CHAPTER 8 MODULATION, PROTOCOLS, AND MODES

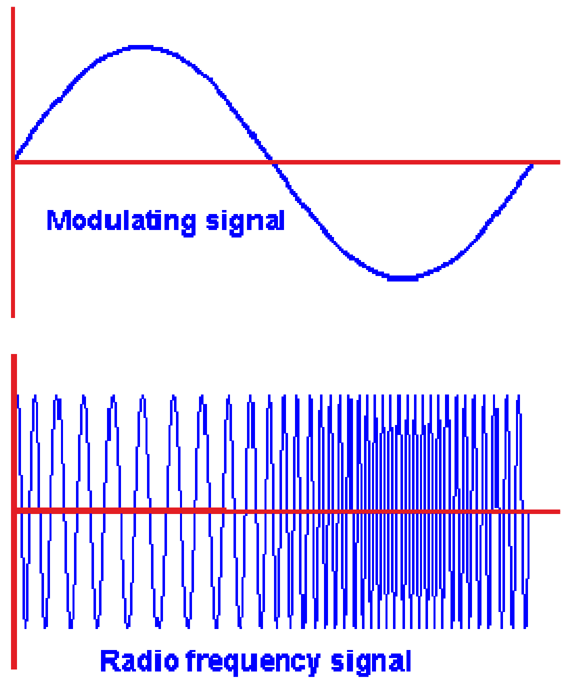
8.1 MODULATING SYSTEMS (page 8-1)

This chapter is on FM (Frequency Modulation) and similar systems.

FCC EMISSION DESIGNATIONS AND TERMS (page 8-1)

EMISSION TYPES (page 8-3)

FM/PM MODULATION AND MODULATORS (page 8-3)



Frequency modulation, FM is widely used for a variety of radio communications applications. FM broadcasts on the VHF bands still provide exceptionally high quality audio, and FM is also used for a variety of forms of two way radio communications, and it is especially useful for mobile radio communications.

The most obvious method of applying modulation to a signal is to superimpose the audio signal onto the amplitude of the carrier. However this is by no means the only method which can be employed. It is also possible to vary the frequency of the signal to give frequency modulation or FM. It can be seen that the frequency of the signal varies as the voltage of the modulating signal changes.

With frequency modulation the frequency of the carrier changes by the amplitude of the modulating signal. Both the amplitude and frequency of the modulating frequency are allowed to vary.

The amount by which the carrier frequency varies is very important. This is known as the deviation and is normally quoted as the number of kilohertz deviation. As an example the carrier may have a deviation of ±3 kHz. In this case the carrier is made to move up and down by 3 kHz.

Peak RF deviation is defined as half the difference between the maximum and minimum carrier frequencies. That is a, a sine wave modulating signal will cause the carrier frequency to move symmetrically higher and lower about the center carrier frequency. If maximum RF deviation is specified as ±5 kHz, a total difference of 10 kHz between maximum and minimum carrier frequency, the peak RF deviation is one-half of 10 KHz, or 5 kHz.

The level of RF deviation is important in many aspects. It obviously is important in determining the bandwidth of the overall signal. As a result the RF deviation used for FM is different between different applications. Broadcast stations in the VHF portion of the frequency spectrum between 88.5 and 108 MHz use large values of RF deviation, typically ±75 kHz. This means that the RF carrier is modulated 150 kHz. Leaving a 25 kHz buffer above the highest and below the lowest frequency to reduce interaction with other channels, a 200 kHz allotment is allowed for each wideband FM transmission. (Wideband FM is used for FM broadcasting, in which music and speech are transmitted with 75 kHz RF deviation from the center frequency and carry audio with up to a 20-kHz bandwidth. Deviation Ratio = 75 kHz / 20 kHz = 3.75. See the next page.)

While most of the energy of the FM signal is contained within the bandwidth, it can be shown by Fourier analysis that a wider range of frequencies is required to precisely represent an FM signal. The frequency spectrum of an actual FM signal has components extending infinitely, although their amplitude decreases and higher-order components are often neglected in practical design problems.

Peak deviation is usually controlled by setting the audio gain control in the FM modulator's circuit. Because it is fixed for that transmitter, there is no microphone gain control on an FM transmitter's front panel.

DEVIATION RATIO (page 8-3)

In an FM system, the ratio of the maximum frequency deviation to the highest modulation frequency is called the deviation ratio. The deviation ratio is a constant value for a given modulation and transmitter. This is a definition of the transmitter.

$$\text{Deviation Ratio} = \frac{\mathbf{D_{max}}}{\mathbf{M}} = \frac{\text{peak deviation in hertz}}{\text{maximum modulating frequency in hertz}}$$

Question E8B09: What is meant by deviation ratio?
Answer: The ratio of the maximum carrier frequency deviation to the highest audio modulating frequency

EXAMPLE 8.1

In the case of narrow-band FM (the type used in amateur analog FM voice communications); peak deviation at 100% modulation is defined as 5 kHz (or less). What is the deviation ratio if the maximum modulating frequency is 3 kHz?

$$\text{Deviation Ratio} = \frac{\mathbf{D_{max}}}{\mathbf{M}} = \frac{5\text{ kHz}}{3\text{ kHz}} = 1.666666667$$

Question E8B05: What is the deviation ratio of an FM-phone signal having a maximum frequency swing of plus-or-minus 5 kHz when the maximum modulation frequency is 3 kHz?
Answer: 1.67

EXAMPLE 8.2

If the maximum deviation of an FM transmitter is 7.5 kHz and the maximum modulating frequency is 3.5 kHz, what is the deviation ratio?

$$\text{Deviation Ratio} = \frac{\mathbf{D_{max}}}{\mathbf{M}} = \frac{7.5\text{ kHz}}{3.5\text{ kHz}} = 2.142857143$$

Question E8B06: What is the deviation ratio of an FM-phone signal having a maximum frequency swing of plus or minus 7.5 kHz when the maximum modulation frequency is 3.5 kHz?
Answer: 2.14

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MODULATION INDEX (page 8-4)

The ratio of the maximum signal frequency deviation to the instantaneous modulating frequency is called the modulation index. Modulation index is a measure of the relationship between deviation and the modulating signal's frequency.

Here is just some more information for fun. Let us take another look at a FM broadcasting radio station. The bandwidth of the modulation signal is from 30 Hz to 15 kHz which is excellent for high-fidelity broadcast. The maximum deviation set by the FCC, $D_{(max)}$, is 75 kHz. The range of the modulation index is:

For minimum modulation index:

Modulation $Index_{(min)} = D_{(max)}$ / Modulation $Frequency_{(max)}$ = 75 kHz / 15 kHz = 5 (for modulation freq. = 15 kHz)

For maximum modulation index:

Modulation $Index_{(max)} = D_{(max)}$ / Modulation $Frequency_{(min)}$ = 75 kHz / 30 Hz = 2,500 (for modulation freq. = 30 Hz)

Note that the modulation index changes a lot with the modulation frequency (from 5 to 2,500).

I have read a lot about Modulation Index and I just have to say, you should learn to figure it and pass the exam.

In question E8B01 they leave out the word "peak" and replace it with "frequency". Also they replace the phase "in hertz at any given frequency" with the phase "of its corresponding FM phone signal."

$$\text{Modulation Index} = \frac{\mathbf{D_{max}}}{\mathbf{m}} = \frac{\text{peak deviation in hertz}}{\text{modulating frequency in hertz at any given instant}}$$

Question E8B01: What is the term for the ratio between the ~~frequency~~ *peak* deviation of an RF carrier wave and the modulating frequency ~~of its corresponding FM-phone signal~~ *in hertz at any given frequency*?
Answer: Modulation index

EXAMPLE 8.3

If the peak deviation of an FM transmitter is 3000 Hz, what is the modulation index when the carrier is modulated by a 1000 Hz sine wave?

$$\text{Modulation Index} = \frac{\mathbf{D_{max}}}{\mathbf{m}} = \frac{3000\text{ Hz}}{1000\text{ Hz}} = 3$$

Question E8B03: What is the modulation index of an FM-phone signal having a maximum frequency deviation of 3000 Hz either side of the carrier frequency when the modulating frequency is 1000 Hz?
Answer: 3

EXAMPLE 8.4

If the peak deviation of an FM transmitter is 6 kHz, what is the modulation index when the carrier is modulated by a 2 kHz sine wave?

$$\text{Modulation Index} = \frac{\mathbf{D_{max}}}{\mathbf{m}} = \frac{6\text{ kHz}}{2\text{ kHz}} = 3$$

Question E8B04: What is the modulation index of an FM-phone signal having a maximum carrier deviation of plus or minus 6 kHz when modulated with a 2 kHz modulating frequency?
Answer: 3

By contrast, in a phase modulator, deviation increases with the modulation frequency. If the modulating signal amplitude stays constant, the modulation index in this modulator will also remain constant.

Question E8B02: How does the modulation index of a phase-modulated emission vary with RF carrier frequency (the modulated frequency)?
Answer: It does not depend on the RF carrier frequency

I guess that I do not understand this question because if the modulation index is one or below then the "**m**" (modulating frequency in hertz at any given instant) must equal or exceed the "$\mathbf{D_{max}}$" (peak deviation in hertz). So remember the FCC says the answer is 1.

Question E1B07: What is the highest modulation index permitted at the highest modulation frequency for angle modulation below 29.0 MHz?
Answer: 1.0

MULTIPLEXING (page 8-5)

The term Multiplexing means to combine more than one stream of information into one modulated signal. There are two common methods of multiplexing, frequency division multiplexing (FDM) and time division multiplexing (TDM).

FDM (Frequency Division Multiplexing) uses more than one [Two or more] subcarrier [information streams], each modulated by a separate analog signal. The subcarriers are combined [merged] into a single baseband signal and used to modulate the RF carrier [transmitter]. (Think of elevator music on top of a FM radio station.)

Question E8B10: What describes frequency division multiplexing?
Answer: Two or more information streams are merged into a baseband, which then modulates the transmitter

TDM (Time Division Multiplexing) is the transmission of two or more signal over a common channel by interleaving so that the signals occur in different, discrete time slots of digital transmission. (Think of D-STAR.)

Question E8B11: What is digital time division multiplexing?
Answer: Two or more signals are arranged to share discrete time slots of a data transmission

CHAPTER 8 MODULATION, PROTOCOLS, AND MODES

8.2 DIGITAL PROTOCOLS AND MODES (page 8-6)

SYMBOL RATE, DATA RATE, AND BEAMWIDTH (page 8-6)

The symbol rate or baud rate is the rate at which the transmitted signal changes

Question E8C02: What is the definition of symbol rate in a digital transmission?
Answer: The rate at which the waveform of a transmitted signal changes to convey information

Question E8C11: What is the relationship between symbol rate and baud?
Answer: They are the same

DATA RATE VERSES SYMBOL RATE

Data rate does not always match symbol rate. For example, a 9600 bps (bits per second) modem (data rate) used to send high-speed packet data actually sends symbols across the air link at 4800 baud (symbol rate.)

PROTOCOLS AND CODES (page 8-7)

Specific segments of each amateur band are designated for stations that operate under fully automated control which can even change bands in search of the station being sought.

Question E2E12: Which type of control is used by stations using the Automatic Link Enable (ALE) protocol?
Answer: Automatic

CODES (page 8-8)

A code is the method, or set of rules, by which information is converted to and from digital data. Amateur radio uses three common types of codes: varicodes (more and PSK31) BAUDOT, and ASCII. The individual symbols that make up a specific code are its elements.

MORSE AND VERICODE (page 8-8)

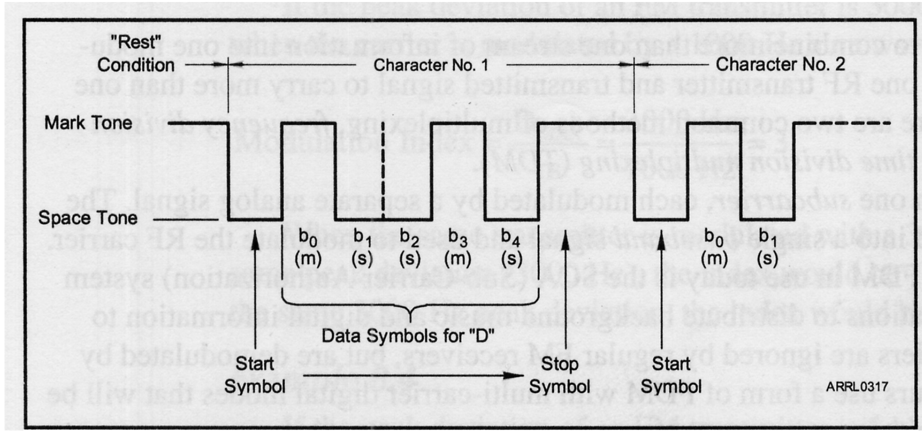
The elements of the PSK31 varicode are the same length but its characters have different lengths with the most-common text character E being the shortest, similarly to Morse code.

Question E2E09: Which of the following HF digital modes uses variable-length coding for bandwidth efficiency?
Answer: PSK31

CHAPTER 8 MODULATION, PROTOCOLS, AND MODES

BAUDOT (page 8-8)

The BAUDOT code is used by RTTY systems. It has two elements – mark and space – each the same length. The code is made up of different combinations of five mark and space elements. There are also framing elements called start and stop bits at the beginning and end of the group of five that represents the characters. These allow the receiving system to synchronize itself with the transmitted codes. A complete received character is called a frame.



ASCII (page 8-8)

ASCII stands for American National Standard Code For Information Interchange and is the most commonly used code in the computer systems. ASCII uses more bits than BAUDOT which makes it possible to include upper-case and lower-case letters, numbers, punctuation and special control characters. BAUDOT uses a shift code to shift between letters and figures. ASCII also has framing bits.

Question E8D11: What is one advantage of using ASCII code for data communications?
Answer: It is possible to transmit both upper and lower case text

Some ASCII codes have a parity bit. The system can set the parity bit so that the transmitted character has an even or odd number of bits with a value of one. The receiving system checks the number of 1s in the received character. If it does not match the system convention of odd or even, the receiving system knows an error has occurred during transmission-reception and it can reject the character.

Question E8D12: What is the advantage of including a parity bit with an ASCII character stream?
Answer: Some types of errors can be detected

Some of the differenced between BAUDOT and ASCII:
BAUDOT uses 5 data bits per character; ASCII uses 7 or 8;
BAUDOT uses 2 characters as letters/figures shift codes; ASCII has no letters/figures shift code

Question E8D10: What are some of the differences between the Baudot digital code and ASCII?
Answer: Baudot uses 5 data bits per character, ASCII uses 7 or 8; Baudot uses 2 characters as letters/figures shift codes, ASCII has no letters/figures shift code

GRAY CODE (page 8-9)

One would use Gray Code when one wants the number of bits that change to be only one bit at a time. Gray Codes are most commonly encountered as the digital values from rotary encoders like the frequency knob on the front of radios. See table 8.2 on page 8-9 of the manual.

Question E8C09: Which is the name of a digital code where each preceding or following character changes by only one bit?
Answer: Gray code

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DIGITAL MODE CHARACTERISTICS (page 8-10)

DIGITAL SIGNAL BANDWIDTHS (page 8-10)

In Amateur Radio, certain simplifications can be made, so that the equations for necessary signal bandwidth, generally takes this form:

BW (bandwidth) = B (speed of transmission in baud) × K (factor relating to the shape of the keying envelope)

CW (page 8-10)

Suppose you are sending Morse code at a speed of 13 WPM (words per minute).

The ITU uses a value of 0.8 for the conversion between baud and WPM. The ITU uses a value of 5 for K on HF.

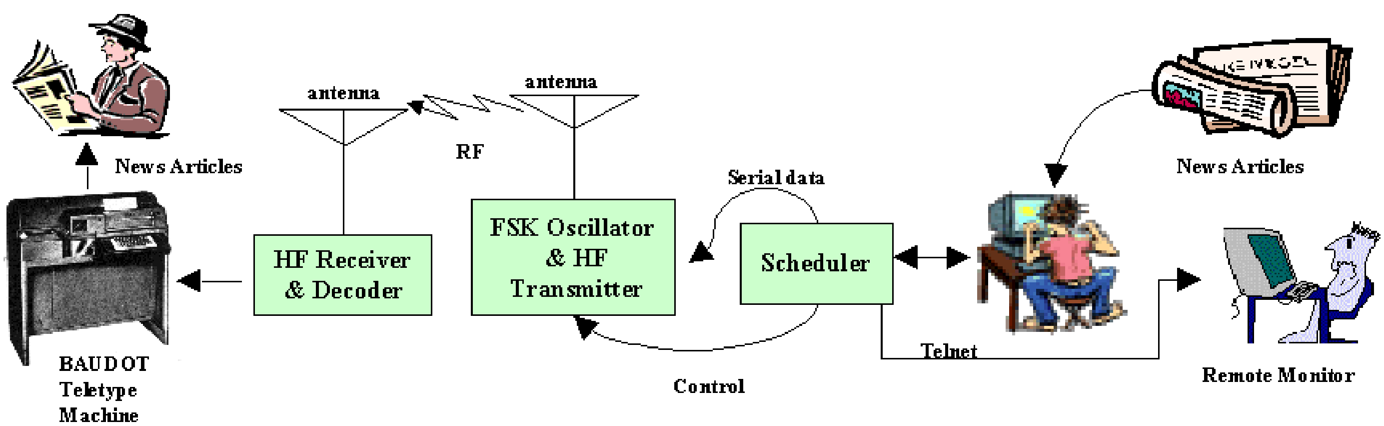
$$BW = B \times K = (WPM \times 0.8) \times 5 = (13 \times 0.8) \times 5 = 10.4 \times 5 = 52$$

Question E8C05: What is the necessary bandwidth of a 13-WPM international Morse code transmission?
Answer: Approximately 52 Hz

Hard keying waveforms with extremely short rise and fall times cause key clicks.

Question E8D04: What is the primary effect of extremely short rise or fall time on a CW signal?
Answer: The generation of key clicks

Here is a cool picture of a BAUDOT transmission used for RTTY. Notice that the flow is backward from normal. (This illustration is here because there was some space,)



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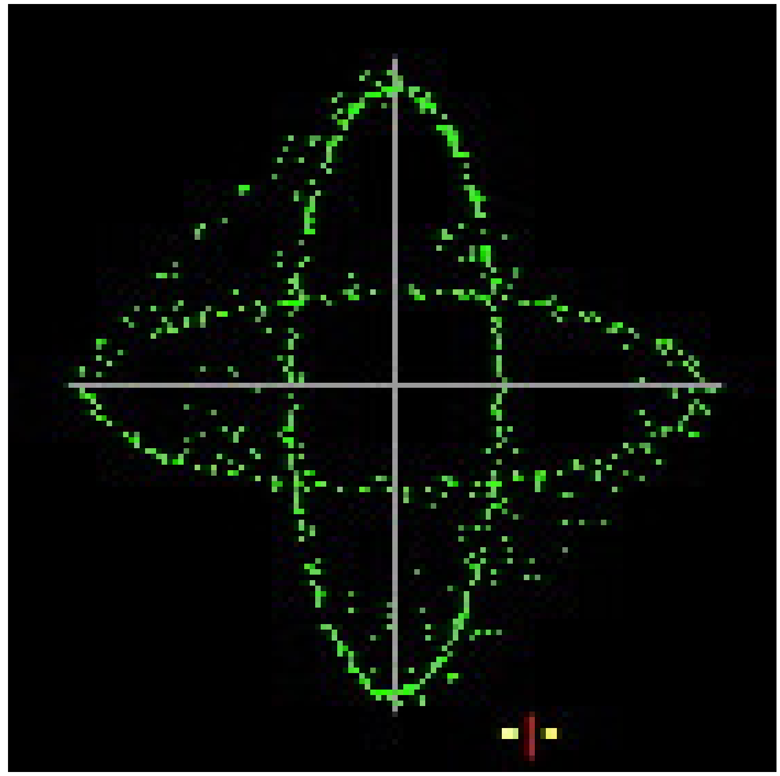
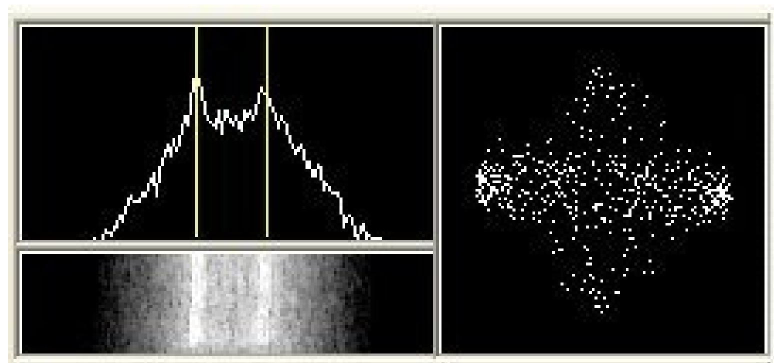
FSK/AFSK (page 8-11)



In FSK (Frequency Shift Keying) systems, the transmitter uses one frequency to represent one state and another frequency to represent the other state. By shifting between these two frequencies (called the mark and space frequencies), the transmitter creates data symbols.

The upper picture, on the right, shows an oscilloscope pattern, of the amplitude, of the two frequencies, one driving the vertical sweep and the other driving the horizontal sweep



The lower picture, on the right, shows a combination of three images. The picture on the upper left is a spectrum analysis with the two humps being the two frequencies for mark and space codes. The picture below the spectrum is a waterfall showing bright lines for the two frequencies. The waterfall has the most recent activity at the top and the signals flow down just like a waterfall. The picture to the right of the waterfall is again the standard "cross" of a properly tuned FSK signal.

Most amateur **data** transmission (AND ALL OF THOSE ON THE HF BANDS) employ frequency shift keying (FSK).

Question E2E01: Which type of modulation is common for data emissions below 30 MHz?
Answer: FSK

Direct FSK is created by shifting a transmitter oscillator's frequency (VFO – Variable Frequency Oscillator) with a digital signal. The difference between the mark frequency and the space frequency is called the shift. (Audio FSK or AFSK is created by injecting two audio tones, separated by the correct shift, into the microphone input of a single-sideband transmitter.)

Question E2E11: What is the difference between direct FSK and audio FSK?
Answer: Direct FSK applies the data signal to the transmitter VFO

CHAPTER 8 MODULATION, PROTOCOLS, AND MODES

Remember the Bandwidth: formula:

BW (bandwidth) = B (speed of transmission in baud) × K (factor relating to the shape of the keying envelope)

$$BW = B \times K$$

Now for FSK we have a different formula:

BW (bandwidth) = B (speed of transmission in baud) + (K × Frequency shift in hertz)

$$BW_{FSK} = B + (K \times Shift)$$

For FSK, the emission mode is J2D, and for AFSK, the emission mode is F1D, for either mode the value of K is 1.2.

EXAMPLE 8.5

What is the bandwidth of a 170-Hz shift, 300 baud ASCII signal transmitted as a J2D emission?

$$BW = 300 + (1.2 \times 170) = 300 + 204 = 504 \text{ Hz} = 0.504 \text{ kHz}$$

Question E8C06: What is the necessary bandwidth of a 170-hertz shift, 300-baud ASCII transmission?
Answer: 0.5 kHz

EXAMPLE 8.6

What is the bandwidth of a 4800-Hz shift, 9600 baud ASCII signal transmitted as a F1D emission?

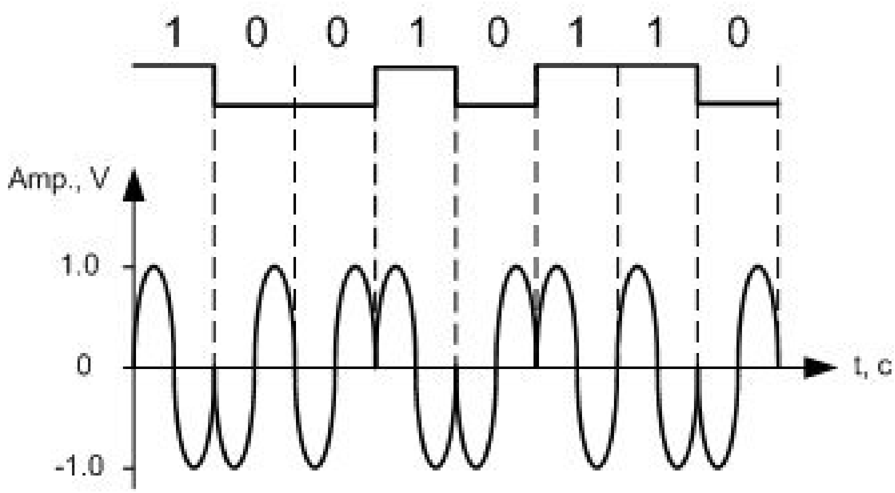
$$BW = 9600 + (1.2 \times 4800) = 9600 + 5769 = 15{,}360 \text{ Hz} = 15.360 \text{ kHz}$$

Question E8C07: What is the necessary bandwidth of a 4800-Hz frequency shift, 9600-baud ASCII FM transmission?
Answer: 15.36 kHz

PSK (page 8-12)

PSK or Phase Shift keying used here is not a direct modification of the carrier frequency, as the manual says, but the modification of an audio tone. The PSK modified audio tone is then transmitted according to the mode desired – FM, SSB, etc.

With Phase Shift Keying the modulating signal is a binary signal operating at the same frequency and in sync with the audio tone. That way the phase shift occurs only when the AUDIO signal crosses zero.
The picture on the right shows a phase shift of



Phase shift keying (PSK)

180°. More complicated system use different phase shift like 90° or 45°. PSK31 can be created by a computer sound card and sent directly in to the microphone input on your transmitter.

Here we are interested in PSK31. The name is derived from the modulation type, which is phase shift keying (PSK), and the data rate which is actually 31.25 baud. This is a real-time keyboard-to-keyboard QSO (a conversation between amateur radio operators.) PSK31 uses a Varicode code set. I am not going to describe the 255 character code set here. BAUDOT and ASCII use framing bits to distinguish characters. PSK31 does this by using the code "00".

To repeat, the bandwidth of PSK31 signals in minimized by the special sinusoidal shaping of the transmitted data symbols and by making shifting of the modulation's phase only when the RF carrier signal (they say RF carrier signal in the manual and use RF carrier in the question even though we know that it is the audio tone that is modified) crosses zero voltage.

Question E8C03: When performing phase shift keying, why is it advantageous to shift phase precisely at the zero crossing of the RF carrier?
Answer: This results in the least possible transmitted bandwidth for the particular mode

Question E8C04: What technique is used to minimize the bandwidth requirements of a PSK31 signal?
Answer: Use of sinusoidal data pulses

The emission designator for PSK31 is J2B and the K factor is 1.2.

Here we go with band width again:

BW (bandwidth) = B (speed of transmission in baud) × K (factor relating to the shape of the keying envelope)

$$BW = B \times K$$

$$BW = 31.25 \times 1.2 = 37.5 \text{ Hz}$$

With a bandwidth of 37.5 Hz, PSK31 has the narrowest of all HF digital modes used by amateurs, including being narrower than CW mode.

Question E2E10: Which of these digital modes has the narrowest bandwidth?
Answer: PSK31

<u>HF PACKET (page 8-12)</u>

We are talking internet, e-mail, and file transfer when we speak of packet mode using AX.25 protocol. HF packet mode uses FSK mode at 300 baud.

Question E2E06: What is the most common data rate used for HF packet?
Answer: 300 baud

When conditions are good and fading is mild, HF packet, at 300 baud, has a significantly higher data rate than RTTY, AMTOR or PSK31.

Question E2D09: Which of these digital modes has the fastest data throughput under clear communication conditions?
Answer: 300 baud packet

CHAPTER 8 MODULATION, PROTOCOLS, AND MODES

PACTOR (page 8-12)

PACTOR is a HF digital mode that performs well under both weak-signal and high-noise conditions. PACTOR also supports the transfer of binary files.

Question E2E08: Which of the following HF digital modes can be used to transfer binary files?
Answer: PACTOR

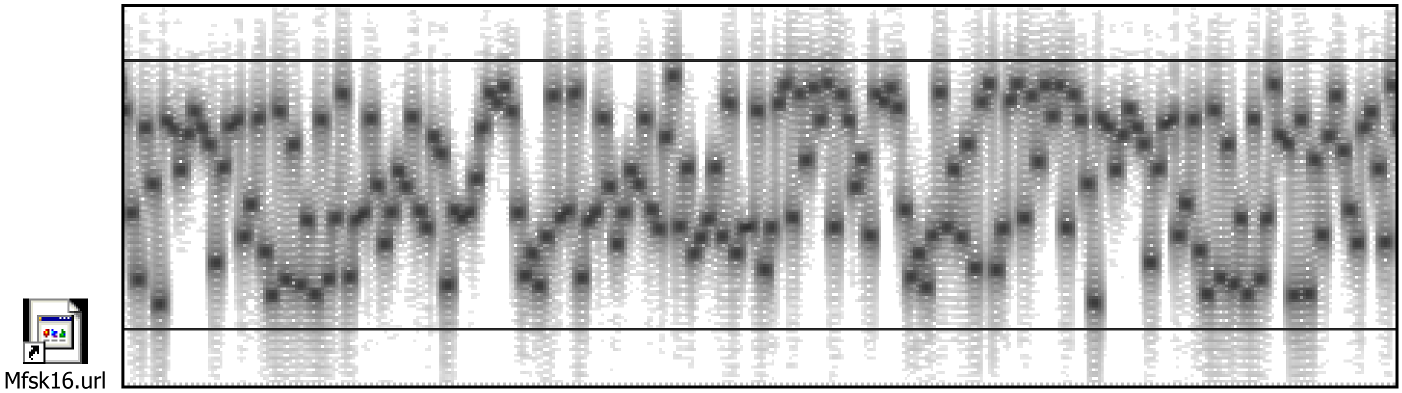
The manual has Winlink under PACTOR but I believe that it more rightfully belongs under HF Packet. Winlink can also work at 1200-baud with AFSK mode on VHF FM packet systems. The question calls Winlink a "digital mode." Winlink is not a mode, it is a system of modes and protocols and Internet services that allow e-mail to be exchanged using Amateur Radio. Winlink can only be used to exchange e-mail and attached files. Winlink does not support keyboard-to-keyboard operations.

Question E2E05: Which type of digital mode does not support keyboard-to-keyboard operation?
Answer: Winlink

MULTI-TONE MODES (page 8-13)

MFSK or Multiple Frequency Shift Keying is a variation of frequency shift keying (FSK) that uses more than two frequencies. These are tones, usually from the computers sound card, that modify the transmitter's frequency such as SSB mode or FM mode. These are not exactly shifts in the carrier frequency.

MFSK was used successfully by the British Foreign Office, the Belgian and French military and others. Some modes of MFSK are Hellschreiber, MFSK16, Olivia, Domino, THOR.



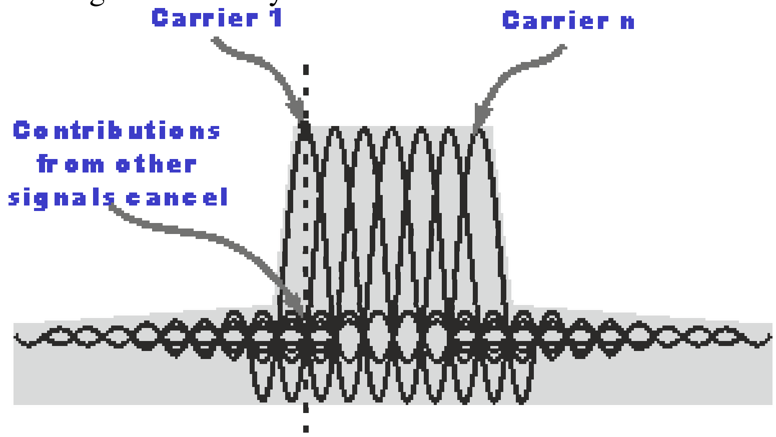
The transmission changes from one tone to the next smoothly, with no sudden change in phase, and no change in amplitude. MFSK also uses relatively narrow tone spacing, and each tone carries multiple data bits, so remarkable data rates are achieved for a given bandwidth. The following picture is a spectrogram of an MFSK16 signal (16 carriers) with a spacing of 15.625 Hz and operating at 15.625 baud (symbols per second). Each tone represents four bits, so transmission operates at 62.5 bps and it occupies about 316 Hz of bandwidth.

Question E2E07: What is the typical bandwidth of a properly modulated MFSK16 signal?
Answer: 316 Hz

CHAPTER 8 MODULATION, PROTOCOLS, AND MODES

OFDM MODULATION (page 8-13)

OFDM, Orthogonal Frequency Division Multiplexing, breaks is like multiple tones except now it is multiple carrier frequencies. This can be used in things like WiFi systems.



Orthogonal Frequency Division Multiplexing is a digital modulation technique using subcarriers at frequencies chosen to avoid inter-symbol interference.

Question E8B08: What describes Orthogonal Frequency Division Multiplexing?
Answer: A digital modulation technique using subcarriers at frequencies chosen to avoid intersymbol interference

Orthogonal Frequency Division Multiplexing is a technique used for high speed digital modes type of amateur communication.

Question E8B07: Orthogonal Frequency Division Multiplexing is a technique used for which type of amateur communication?
Answer: High speed digital modes

WSJT PROTOCOLS (page 8-14)

Joe Taylor developed a family of digital protocols for weak signal communications on VHF and UHF. Though some of these protocols are used in other bands like HF and microwave.

The WSJT family of protocols was developed for VHF/UHF weak signal scatter-type communications such as:
FSK441 for meteor scatter.

Question E2D01: Which of the following digital modes is especially designed for use for meteor scatter signals?
Answer: FSK441

The WSJT family of protocols was developed for VHF/UHF weak signal scatter-type communications such as:
JT65 for EME (Earth-Moon-Earth) bounce.

Question E2D03: Which of the following digital modes is especially useful for EME communications?
Answer: JT65

These protocols, including JT65, use advance multi-tone AFSK modulation and sophisticated codes.

Question E2D13: What type of modulation is used for JT65 contacts?
Answer: Multi-tone AFSK

The JT65 mode, which is useful for EME communications, decodes signals, virtually perfectly, that have very low signal-to-noise ratio, even signals that are well below the noise level or noise floor! JT65 also uses (FEC) forward error correction.

Question E2D12: How does JT65 improve EME communications?
Answer: It can decode signals many dB below the noise floor using FEC

Repeat: The JT65 mode decodes signals, virtually perfectly, that have very low signal-to-noise ratio, even signals that are well below the noise level!

Question E2D14: What is one advantage of using JT65 coding?
Answer: The ability to decode signals which have a very low signal to noise ratio

The protocols use precise timing between the transmitting and receiving stations and extensive codes allow the received signal to be extracted from the noise. For example, JT65 uses 1-minute alternating transmit-receive periods synchronized to accurate timing signals.

Question E2E03: How is the timing of JT65 contacts organized?
Answer: Alternating transmissions at 1 minute intervals

TRANSMITTING DIGITAL MODE SIGNALS (page 8-14)

Here are some rules about transmitting digital modes.

If the transceiver's ALC meter is active (moving) during digital transmissions (AFSK, PSK), the signal is over modulating the transmitter and the audio level should be reduced.

Question E8D06: Which of the following indicates likely overmodulation of an AFSK signal such as PSK or MFSK?
Answer: Strong ALC action

Excessive signal levels (transmit audio levels) into the transmitter's audio input can overdrive the modulator (over-modulation) or overdrive the RF amplifier just as when using loud speech.

Question E8D07: What is a common cause of overmodulation of AFSK signals?
Answer: Excessive transmit audio levels

Software that receives AFSK digital signals often measure the distortion level, caused by microphone gain, or other sources of high input levels, of signals, reporting it as "IMD Level" parameters.

Question E8D08: What parameter might indicate that excessively high input levels are causing distortion in an AFSK signal?
Answer: Intermodulation Distortion (IMD)

CHAPTER 8 MODULATION, PROTOCOLS, AND MODES

A clean PSK (phase shift keying) signal that is idling (not sending characters) should have a received IMD level of (a minimum) -30dB with respect to the main signal.

Question E8D09: What is considered a good minimum IMD level for an idling PSK signal?
Answer: -30 dB

Some of the following are possible reasons that attempts to initiate contact with a digital station on a clear frequency are unsuccessful:
- Your transmit frequency is incorrect
- The protocol version you are using is not the supported by the digital station
- Another station you are unable to hear is using the frequency

Question E2E13: Which of the following is a possible reason that attempts to initiate contact with a digital station on a clear frequency are unsuccessful?

Answer: Your transmit frequency is incorrect
Answer: The protocol version you are using is not the supported by the digital station
Answer: Another station you are unable to hear is using the frequency
Answer: All of these choices are correct

SPREAD SPECTRUM TECHNIQUES (page 8-15)

Received spread spectrum signals are resistant to interference because any signal not using the spread spectrum algorithm are suppressed in the receiver.

Question E8D01: Why are received spread spectrum signals resistant to interference?
Answer: Signals not using the spread spectrum algorithm are suppressed in the receiver

TYPES OF SPREAD SPECTRUM (page 8-16)

FREQUENCY HOPPING (page 8-16)

Frequency hopping (FH) is a form of (spectrum) spreading in which the center frequency of a conventional carrier is altered many times per second in accordance with a pseudo-random list of channels.

The frequency of the transmitted signal is changed very rapidly according to a particular sequence also used by the receiving station.

Question E8D03: How does the spread spectrum technique of frequency hopping work?
Answer: The frequency of the transmitted signal is changed very rapidly according to a particular sequence also used by the receiving station

DIRECT SEQUENCE (page 8-16)

In direct sequence (DS) spread spectrum, a very fast binary bit stream is used to shift the phase of the modulated carrier.

The Direct Sequence spread spectrum communications technique uses a high speed binary bit stream to shift the phase of an RF carrier.

Question E8D02: What spread spectrum communications technique uses a high speed binary bit stream to shift the phase of an RF carrier?
Answer: Direct sequence

WiFi is a very common application of Direct Sequence spread spectrum and can even be used on amateur channels in the shared 2.4 GHz band.

A standard wireless router running custom software is commonly used to implement a ham radio mesh network.

Question E2C09: What type of equipment is commonly used to implement a ham radio mesh network?
Answer: A standard wireless router running custom software

Related to WiFi are Amateur Radio high speed multimedia (HSMM) mesh networks such as Broadband-Hamnet (BBHN) are constructed from commercial WiFi routers reprogrammed with custom software to meet Amateur Radio regulations.

Transmitting spread spectrum in the 2.4 GHz band is most often used for a ham radio mesh network.

Question E2C04: What type of transmission is most often used for a ham radio mesh network?
Answer: Spread spectrum in the 2.4 GHz band

ERROR DETECTION AND CORRECTION

Once the system has detected an error, what it decides to do about it is another matter. This moves the process from error detection to error correction. The simplest form of error correction is ARQ (Automatic Repeat Request). If the receiving system detects an error, it requests a retransmission of the corrupted packet or message by sending a NAK (Not Acknowledge) message to the transmitting station.

Question E8C08: How does ARQ accomplish error correction?
Answer: If errors are detected, a retransmission is requested

Another popular error correction technique is to send some extra data about the information in the packet or message so that the receiving station can actually correct some types of error. This technique is called forward error correction or (FEC).

Question E2E02: What do the letters FEC mean as they relate to digital operation?
Answer: Forward Error Correction

The term “forward” stems from sending extra error correction data “ahead” with the original information. The combination of the FEC data and the algorithm by which error are detected and corrected is called FEC (Forward Error Correction) code. Forward Error Correction is implemented by transmitting extra data that may be used to detect and correct transmission errors

Question E8C01: How is Forward Error Correction implemented?
Answer: By transmitting extra data that may be used to detect and correct transmission errors

CHAPTER 8 MODULATION, PROTOCOLS, AND MODES

8.3 AMATEUR TELEVISION (page 8-18)

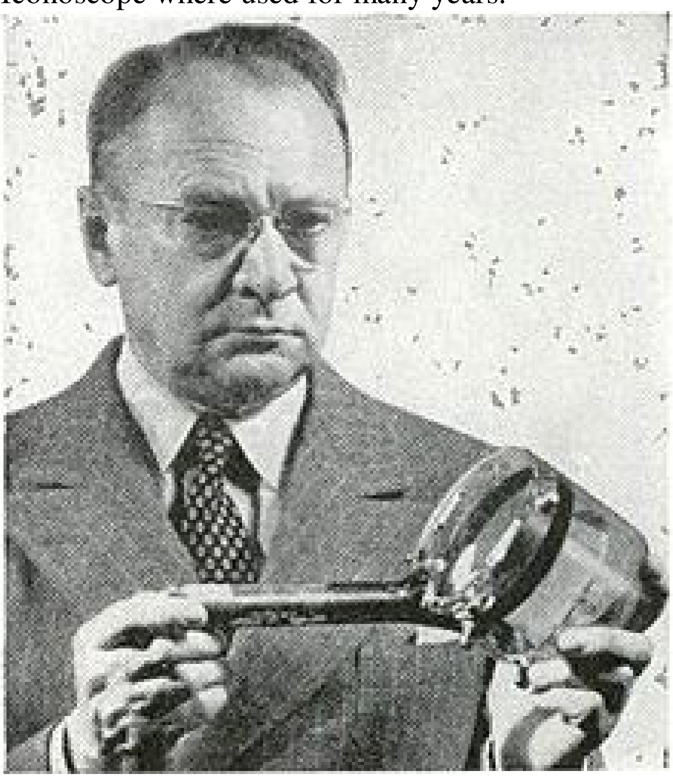
We all love to watch TV and so do HAMs. There is regular Fast-Scan TV on the VHF and higher bands. There is Slow-Scan TV on all bands.

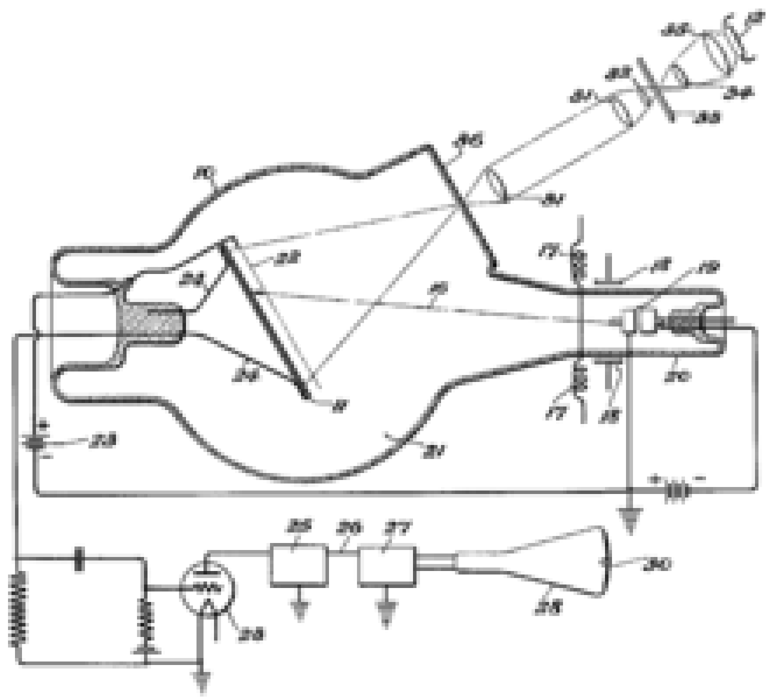
FAST-SCAN TELEVISION (page 8-18)

Fast-Scan TV (FSTV) can be sent by any amateur radio operator – even those with a Technician license. FSTV or amateur TV (ATV) closely resembles broadcast-quality television, because it normally uses the same technical standards. Being amateurs we do not have to match the RS-170A standard but then your receiver much match your transmitted signal.

FAST-SCAN SYSTEM COMPONENTS (page 8-18)

The original standards where designed to use a cathode ray vacuum tube as a video pickup device. Tubes like the Iconoscope where used for many years.

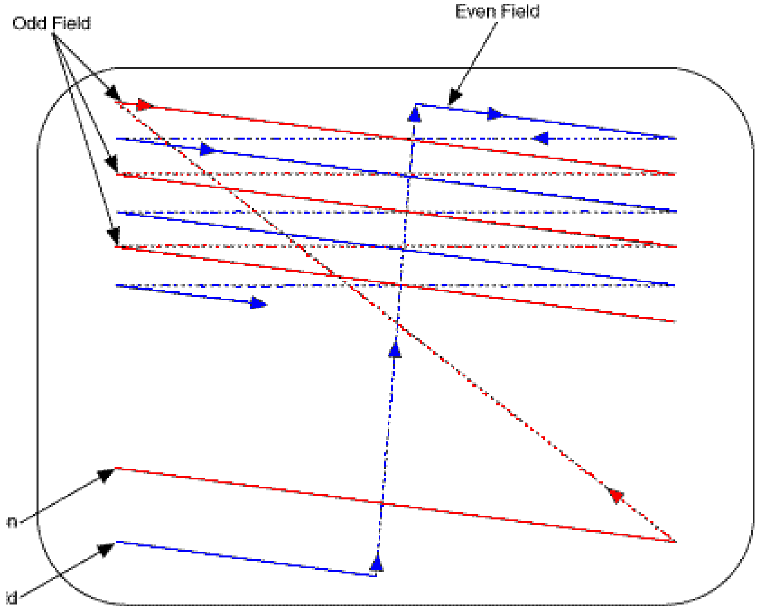




Today TV camera use Charged Coupled Devices (CCD) and their signal must be converted to the RS-170A specification before we can use them. This is done for us automatically in most cameras.

CHAPTER 8 MODULATION, PROTOCOLS, AND MODES

IMAGE SIGNAL DEFINITIONS (page 8-19)



OK. We scan the field of view. We go left to right and then quickly return to the left. This is called a horizontal scan. While this is happening we scan from top to bottom and then return quickly to the top. This is called a vertical scan. These scans are done as a single scan not two individual scans. During the first horizontal scan there are 262.5 vertical scans before we return to the top. During the second horizontal scan there are another 262.5 vertical scans before we return to the top. The second scan occupies the space between the first scan. This make a total of 525 scan line in a picture. I think that 13 scan lines are blanked during vertical retrace (return to the top of the field.) These scan can be called the Odd and Even fields. This is called interlacing. A complete field is scanned 60 times a second for black and white and 59.94 times a second for color. A complete frame, two fields, is scanned 30 (29.97-color) times a second. The horizontal sweep rate is 15,750 (15,734-color) Hz. This is at the top of human hearing but some people could hear the old TVs whistle.

The video standard used by North American Fast Scan ATV stations is known as NTSC (National Television System Committee).

Question E2B16: Which is a video standard used by North American Fast Scan ATV stations?
Answer: NTSC

525 horizontal lines make up a fast-scan (NTSC) television frame.

Question E2B02: How many horizontal lines make up a fast-scan (NTSC) television frame?
Answer: 525

30 times per second a new frame is transmitted in a fast-scan (NTSC) television system.

Question E2B01: How many times per second is a new frame transmitted in a fast-scan (NTSC) television system?
Answer: 30

By scanning odd numbered lines in one field and even numbered lines in the next an interlaced scanning pattern generated in a fast-scan (NTSC) television system.

Question E2B03: How is an interlaced scanning pattern generated in a fast-scan (NTSC) television system?
Answer: By scanning odd numbered lines in one field and even numbered lines in the next

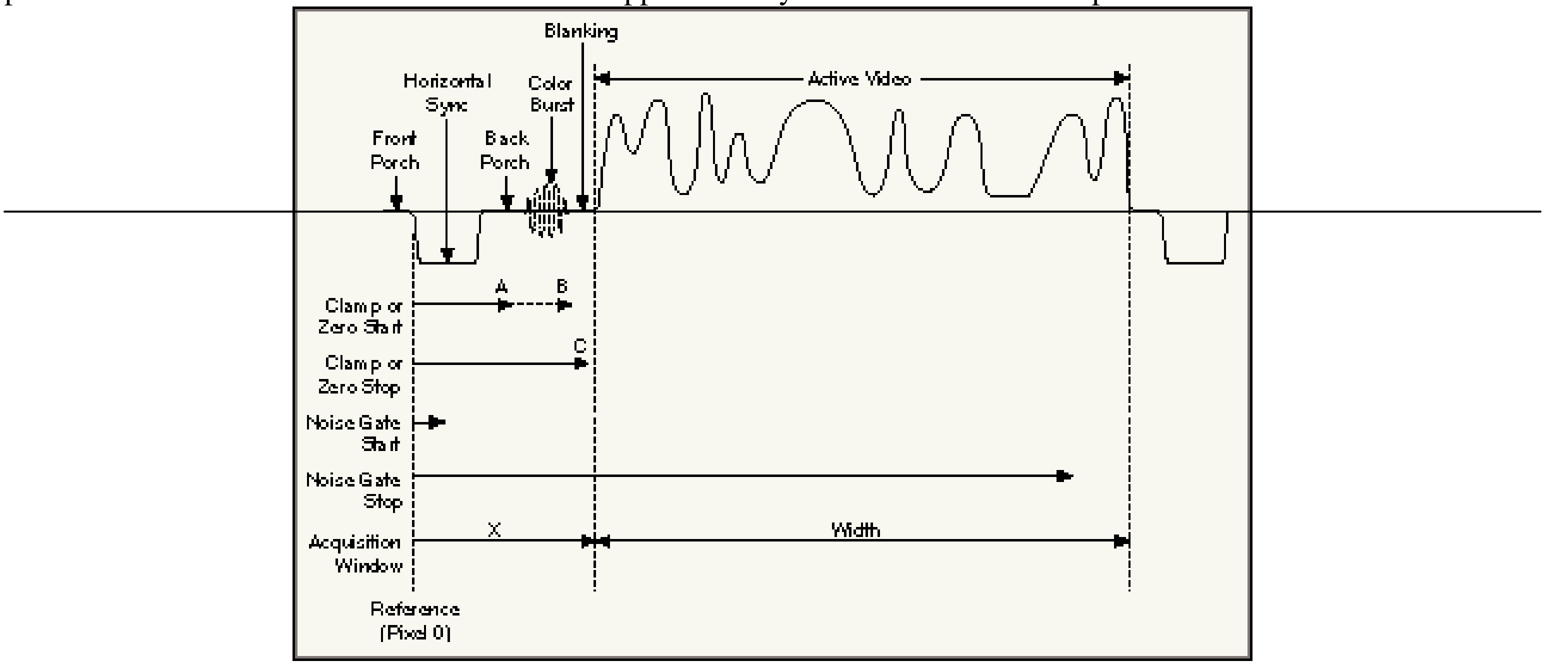
Turning off the scanning beam, while it is traveling from right to left side, or from bottom to top, is called blanking the video signal.

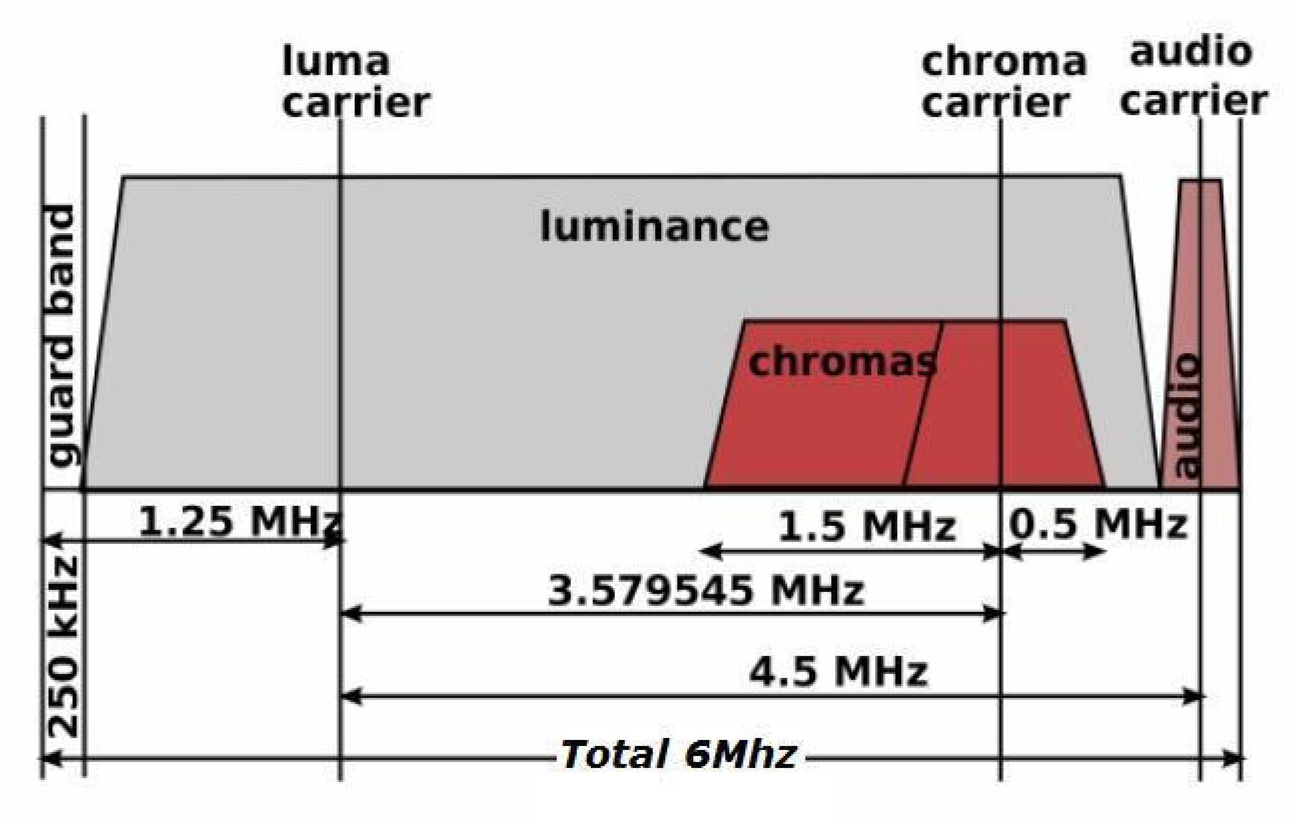
Question E2B04: What is blanking in a video signal?
Answer: Turning off the scanning beam while it is traveling from right to left or from bottom to top

CHAPTER 8 MODULATION, PROTOCOLS, AND MODES

VIDEO SIGNAL DEFINITIONS (page 8-1)

Here are some graphs of the ideal video signal. This is usually called a composite video and is described in the standard as ANSI RS-170 or RS-170A. By definition this is a negative going signal. They use funny names for the different portions of the wave. These illustrations show approximately one scan line of video picture.

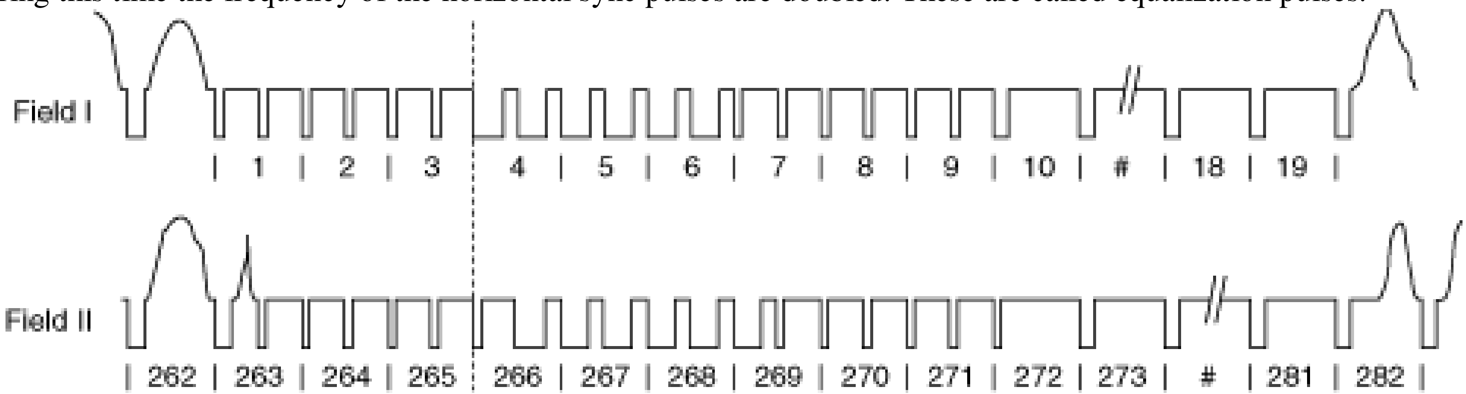


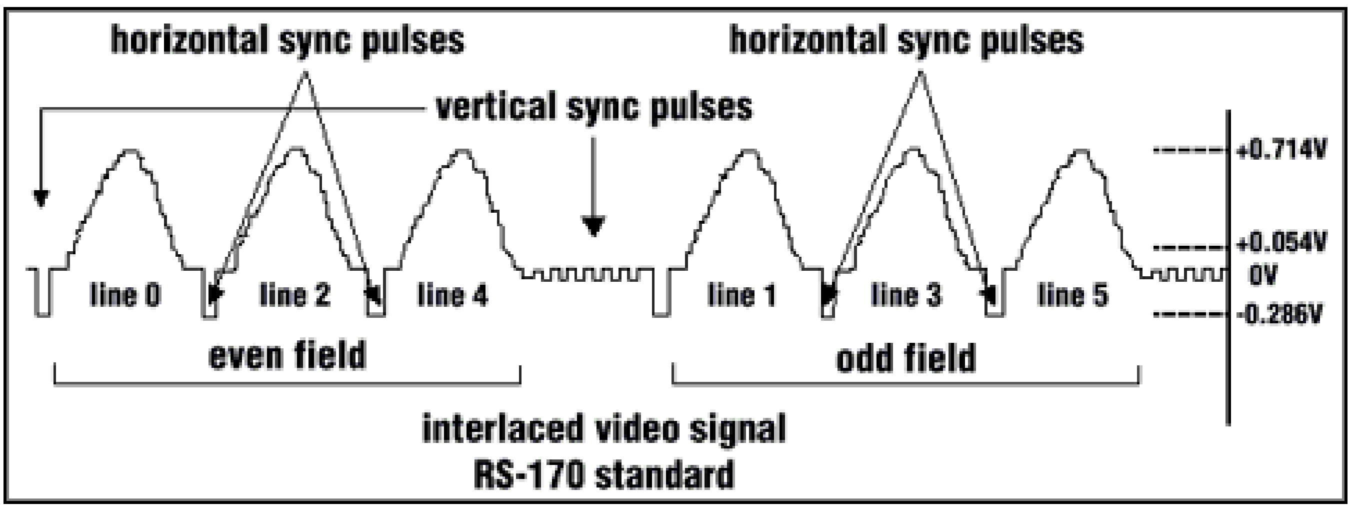


CHAPTER 8 MODULATION, PROTOCOLS, AND MODES

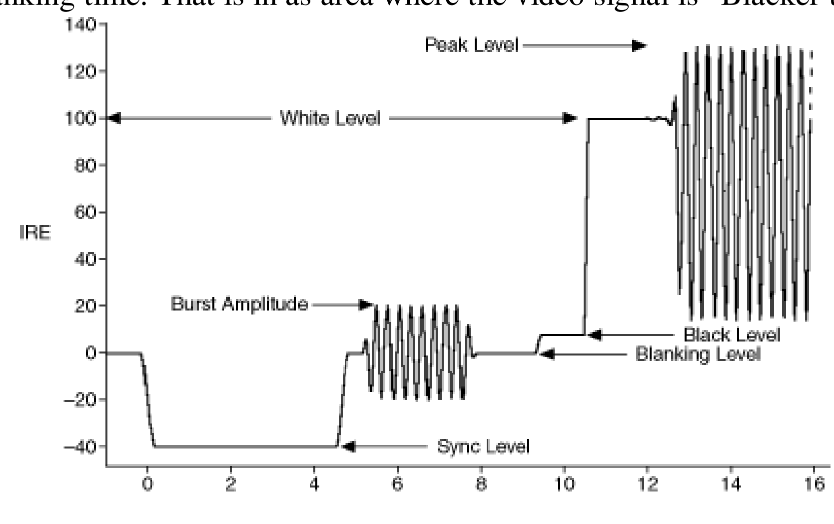
COMPOSITE AND RGB VIDEO (page 8-21)

There is a lot of information on the composite video signal. The book shows horizontal synchronization pulses but neglect the vertical synchronization. Simply put during the vertical retrace blanking interval no video signal is present. Then the horizontal sync pulses are narrowed – according to the book. To keep the horizontal oscillator synchronized during this time the frequency of the horizontal sync pulses are doubled. These are called equalization pulses.





When color was introduced it needed synchronization too. They did this by adding a signal called a Chroma Burst to the "back porch" of the blanking time. That is in as area where the video signal is "Blacker than Black."



Question E2B07: What is the name of the signal component that carries color information in NTSC video?
Answer: Chroma

CHAPTER 8 MODULATION, PROTOCOLS, AND MODES

MODULATED TELEVISION SIGNALS (page 8-22)

This negative signal is inverted for transmission and inverted again when received.

RF ATV SIGNAL CHARACTERISTICS (page 8-22)

Amateur fast scan TV can be found in the 420 to 450 MHz band (and at higher frequencies.) This is in the range of cable TV, not broadcast TV, channels 57 to 61.

Broadcast TV and amateur fast scan TV use a modulation called vestigial sideband (VSB) for transmission. This is the upper side band, carrier, and 1MHz of the lower sideband.

Question E2B06: What is vestigial sideband modulation?
Answer: Amplitude modulation in which one complete sideband and a portion of the other are transmitted

By not using the full lower sideband the overall band width is reduced but they say that a simple video detector can be used.

Question E2B05: Which of the following is an advantage of using vestigial sideband for standard fast- scan TV transmissions?
Answer: Vestigial sideband reduces bandwidth while allowing for simple video detector circuitry

FM TELEVISION (page 8-22)

FM television uses FM modulation – imagine that. Most FM ATVs operate in the **(1.2)**, 2.4 and 10.25 GHz bands.

Question E2B18: On which of the following frequencies is one likely to find FM ATV transmissions?
Answer: 1255 MHz

THE AUDIO CHANNEL (page 8-23)

Audio on TV, Use the FM-Voice described in the NTSC standard; use a 2 meter radio, or modulate the video carrier.

Question E2B08: Which of the following is a common method of transmitting accompanying audio with amateur fast-scan television?
Answer: Frequency-modulated sub-carrier
Answer: A separate VHF or UHF audio link
Answer: Frequency modulation of the video carrier
Answer: All of these choices are correct

SLOW SCAN TELEVISION (page 8-23)

A picture from a camera, or a FAX, or a scanner, or a frame captured from a fast-scan TV can be sent as slow-scan television.

CHAPTER 8 MODULATION, PROTOCOLS, AND MODES

ANALOG SSTV SIGNAL BASICS (page 8-24)

SSTV (slow-scan TV) uses the video information to modulates a tone's frequency and the tone is transmitted using HF single sideband.

Question E2B12: How are analog SSTV images typically transmitted on the HF bands?
Answer: Varying tone frequencies representing the video are transmitted using single sideband

Since we are using tones, just assign a tone to indicate a new picture line – 1200 Hz.

Question E2B15: What signals SSTV receiving equipment to begin a new picture line?
Answer: Specific tone frequencies

The brightness of the picture is encoded to at tone of varying frequency.

Question E2B14: What aspect of an amateur slow-scan television signal encodes the brightness of the picture?
Answer: Tone frequency

Amateur slow-scan (black and white or color) TV usually has either a 128 or 256 scan lines in a frame.

Question E2B13: How many lines are commonly used in each frame of an amateur slow-scan color television picture?
Answer: 128 or 256

The approximate band width of COLOR slow-scan TV is 3 KHz.

Question E2B17: What is the approximate bandwidth of a slow-scan TV signal?
Answer: 3 kHz

The Vertical Interval Signal (VIS) tone code is sent to identify the SSTV mode being used.

Question E2B11: What is the function of the Vertical Interval Signaling (VIS) code sent as part of an SSTV transmission?
Answer: To identify the SSTV mode being used

DIGITAL SSTV (page 8-25)

To use Digital Radio Mondiale (DRM) digital TV no special equipment is needed.

Question E2B09: What hardware, other than a receiver with SSB capability and a suitable computer, is needed to decode SSTV using Digital Radio Mondiale (DRM)?
Answer: No other hardware is needed

On the amateur bands the 4 KHz of bandwidth usual for Digital Radio Mondiale (DRM) must be reduced to 3 KHz.

Question E2B10: Which of the following is an acceptable bandwidth for Digital Radio Mondiale (DRM) based voice or SSTV digital transmissions made on the HF amateur bands?
Answer: 3 KHz

CHAPTER 8 MODULATION, PROTOCOLS, AND MODES

SSTV OPERATING (page 8-26)

Slow-scan TV (SSTV) is allowed in all bands that allow phone communications. Also the bandwidth must be no larger that of a voice signal of the same modulation type.

Question E2B19: What special operating frequency restrictions are imposed on slow scan TV transmissions?

Answer: They are restricted to phone band segments and their bandwidth can be no greater than that of a voice signal of the same modulation type