - Timeouts or dropped connections.

242

**G1E03 -- What is required to conduct communications with a digital station operating under automatic control outside the automatic control band segments?**

A. The station initiating the contact must be under local or remote control
B. The interrogating transmission must be made by another automatically controlled station
C. No third-party traffic may be transmitted
D. The control operator of the interrogating station must hold an Amateur Extra class license

243

**G1E09 -- Under what circumstances are messages that are sent via digital modes exempt from Part 97 third-party rules that apply to other modes of communication?**

A. Under no circumstances
B. When messages are encrypted
C. When messages are not encrypted
D. When under automatic control

244

**G1E11 -- On what bands may automatically controlled stations transmitting RTTY or data emissions communicate with other automatically controlled digital stations?**

A. On any band segment where digital operation is permitted
B. Anywhere in the non-phone segments of the 10-meter or shorter wavelength bands
C. Only in the non-phone Extra Class segments of the bands
D. Anywhere in the 6-meter or shorter wavelength bands, and in limited segments of some of the HF bands

245

**G2E03 -- What symptoms may result from other signals interfering with a PACTOR or VARA transmission?**

A. Frequent retries or timeouts
B. Long pauses in message transmission
C. Failure to establish a connection between stations
D. All these choices are correct

246

**G2E10 -- Which of the following is a way to establish contact with a digital messaging system gateway station?**

A. Send an email to the system control operator
B. Send QRL in Morse code
C. Respond when the station broadcasts its SSID
D. Transmit a connect message on the station's published frequency

247

**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

248

**G8C14 -- 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

249

# Questions?

250


General License Class

# Next Week
# Chapter 3

## Rules & Regulations

251