





FCC Emission Designations and Terms

- Specified by ITU.
 - Either 3 or 7 characters long.
 - If 3 characters:
 - 1st Character = The type of modulation of the main carrier.
 - 2nd Character = The nature of the signal(s) modulating the main carrier.
 - 3rd Character = The type of information to be transmitted.
 - If 7 characters, add a 4-character bandwidth designator in front of the 3-character designator.









FCC Emission Designations and Terms

- 3-character designator examples:
 - A1A = CW.
 - A3E = Amplitude-modulated phone.
 - J3E = Single-sideband phone.
 - F3E = Frequency-modulated phone.
 - F1B = Radioteletype (RTTY) using FSK.
 - F2B = Radioteletype (RTTY) using AFSK.





FM/PM Modulation and Modulators

- The amount of frequency change is proportional to the amplitude of modulating signal.
 - This is called "deviation".
- The speed of the frequency change is equal to the frequency of the modulating signal.
- Need to understand 2 terms to fully describe an FM or PM signal.
 - Deviation Ratio.
 - Modulation Index.







FM/PM Modulation and Modulators

- Modulation index.
 - Modulation Index = $f_{\text{Dev}} / f_{\text{m}}$
 - f_{Dev} = Maximum frequency deviation.
 - $f_{\rm m}$ = Instantaneous modulating frequency.
 - The modulation index changes with the modulating frequency in an FM modulator.
 - The modulation index is constant in a PM modulator.
 - If the modulating frequency increases, then the deviation also increases.



E1C09 -- What is the highest modulation index permitted at the highest modulation frequency for angle modulation below 29.0 MHz?





E8B02 -- How does the modulation index of a phase-modulated emission vary with RF carrier frequency?

- A. It increases as the RF carrier frequency increases
- B. It decreases as the RF carrier frequency increases
- C. It varies with the square root of the RF carrier frequency
- D. It does not depend on the RF carrier frequency



E8B04 -- What is the modulation index of an FM phone signal having a maximum carrier deviation of plus or minus 6 kHz if the highest modulating frequency is 2 kHz?



- B. 3 C. 0.6
- D. 6
- D. 6



E8B06 -- What is the deviation ratio of an FM phone signal having a maximum frequency swing of plus or minus 7.5 kHz if the highest modulation frequency is 3.5 kHz?



- B. 0.214
- C. 0.47
- D. 47





Multiplexing.

- Multiplexing is transmitting multiple, independent signals on one carrier.
- There are two different types of multiplexing:
 - Frequency division multiplexing (FDM).
 - Time division multiplexing (TDM).





Multiplexing.

- Time-division multiplexing.
 - Signals are sampled & samples from each signal are interleaved in sequential time slots of a digital transmission.
 - D-Star.
 - DMR.
 - a.k.a. MOTOTRBO
 - Often used for telemetry.









Symbol Rate and Data Rate

- Data speeds.
 - There are 3 different values involved when describing the speed of a digital transmission.
 - Air link.
 - The speed that the data is transmitted over the air.
 - Data stream.
 - The speed that the data is transferred between the modem & the computer.
 - Data throughput.
 - The overall data transfer speed.





Symbol Rate and Data Rate

- The data rate may or may not equal the symbol rate.
 - RTTY or 1200 baud packet
 - 1 symbol = 1 bit.
 - Data Rate = Symbol Rate.
 - bps = baud
 - 9600 baud packet
 - 1 symbol = 2 bits.
 - Data Rate = 2 x Symbol Rate.
 - Bps = 2x baud













Protocols and Codes

- Control Operator Responsibilities.
 - When using digital modes, the transmitter & receiver are actually controlled by the computer.
 - It is still the responsibility of the control operator to avoid interfering with communications already in progress.

















- A. RTTY
- **B. PACTOR**
- C. MT63
- ➡ D. PSK31









Protocols and Codes

• ASCII.

- Maximum of 128 (2⁷) characters.
 - Both upper & lower case letters can be encoded.
 - 256 (2⁸) maximum characters (if 8 data bits).
 - The extra characters are often used to represent non-English alphabet letters
- A start bit is at the beginning of each character.
- One or two stop bit(s) are at the end of each character.









Protocols and Codes

- Gray code.
 - A code arranged so that only one bit changes between consecutive characters.
 - Often used in rotary encoders.
 - Less likelihood of errors occurring.
 - Easier to detect errors when they do occur.







Digital Modes

- Digital Signal Bandwidth.
 - The bandwidth required by a digital signal depends on the symbol rate & the shape of the transmitted waveform.
 - BW = B x K
 - B = The symbol rate in baud.
 - K = A factor relating to the shape of the keying envelope.





Digital Modes

- CW.
 - ITU designator = A1A.
 - Speed is usually expressed in words per minute (wpm).
 - The word "PARIS" is used as a standard for speed calculations.
 - The word "PARIS" contains 50 elements.
 - 50 elements in 60 seconds = 0.83 baud.
 - Baud = 0.83 x wpm = wpm / 1.2
 - The typical shape factor (K) for CW is 4.8.
 - BW = (wpm / 1.2) x 4.8 = 4 x wpm.











E8D04 -- What is the primary effect of extremely short rise or fall time on a CW signal?

- A. More difficult to copy
- B. The generation of RF harmonics
- C. The generation of key clicks
 - D. More difficult to tune





Digital Modes

- FSK/AFSK.
 - FSK = shifting the frequency of the oscillator (F1B or F1D).
 - AFSK = modulating an SSB transmitter with frequencyshifted tones (J1B or J1D).
 - AFSK with a properly adjusted SSB transmitter is not distinguishable from FSK.
 - BW = (K x Shift) + B.
 - Typical value for K is 1.2.
 - BW = (1.2 x 170) + 45.45 ≈ 250 Hz.







Digital Modes

- FSK/AFSK.
 - The original crossed-ellipse display was 2 ellipses shown on an oscilloscope screen.
 - The mark signal was fed to the horizontal input of the oscilloscope.
 - The space signal was fed to the vertical input of the oscilloscope.
 - The result was a pair of ellipses at right-angles to each other.
 - The receiver was tuned until the 2 ellipses were as close to vertical & horizontal as possible.













Digital Modes

- PSK.
 - G3PLX developed PSK31 for keyboard-to-keyboard communications.
 - PSK = phase-shift keying.
 - 31 = data rate (31.25 baud).
 - Uses a variable-length code (Varicode).
 - Most common characters have shortest code.
 - Uses 00 as a separator between characters.


E8C03 -- Why should the phase of a PSK signal be changed at the zero crossing of the RF signal?

- ➡ A. To minimize bandwidth
 - B. To simplify modulation
 - C. To improve carrier suppression
 - D. All these choices are correct

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Digital Modes

- Packet Radio and APRS.
 - The data to be sent is divided into blocks.
 - Usually 128 or 256 bytes long.
 - A header with addressing & other information is added before the data bytes.
 - A footer with error detection information is added after the data bytes
 - The header, data, & footer are sent in a single transmission called a "packet" or "frame".





















- Developed by Bob Bruniga, WB4APR.
- Standard packet transmission.
 - AX.25 protocol.
 - Uses unnumbered information (UI) frames.
- Standard frequency.
 - 144.390 MHz (North America)

















Digital Modes

- HF Packet.
 - Uses AX.25 protocol (same as VHF packet).
 - Mostly FSK at 300 baud.
 - VHF packet uses AFSK at 1200 baud.
 - Not well suited for HF propagation conditions.
 - Needs good conditions with minimal fading.
 - Higher data rate than RTTY, AMTOR, or PSK31 when conditions are good.

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E2D04 -- What technology is used for real-time tracking of balloons carrying amateur radio transmitters?

- A. FT8
- B. Bandwidth compressed LORAN
- ♦ C. APRS
 - D. PACTOR III













Digital Modes

- PACTOR.
 - PACTOR-I developed by DL6MAA & DK4FV.
 - Overcame shortcomings of AMTOR & HF packet.
 - Works well in weak-signal & high-noise conditions.
 - PACTOR-II, PACTOR-III, PACTOR-IV are used today.
 - Automatic repeat request (ARQ) is used to eliminate errors.
 - Adjusts speed ("trains") to match conditions.
 - PACTOR III up to 5 kbps data rates possible.
 - PACTOR IV- up to 10.5 kbps data rates possible.









- A. PSK31
- ➡ B. PACTOR
 - C. RTTY
 - D. AMTOR







Digital Modes

- WSJT-X Modes.
 - Developed by K1JT for weak-signal VHF/UHF work.
 - WSJT-X is a family of digital protocols.
 - Each protocol is designed for a particular type of operation.
 - Each protocol controls timing of transmitting and receiving data by synchronizing with the computer clock.
 - It is important that the computer clock is accurate (<1 sec).
 - Use a Network Time Protocol (NTP) service.
 - Windows Time, D4, etc.





Digital Modes

- WSJT-X Modes.
 - WSPR → Provides propagation reports.
 - Can decode signals with a S/N ratio of -25dB.
 - Stations with internet access upload their reports to an online database.
 - <u>http://packetreporter.info/pskmap.html</u>
 - Does NOT support keyboard-to-keyboard communications.





Digital Modes

- WSJT-X Modes.
 - JT65 \rightarrow VHF moonbounce (EME) & HF QRP.
 - Multi-tone AFSK.
 - Stations alternate transmissions at 1-minute intervals.
 - Will copy signals below the noise level without error!
 - Q65 \rightarrow VHF moonbounce (EME).
 - Same as JT65 except multiple receive cycles are averaged to improve performance.





Digital Modes

- WSJT-X Modes.
 - FT4 Adapted for contests & DXpeditions.
 - A modification of the FT-8 protocol.
 - Transmits a 4-tone FSK continuous phase signal.
 - Stations transmit at 7.5-second intervals, & it takes about 30 seconds for a complete contact.



























Digital Modes

- OFDM Modulation.
 - Many advanced digital modes use multiple tones to encode the data.
 - PACTOR, MFSK-16, MT-63, etc.
 - The multiple tones can interfere with each other, making decoding difficult.
 - To reduce this interference, a technique called orthogonal frequency division multiplexing (OFDM) is used.



E8B07 -- Orthogonal frequency-division multiplexing (OFDM) is a technique used for which types of amateur communication?

- A. Digital modes
 - B. Extremely low-power contacts
 - C. EME
 - D. OFDM signals are not allowed on amateur bands









Digital Modes

- Transmitting digital mode signals.
 - In addition to transmitted signal quality, there are other reasons that a station may not be able to decode your signals.
 - Wrong frequency.
 - Wrong protocol.
 - Interference from an unheard station.





- A. Signal-to-noise ratio
- B. Baud error rate
- C. Repeat Request Rate (RRR)
- D. Intermodulation Distortion (IMD)

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Spread Spectrum Techniques

- Spreading a signal out over a wide bandwidth has the following advantages:
 - Spread spectrum signal sounds like low-level broadband noise to a conventional receiver.
 - Strong on-frequency conventional signals are ignored by a spread-spectrum receiver.
 - By using different spreading algorithms, several different signals can share the same band of frequencies without interfering with each other.




















- A. If interference is detected by the receiver, it will signal the transmitter to change frequencies
- B. RF signals are clipped to generate a wide band of harmonics which provides redundancy to correct errors
- C. A binary bit stream is used to shift the phase of an RF carrier very rapidly in a pseudorandom sequence
- D. Rapidly varying the frequency of a transmitted signal according to a pseudorandom sequence





Digital Protocols and Modes

Spread Spectrum Techniques

- Amateur Spread Spectrum Applications.
 - When a node is activated in an amateur radio mesh network, discovery and link establishment protocols are used which are similar to those used by commercial wireless data networks.
 - Addressing is via Internet Protocol (IP) addresses.
 - Messages cannot be encrypted to obscure meaning.

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E1F09 -- Which of the following cannot be transmitted over an amateur radio mesh network?
A. Third party traffic
B. Email
C. Messages encoded to obscure their meaning
D. All these choices are correct























Amateur Television

Amateur Television

- Fast-Scan Television.
 - ATV transmissions can be either AM or FM.
 - AM Television.
 - Bandwidth = 4 MHz to 6 MHz.
 - Can receive using a standard cable TV convertor.
 - FM.
 - Bandwidth = 17 MHz to 21 MHz.
 - Can receive using a Part 15 TV device on 2.4 GHz.





Amateur Television

Amateur Television

- Fast-Scan Television.
 - Most ATV signals use the same standards used by analog commercial broadcast television stations.
 - NTSC in North America.
 - PAL or SECAM in other parts of the world.
 - Many amateurs are migrating to the newer digital TV (DATV) standards.









Amateur Television

Amateur Television

- Fast-Scan Television.
 - Video Signal Definitions.
 - In analog ATV, the video image is converted to a series of horizontal lines by a technique called "scanning".
 - In the NTSC standard, an image is converted into 525 lines called a "frame".
 - Each frame is sent in 2 pieces called "fields".
 - The scanning speed is 30 frames per second or 60 fields per second.





















E2B07 -- Which types of modulation are used for amateur television DVB-T signals?

- A. FM and FSK
- B. QAM and QPSK
 - C. AM and OOK
 - D. All these choices are correct







E2B05 -- Which of the following describes the use of vestigial sideband in analog fast-scan TV transmissions?

- A. The vestigial sideband carries the audio information
- B. The vestigial sideband contains chroma information
- C. Vestigial sideband reduces the bandwidth while increasing the fidelity of low frequency video components
 - D. Vestigial sideband provides high frequency emphasis to sharpen the picture









Amateur Television

Amateur Television

- Slow-Scan Television.
 - Still images.
 - SSTV may be transmitted on any frequency where phone transmissions are allowed.
 - The bandwidth must not exceed that required for normal voice transmissions (~3kHz).
 - The most popular SSTV frequency is 14.230 MHz.
 - SSTV transmissions have a 100% duty cycle.





- Specific tone frequencies are used for horizontal and vertical sync pulses.
 - The sync pulse frequencies are below the black frequency.















E2B11 -- What is the function of the vertical interval signaling (VIS) code sent as part of an SSTV transmission?

- A. To lock the color burst oscillator in color SSTV images
- ➡ B. To identify the SSTV mode being used
 - C. To provide vertical synchronization
 - D. To identify the call sign of the station transmitting







E2B09 -- What kind of receiver can be used to receive and decode SSTV using the Digital Radio Mondiale (DRM) protocol?



- C. AM
- ➡ D. SSB





Amateur Extra Class

Next Week Chapter 9 Antennas and Feedlines