



Chapter 5 Radio Signals

Modulation Modes

Digital Modes

RTTY, PSK, Packet



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Modulation

Combining information wave with the radio wave at the transmitter.

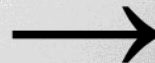
- Morse or CW is on-off keying
- AM varies the field *amplitude*
- FM varies the field *frequency*
- PM varies the field *phase*
- Modulations by type of information
 - Voice or *phone*
 - Data; *Analog* or *Digital*



Demodulation

Recovering the information wave from the radio wave at the receiver

- CW – Makes a *beat* note or *heterodyne* from *mixing* with a reference oscillator
- AM – Sideband frequencies mix with carrier
- SSB – Sideband frequencies mix with a carrier oscillator
- FM – Signal frequency is compared to a reference frequency in a frequency discriminator



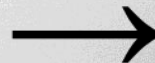
Amplitude Modulation

Varies the power of the RF signal in proportion to the information signal analog voltage

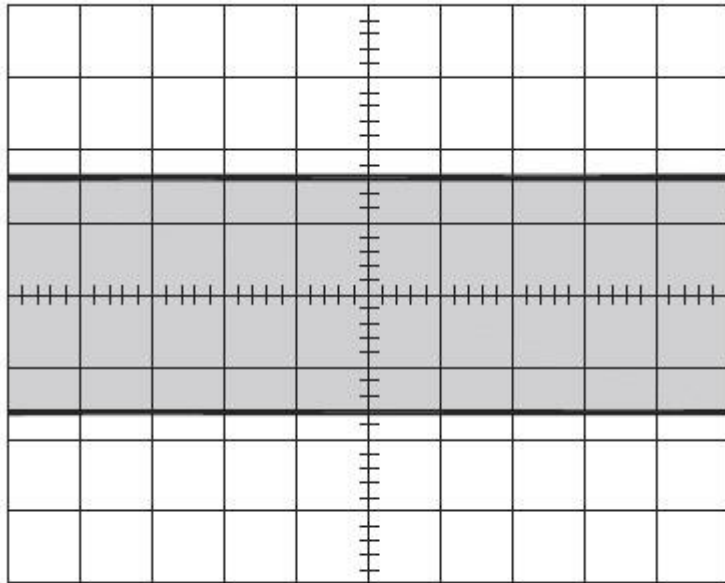
- Signal envelope varies at the information rate
- *Sidebands* are created – *USB, LSB*
- Same information is in each sideband so one may be suppressed – SSB
- The base frequency or *carrier* contains no information so it may be suppressed – SSBSC
- SSB *bandwidth* equals the highest information frequency.



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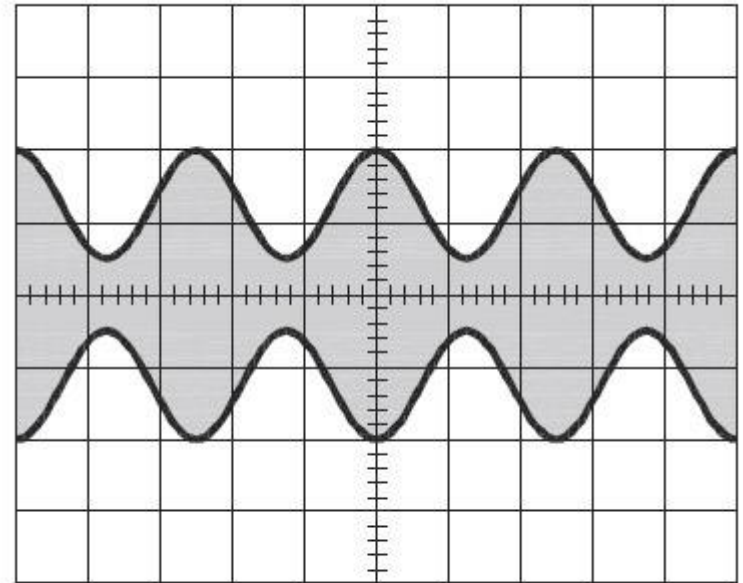


AM Waveforms



(A)

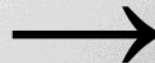
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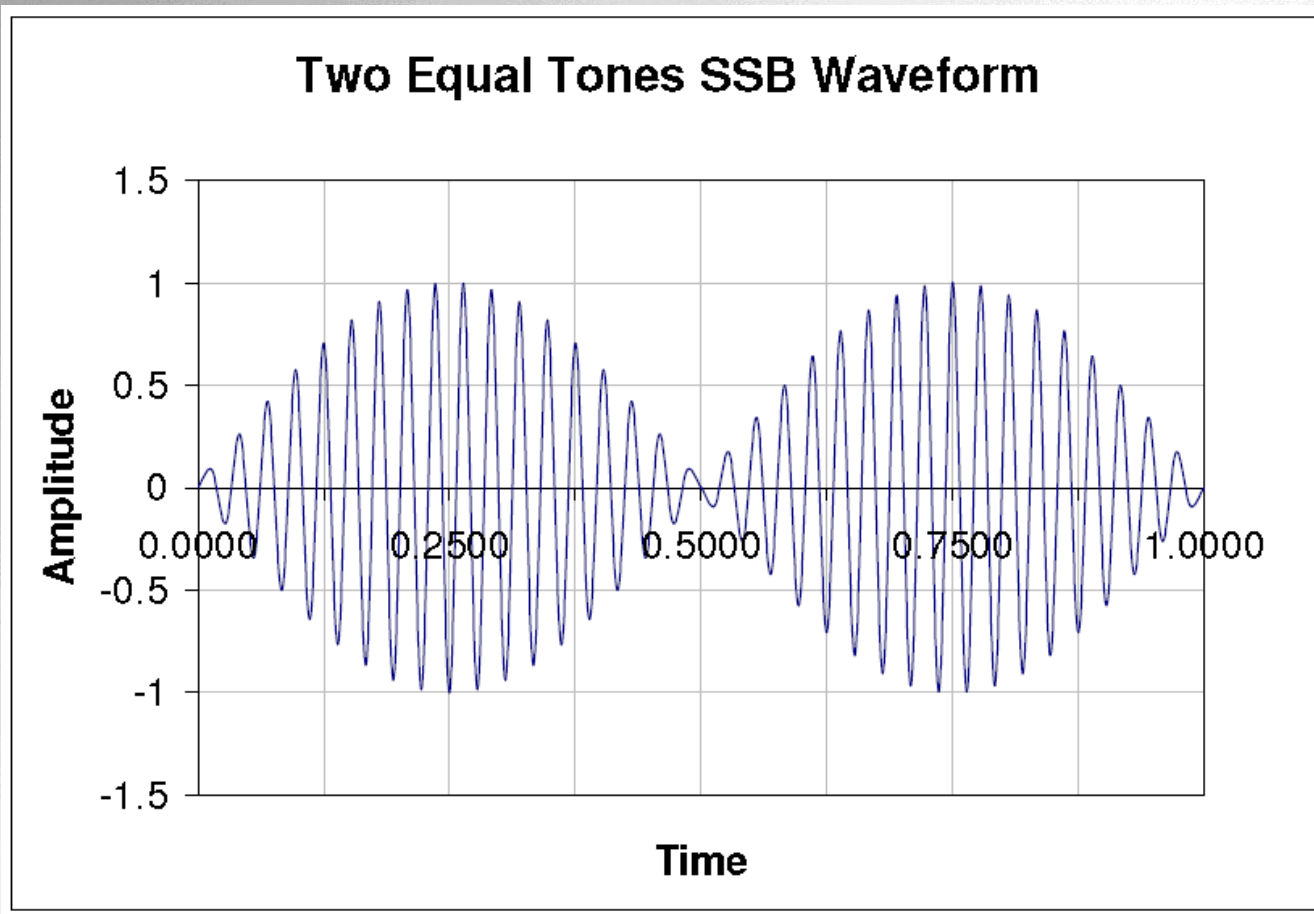
(B)

(A) Unmodulated

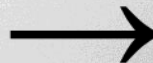
(B) Modulated



SSB Waveforms



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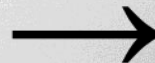
Frequency Modulation

Varies the frequency (or phase) of the radio wave in proportion to the analog information

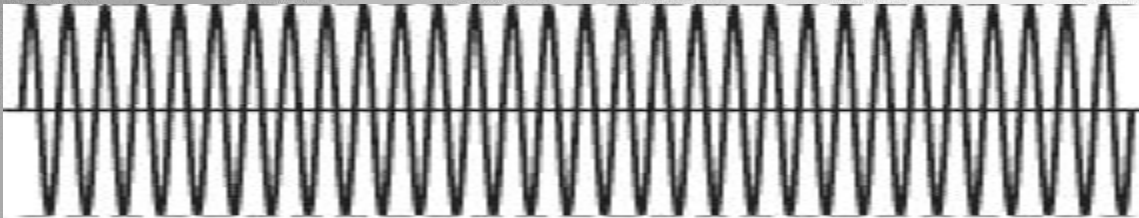
- The amount of frequency change is called *deviation*.
- Phase and Frequency modulation are similar except for information frequency emphasis.
- FM envelope is constant level.
- Pairs of sideband frequencies are created.
- Bandwidth usually wider than highest information frequency.



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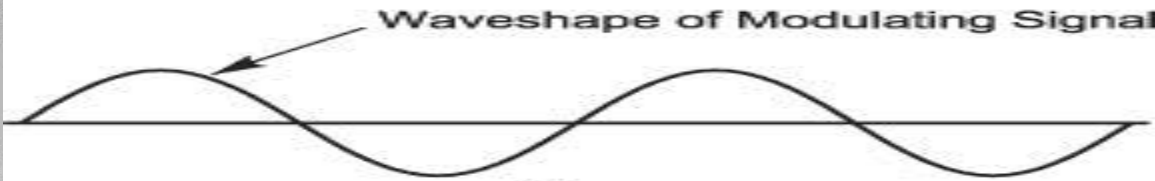


FM Waveforms



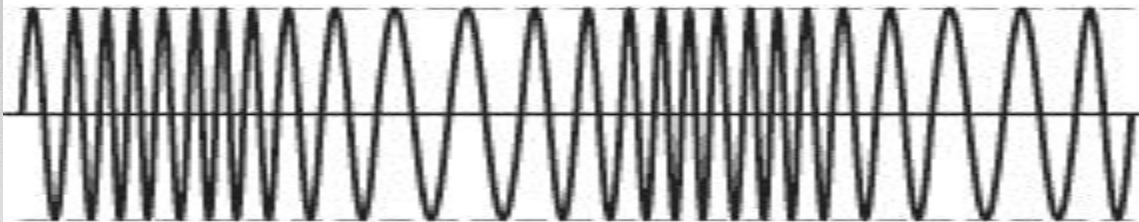
Unmodulated
Carrier

(A)



Modulating
Signal

(B)



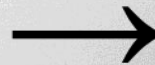
Modulated
Carrier

(C)

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Typical Bandwidths

Table 5-1

Amateur Signal Bandwidths

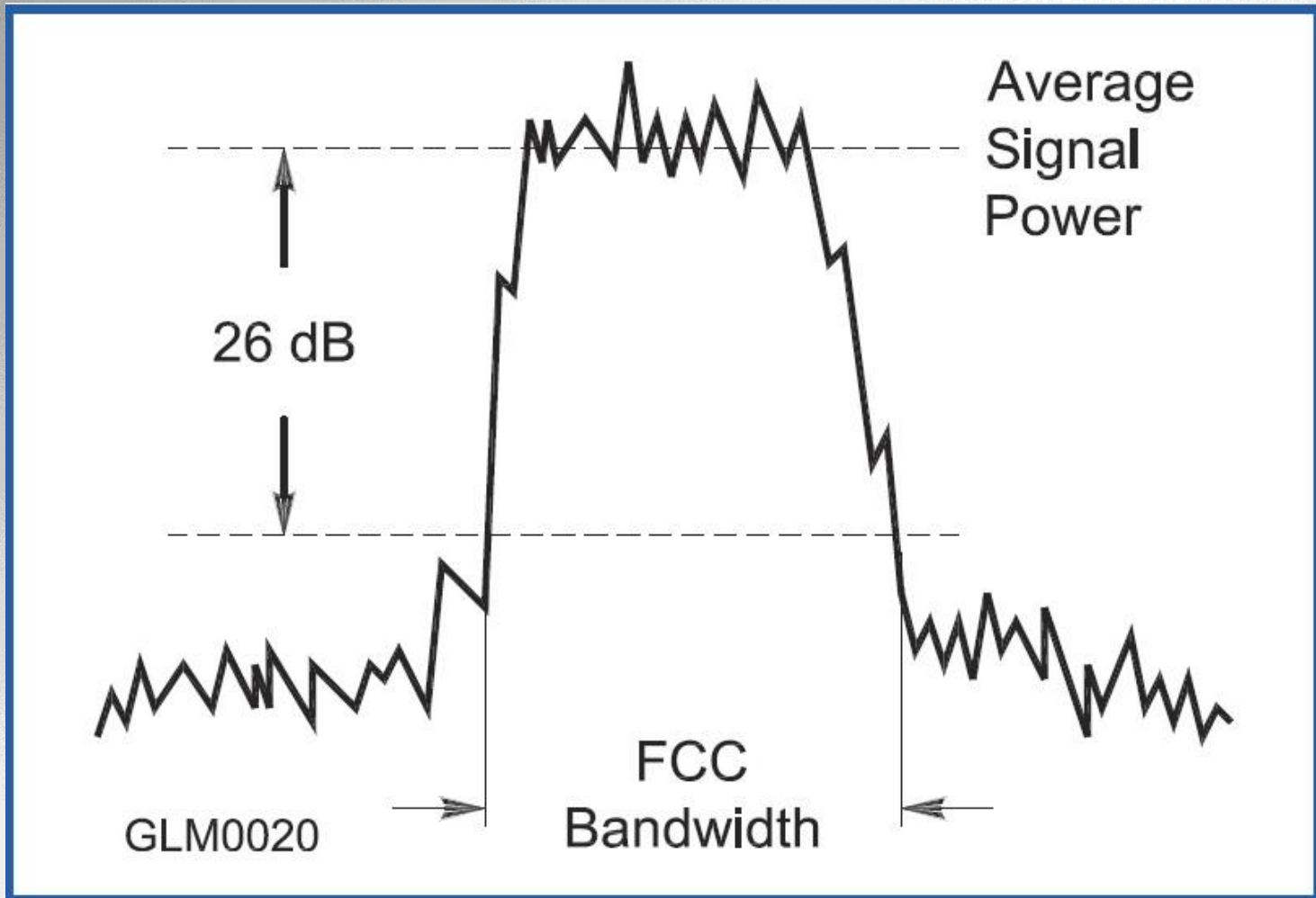
<i>Type of Signal</i>	<i>Typical Bandwidth</i>
AM voice	6 kHz
Amateur television	6 MHz
SSB voice	2 to 3 kHz
Digital using SSB	500 to 3000 Hz (0.5 to 3 kHz)
CW	100 to 300 Hz (0.1 to 0.3 kHz)
FM voice	5 to 15 kHz



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FCC Bandwidth Definition



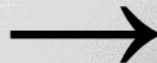
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Digital Modes

Digital information consists of binary values – 0 and 1. Sending binary values at high rates causes a wide bandwidth

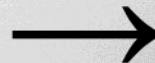
- Each bit or group of bits is usually encoded into an analog feature of a tone – frequency, phase, etc. i.e.
 - low frequency \Leftrightarrow “1” , high frequency \Leftrightarrow “0”.
 - Phases 0, 90, 180, 270 \Leftrightarrow “00”, “01”, “10”, “11”
- Tone may be transmitted by AM, FM, or SSB



Digital Mode Terminology

Baud – the rate that symbols are sent

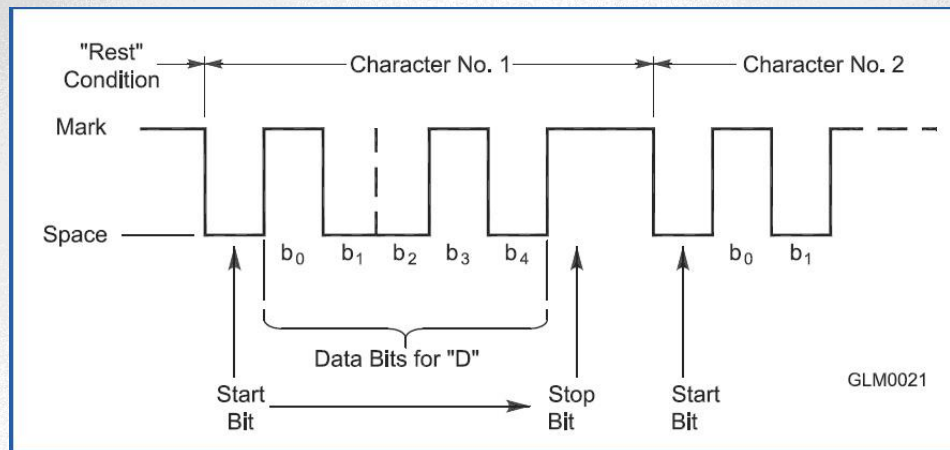
- Symbol – A tone containing one or more bits
- Bit rate can be higher than symbol rate
- Bandwidth increases with symbol rate
- Protocol – rules for encoding and decoding
- Duty cycle – the percentage of time at full power
 - RTTY – 100%, Reduce transmitter power to 50%
 - PSK – nearly 100%, Reduce power
 - TOR – Low, Can usually run full power



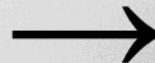
TTY and Baudot Code

TTY characters are ***Baudot*** encoded using five **data** bits framed by a **start** and **stop**.

- Start is a “0” or low
- Stop is a “1” or high, usually longer than other bits
- Five data bits can represent 32 characters



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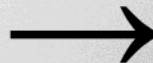


RTTY

The bits of ***baudot*** characters shift the frequency of a tone.



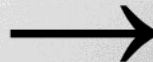
- The tone frequencies are called ***mark*** (Logical 1) and ***space*** (Logical 0)
- Rate of shift determines character speed (WPM)
 - 45, 56, 75 Baud \Leftrightarrow 60, 75, 100 WPM
 - Most Hams on HF use 45 Baud with 170Hz shift with 2125Hz Mark, 2295Hz Space
- FSK tone can be sent on SSB or FM phone.
 - On SSB, use Lower Sideband



Multi-Tone FSK


MFSK16 uses 16 tones in a 300Hz bandwidth

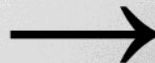
- Can be received through a 500Hz bandwidth CW filter
- Tones are 15.625 Hz apart
- Keying of tones is shaped to control bandwidth and reduce effects of ionospheric *selective fading*
- Good performance with weak sky-wave signals
- Data rate is about 42WPM



Phase Shift Keying and PSK31



In PSK, the phase of the tone may change for each symbol. The phase reference is transmitted at the beginning of a message and/or between symbols.

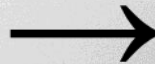
- Sounds like a humming or buzzing tone 
- PSK31 is popular for sending from a keyboard
 - Symbol rate is 31.25Baud
 - Varicode – shorter codes for most common characters
 - Up to 50 WPM under good conditions
 - Signals can be copied well through noise
 - Encoded and decoded by computer sound cards



Packet over Radio

Packet is a collection of data characters sent in one message.

- Packet Radio for VHF/UHF FM uses 1200Baud or 9600Baud
- Packet is not suited for HF because of fading
- Error Detection and Correction
 - CRC checksum 
 - ACK or NAK
 - ARQ and FEC 



Packet Contents



Header - Contains routing, control, status and error correction data

Data (payload) - Contains data being transferred

Trailer - Contains status and error detection data

GLM0022




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TOR – Teletype Over Radio

PACTOR and WINMOR improve teletype reliability in presence of fading and noise.

- Short bursts of characters with error detection and correction 
- FSK (PACTOR I), PSK (PACTOR II, III)
- Error detection and Automatic Repeat Request
- WINMOR is popular for WinLink 2000 HF email system for sailboats and campers.

