Class 4
Ham Radio Technician Course

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Review

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Keywords

- ITU
- FCC
- VE
- VEC
- RACES
- ARES
- PEP
- Broadcasting
- One-Way Communication
- Repeater
- Control point
- Control operator
- Station Licensee

3

More Keywords

- Automatic Control
- Remote Control
- Call Sign
- Tactical Call Sign
- Indicator
- Third Party Agreement
- Club Station
- CTCSS
- DCS
- DTMF
- Repeater Offset
- Offset Direction
- Band Plan

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Even More Keywords?

- Simplex
- Duplex
- “Reverse” function
- QRM, QRN, QRP
- QSO, QSL, QSY
- Net Control Station
- “Traffic”
- ”Check”
- Picket Fencing
- Flat topping
- Wavelength
- Frequency
- RF
- EMF

5

OMG Make it Stop!

- Meteor scatter
- Auroral backscatter
- Knife-edge Diffraction
- Tropospheric Ducting
- D, E, F1, F2
- Farad
- AM, FM, SSB
- VFO
- RIT / Clarifier
- DMR, D-STAR
- Volts, Amps, Ohms
- Hertz
- PEP
- Henry

6

Magic Numbers

- Speed of light
- Rule of 3s
- 2m National Calling Frequency
- 2m repeater offset
- 70cm repeater offset
- 219-220 MHz
- 3dB
- 6dB
- 10dB
- License Term
- License Grace Period
- Our ITU region
- Grid Square

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Computers and Radios Living in Harmony

8

Computers and Radios Living Together

- PTT <= a pin on a serial output port
- Mic In <= Audio ("Sound Card") Output
- Speaker out => Audio ("Sound Card") Input
- Add Software and Stir

9

OR: Embed the Computer in the Radio

- Automatic Packet Reporting System (APRS)
- Report location and other data
- Common use is automated weather stations

10

The Ultimate Morse Code Cheat

- Electronic Keyer
- Software to Decode as Well

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The Grandaddy of Digital Modes
RTTY

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Explosion of Newer/Better Digital Modes!

FSK441 [edit]

FSK441, introduced in 2001 as the first communications mode included with WSJT,[3] is designed to support communication using streaks of radio-reflecting ions created in the ionosphere by the trails of meteors entering the Earth's atmosphere.[2] The bursts of signal created by such trails are commonly referred to as "pings", due to their characteristic sound. Such pings may be as short as a tenth of a second and carry enough information to complete at least one stage of a contact.[8] FSK441 employs multi-frequency shift keying using four tones, at a data rate of 441 baud. Because of the choice of character codes in the protocol, it is self-synchronizing and does not require an explicit synchronization tone.[2] FSK441 is generally used on the 2-meter and 70-centimeter amateur bands. Contacts may be made at almost any time (that is, a meteor shower is not required to be in progress) at distances of up to 1400 miles (2250 km).[8]

When transmitted messages include at least one space, the FSK441 decoding algorithm uses that space character as a syncword for zero-overhead synchronization.[2]:30[6](12.2)

Mode is no longer part of wsjt-x v.2.1.2.

JT6M [edit]

JT6M, introduced in late 2002,[3] is intended for meteor scatter and other ionospheric scattering of signals, and is especially optimized for the 6-meter band. The mode also employs multiple frequency-shift keying, but at 44 tones. One of the tones is a synchronization tone, leaving 43 tones to carry data (one tone per character in the character set, which includes alphanumerics and some punctuation). The symbol rate is 21.53 baud; the actual data rate as encoded for transmit is 14.4 characters per second. The mode is known for sounding "a bit like piccolo music".[2]

Mode is no longer part of wsjt-x v.2.1.2.

JT65 [edit]

JT65, developed and released in late 2003,[3] is intended for extremely weak but slowly varying signals, such as those found on troposcatter or Earth-Moon-Earth (EME, or "moonbounce") paths.[2] It can decode signals many decibels below the noise floor in a 2500 Hz band (note that SNR in a 2500 Hz band is approximately 28 dB lower than SNR in a 4 Hz band, which is closer to the channel bandwidth of an individual JT65 tone), and can often allow amateurs to successfully exchange contact information without signals being audible to the human ear. Like the other modes, multiple-frequency shift keying is employed; unlike the other modes, messages are transmitted as atomic units after being compressed and then encoded with a process known as forward error correction (or "FEC"). The FEC adds redundancy to the data, such that all of a message may be successfully recovered even if some bits are not received by the receiver. (The particular code used for JT65 is Reed-Solomon.) Because of this FEC process, messages are either decoded correctly or not decoded at all, with very high probability. After messages are encoded, they are transmitted using MFSK with 65 tones.[9]

Operators have also begun using the JT65 mode for contacts on the HF bands, often using QRP (very low transmit power);[10] while the mode was not originally intended for such use, its popularity has resulted in several new features being added to WSJT in order to facilitate HF operation.[11]

JT9 [edit]

JT9, intended for MF and HF use, was introduced in an experimental version of WSJT, known as **WSJT-X**.[12] It uses the same logical encoding as JT65, but modulates to a 9-FSK signal. With 1-minute transmission intervals, JT9 occupies less than 16 Hz bandwidth. JT9 also has versions designed for longer transmission intervals of 2 minutes, 5 minutes, 10 minutes or 30 minutes. These extended versions take increasingly less bandwidth and permit reception of even weaker signals.[13]

FT8 [edit]

Joe Taylor, K1JT, announced on June 29, 2017 the availability of a new mode in the WSJT-X software, FT8.[14] FT8 stands for "Franke-Taylor design, 8-FSK modulation" and was created by Joe Taylor, K1JT

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WSJT Software

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What is One Big Advantage of Digital Modes?

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Even Radios are Online

- Gateways
- EchoLink
- WinLink
- IRLP

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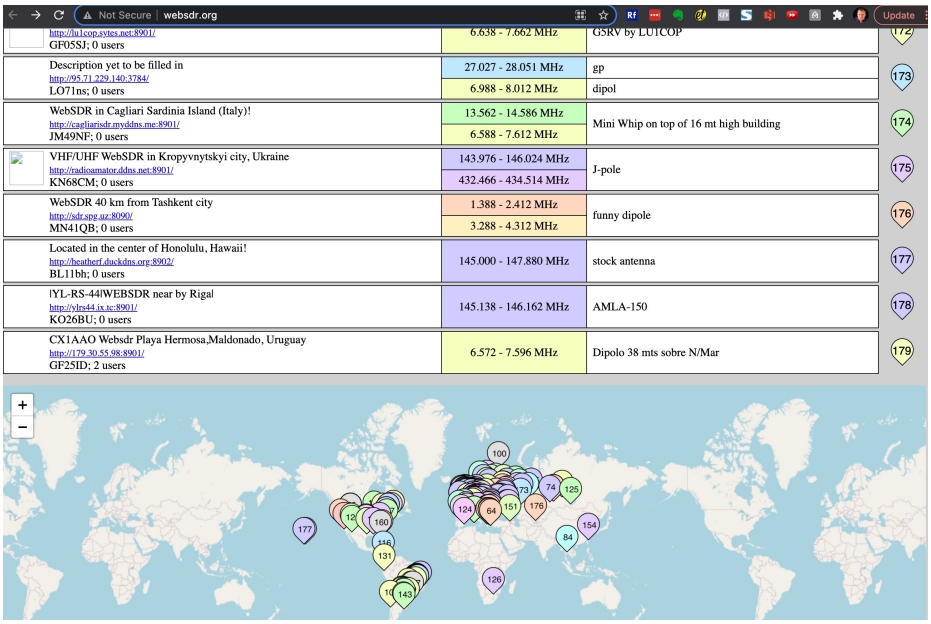
Online SDRs



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TV is Just Radio So…

- Fast Scan - a 6MHz wide transmission
- Slow Scan is just 3kHz

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Space Stations

- Definition:
  - A transmitter 50 KMs above the earth
- Beacons
- Repeaters
- Manned spacecraft

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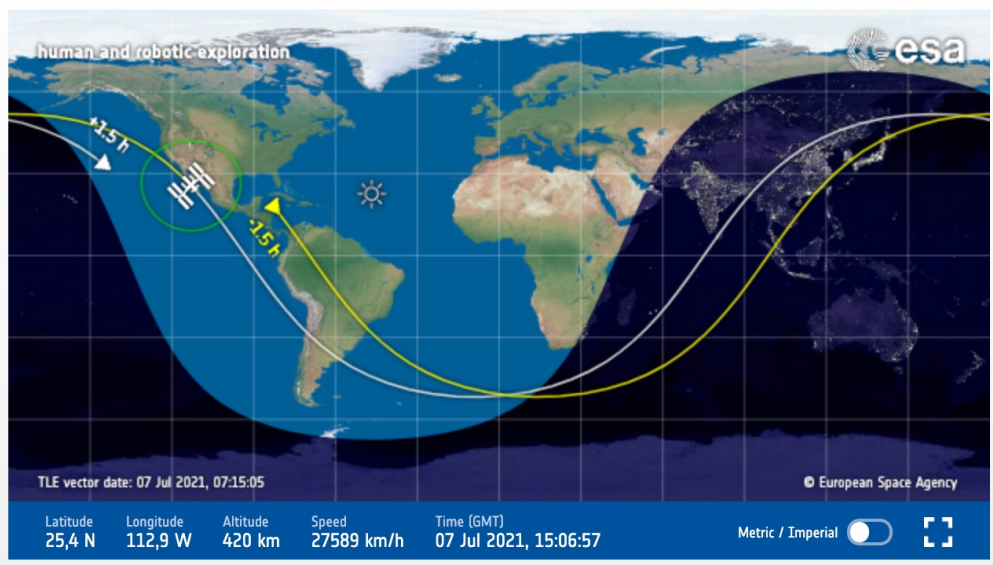
The International Space Station and other Satellites

20

ISS018E011703

21



Map Source: www.esa.int

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OSCAR 1

- Built by amateurs
- Cost $63
- Launched 4 years after Sputnik-1
- First "piggyback" satellite
- First private spacecraft
- Operated for 22 days

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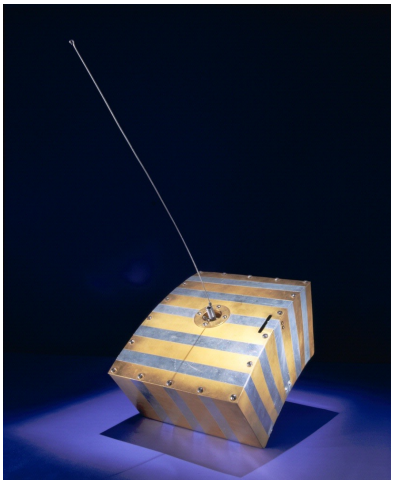

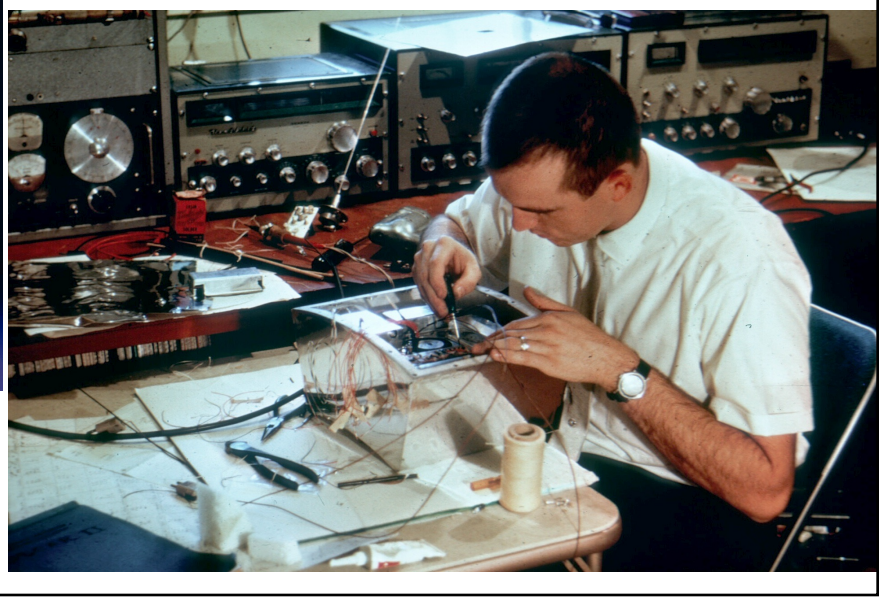

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Many more since

N2YO.com

Like 28K

Tracking 23487 objects as of 7-Jul-2021
HD Live streaming from Space Station
2,340 objects crossing your sky now

ISS will cross your sky in 11h 55m 20s

Find a satellite... Search
N2YO.com on Facebook Advanced

Home | Most tracked | Just launched | Satellites on orbit | Alerting tools | More stuff | Sign in

1 Real Time Satellite Tracking
2 Live Satellite Tracking
3 Trace a Cell Phone Location
4 Iss Live Tracking
5 Live Satellite Maps
6 Satellite View of My House
7 Live Satellite Images
8 Track a Cell Phone

AMATEUR RADIO SATELLITES

There are a few satellites specifically designed to be used by amateur radio (licensed) operators. You can check the status and communication frequencies of all active amateur radio satellites on the following web pages: DK3WN, JE9PEL.
Satellites marked with C support uplink communication in amateur radio bands.
Ham radio exclusive: Amateur radio satellite passes for the next 6 hours

The table is sortable. Please click on the header for ascending/descending sorting.

Name	NORAD ID	Int'l Code	Status	Beacon (MHz)	Period [minutes]	Action
SMOG-1	47964	2021-022AJ	Active	437.345	95.5	TRACK IT
DIY-1/ARDUIQUBE	47963	2021-022AH	Active	437.125	95.5	TRACK IT
ORBICRAFT-ZORKIY	47960	2021-022AE	Active		95.6	TRACK IT
CUBESX-HSE	47952	2021-022W	Active		95.6	TRACK IT
CUBESX-SIRIUS-HSE	47951	2021-022V	Active		95.6	TRACK IT
NANOSAT C BR2	47950	2021-022U	Active		95.6	TRACK IT
FEES	47947	2021-022R	Active		95.6	TRACK IT
OBJECT Q	47946	2021-022Q			95.6	TRACK IT
UNISAT 7	47945	2021-022P	Active		95.6	TRACK IT
STECCO	47943	2021-022M			95.6	TRACK IT
GRBALPHA	47941	2021-022K	Active	437.025	95.6	TRACK IT
GUARANISAT-1 (BIRDS-4) C	47931	1998-067SH	Active	437.375	92.8	TRACK IT
HIROGARI (OPUSAT-II)	47930	1998-067SG	Active	145.900	92.7	TRACK IT
MAYA-2 (BIRDS-4) C	47929	1998-067SF	Inactive	437.375	92.8	TRACK IT
STARS EC	47928	1998-067SE	Active	437.245	92.8	TRACK IT
STARS EC	47928	1998-067SE	Active	437.255	92.8	TRACK IT
STARS EC	47928	1998-067SE	Unknown	437.350	92.8	TRACK IT
TSURU (BIRDS-4) C	47927	1998-067SD	Active	437.375	92.8	TRACK IT
TAUSAT-1	47926	1998-067SC	Active	436.400	92.7	TRACK IT
RSP-01	47925	1998-067SB	Active	145.810	92.8	TRACK IT

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Amateur Clean Room

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Most are in Low Earth Orbit (LEO)

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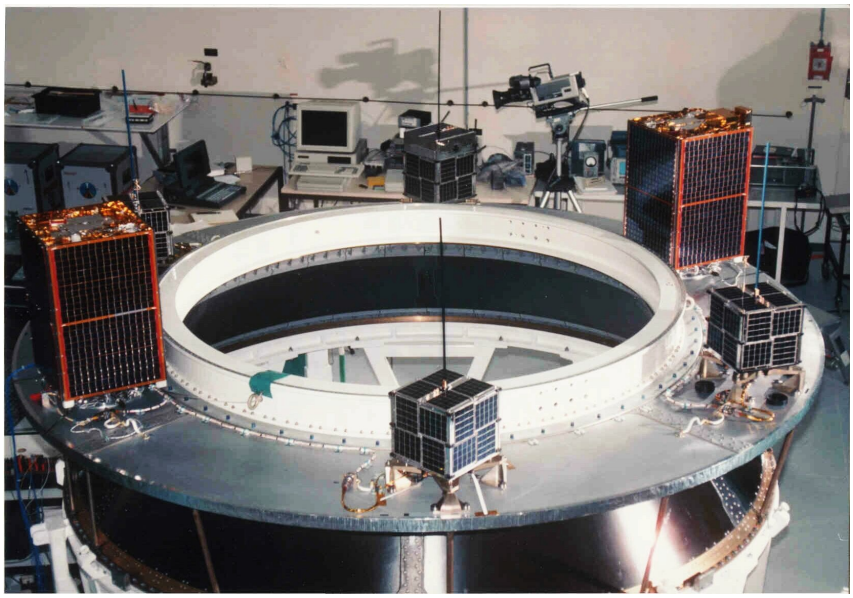
Partnership with ESA



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Doppler Shift

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The Frequency of the Signal Changes

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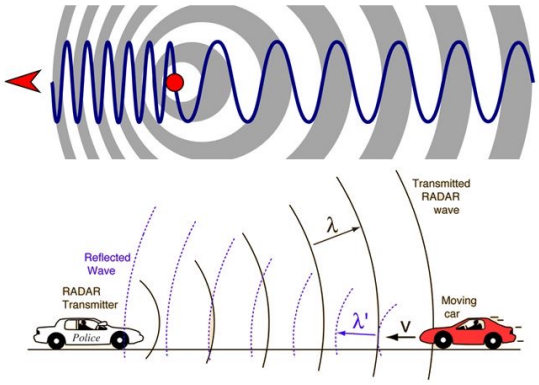
Police Radar

Basic Concept

Doppler Effect: Generic Definition

- A *frequency shift* (cycles per second → Hertz) of *any electromagnetic wave pulse* due to the "target" moving toward or away from the observer



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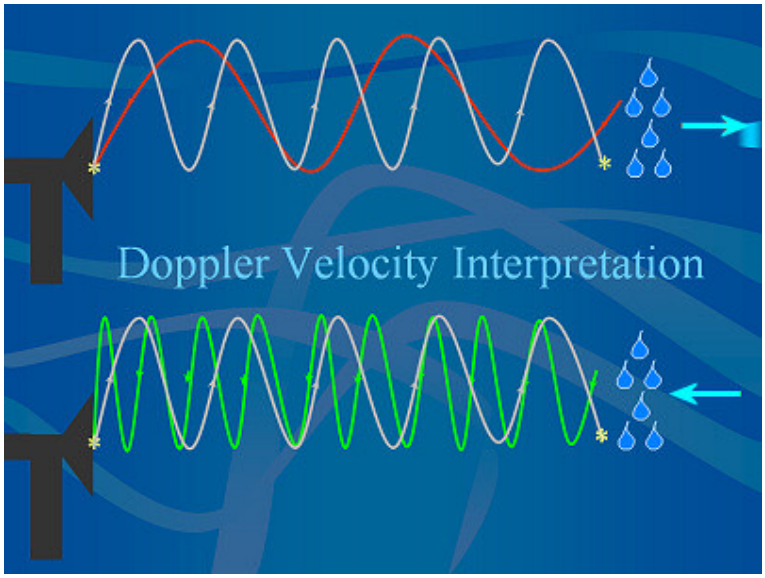
Weather Radar



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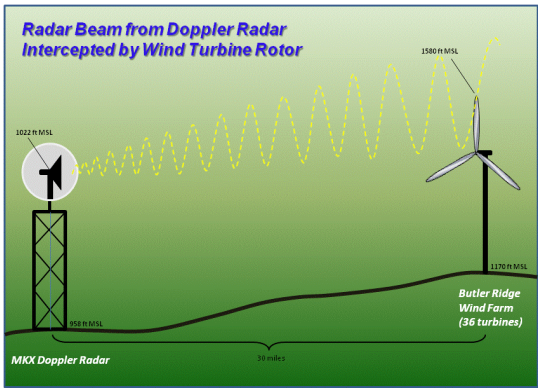
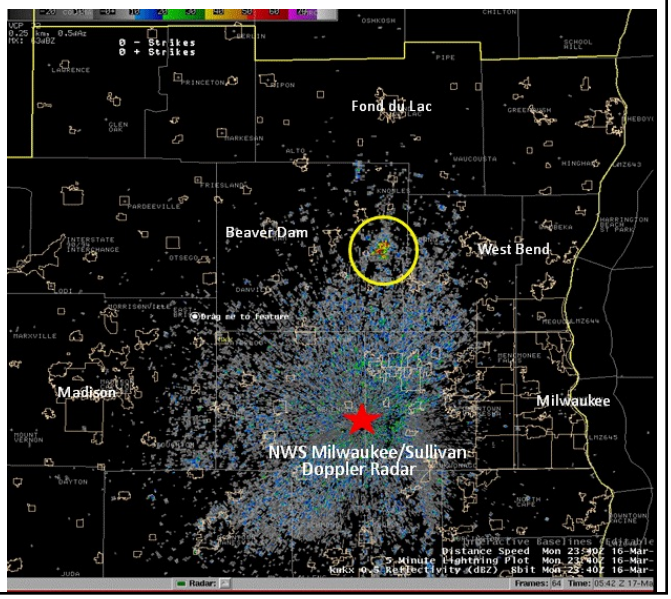
Wind Farm Interference





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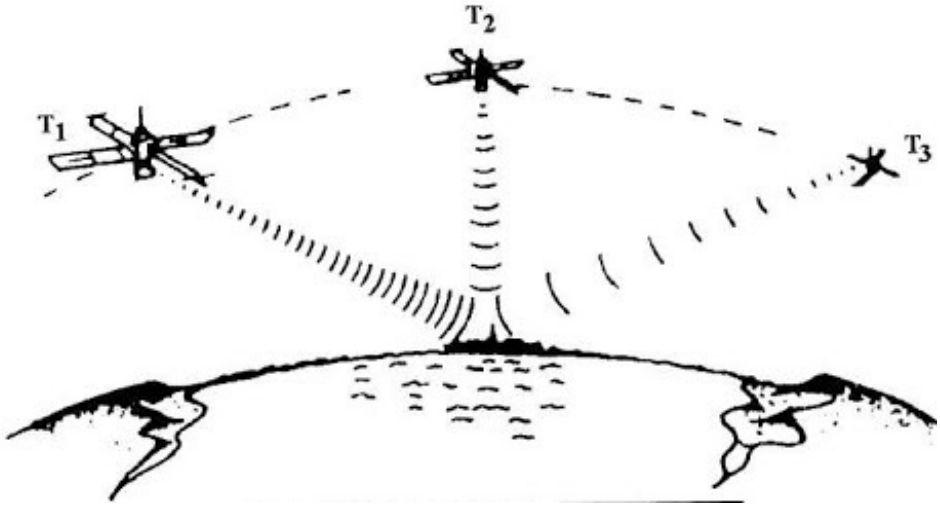
Satellite Communications



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Receiver Incremental Tuning (RIT)

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Satellite U/V Mode

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Modulation

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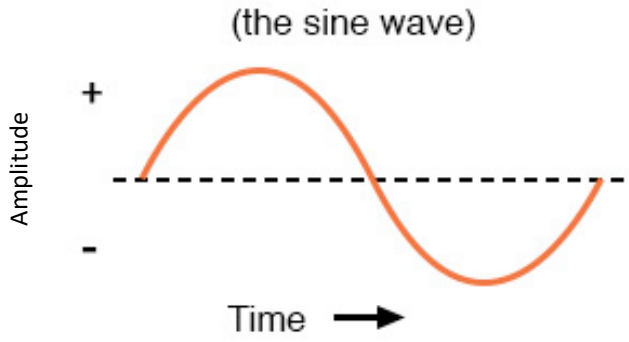
The "Time Domain"



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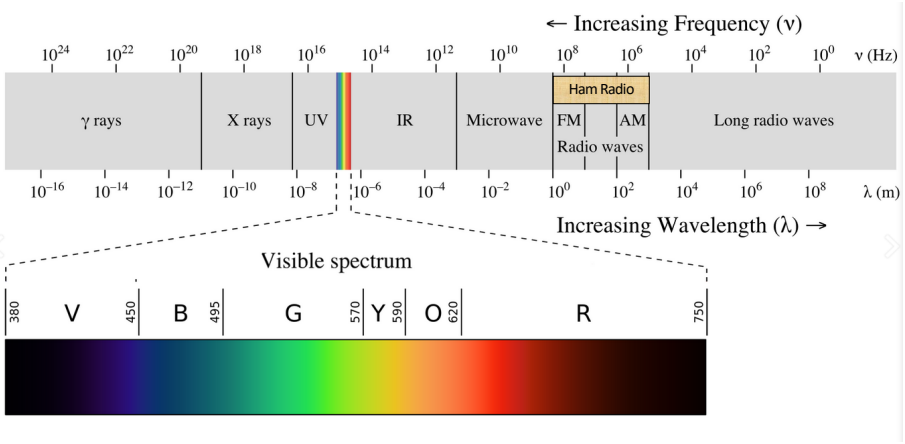
The "Frequency Domain"



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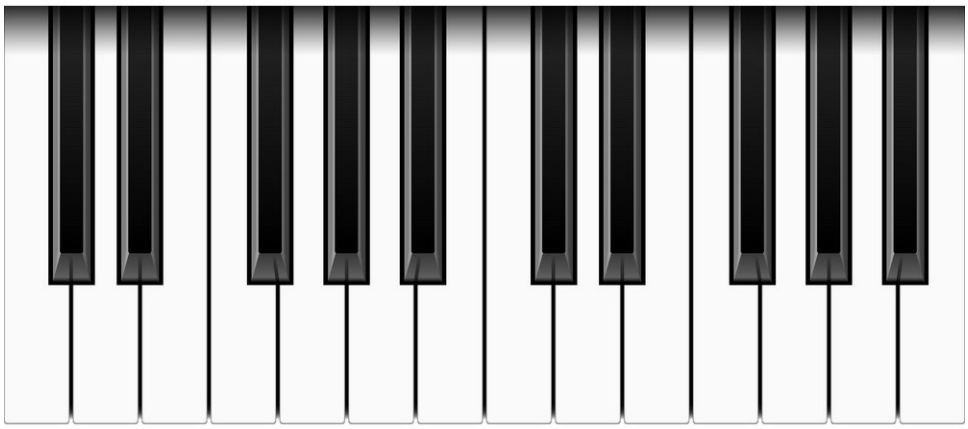
The Sound "Frequency Domain"



Frequency

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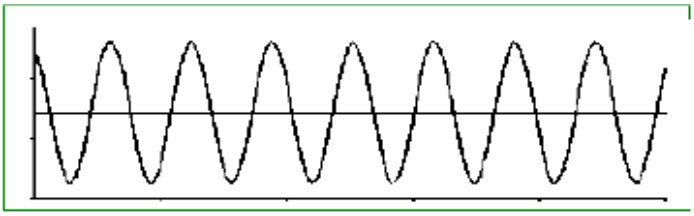
Time vs. Frequency

Fixed Frequency Signal



Frequency Spectrum

The Spectrum of a Sine Wave

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AM

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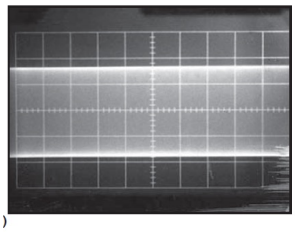
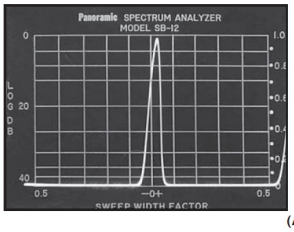
Carrier Amplitude Modulated by a Pure Tone

Time Domain

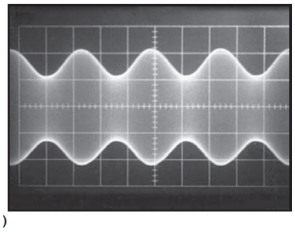
Frequency Domain

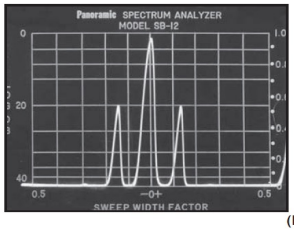
Carrier Only





Modulated Signal





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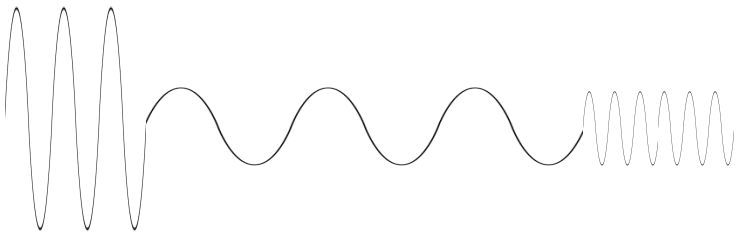
The Two Features of Audio

- Frequency
- Amplitude



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AM Voice Modulation

- The deviation = voice frequency
- Voice amplitude changes power output
- Filter limits audio frequency to 3kh
- Max Deviation is 3khz
- There are two sidebands
- The total bandwidth is 6khz

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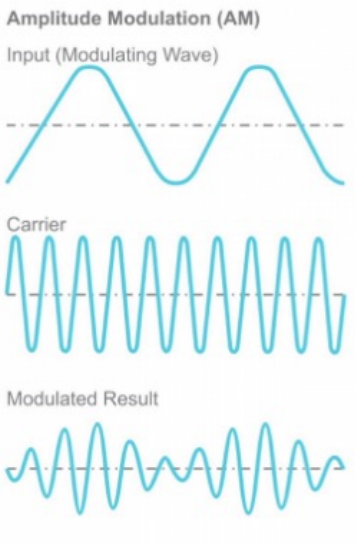
Amplitude Modulation



The information you want to transmit - such as your voice

The radio frequency you want to use

The signal that comes out of the radio

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Transmitting and Receiving an AM Signal

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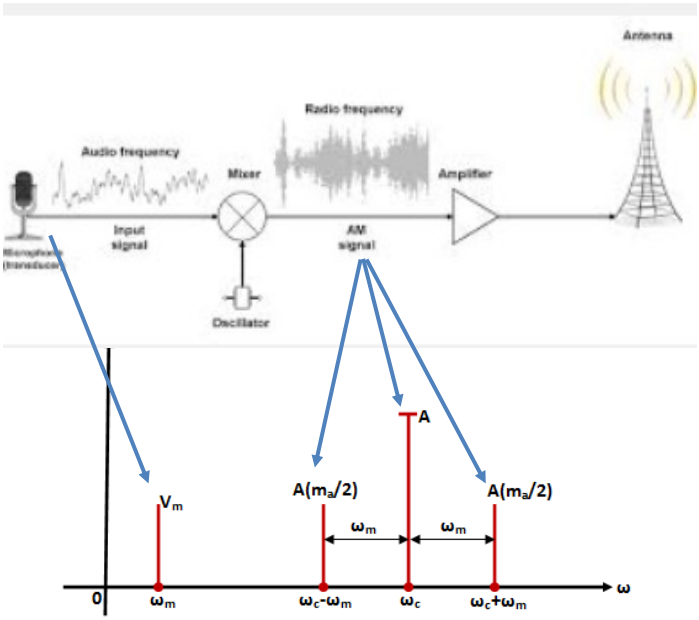
AM Transmitter



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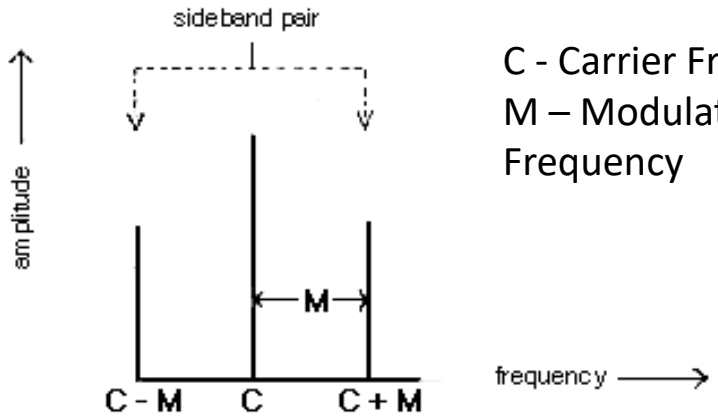
Modulation Creates Two Products



C - Carrier Frequency
M – Modulation Frequency

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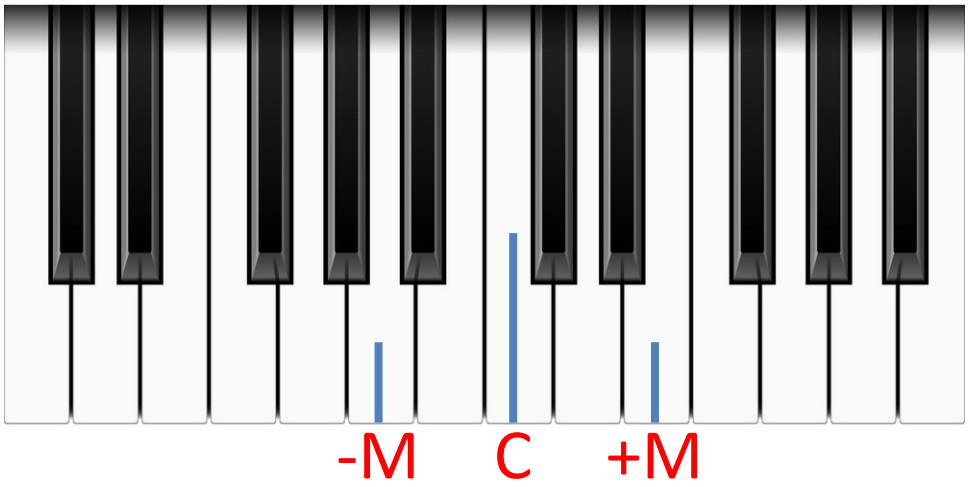
It's Sorta Like a Chord



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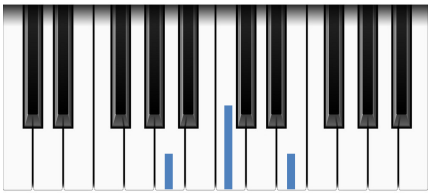
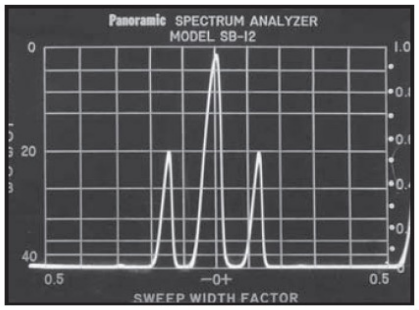
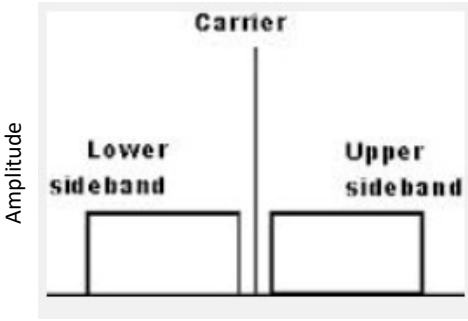
AM Has Two "Sidebands"







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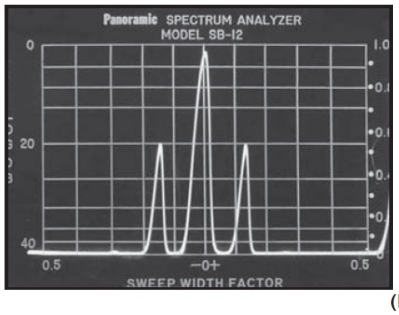
Can We Make AM Better?



- Most of the power is in the carrier
- The upper and lower sidebands are the same!
- Let's remove the carrier and one sideband
- We call that SINGLE SIDEBAND

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SSB

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SSB Voice Modulation

- Starts with an AM signal
- Filter out one sideband
- Bandwidth is half the AM bandwidth

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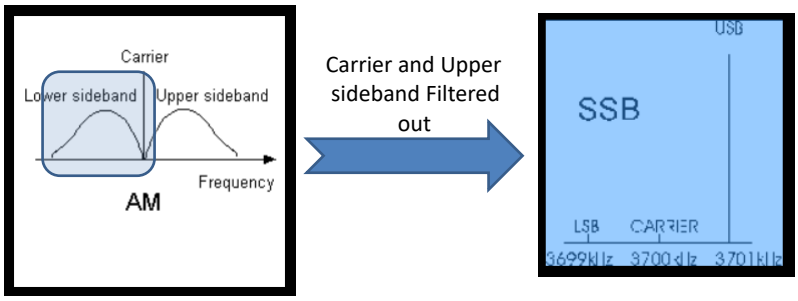
Single Side Band Signals



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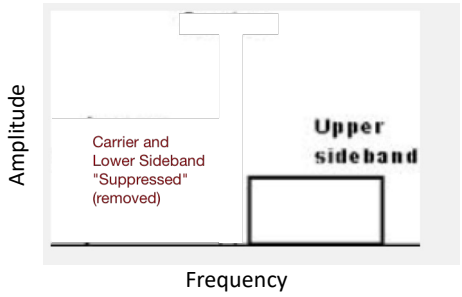
Single Sideband Modulation

- SSB is amplitude modulation with the carrier and one of the side lobes removed
- No carrier power is transmitted
- Only one copy of the modulation is transmitted



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What If We Disagree on Carrier Frequency?

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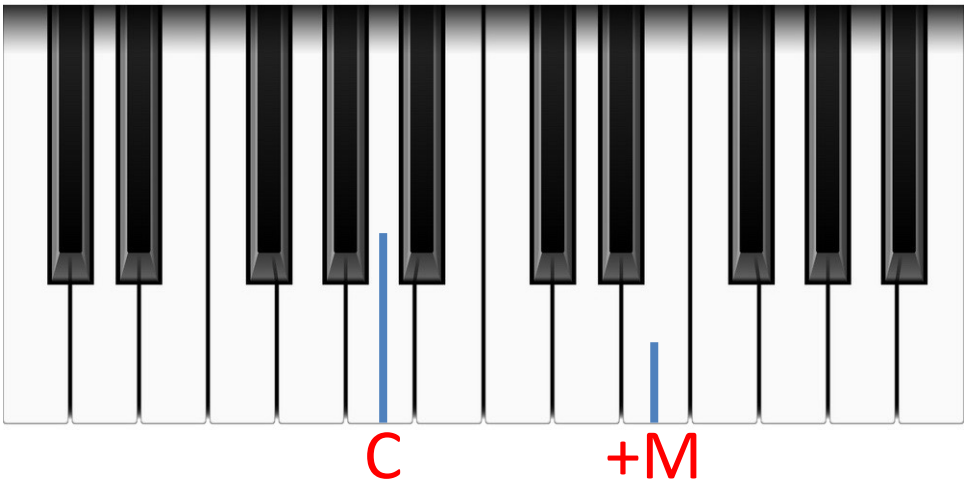
As You Move "C" the Pitch of "M" Changes



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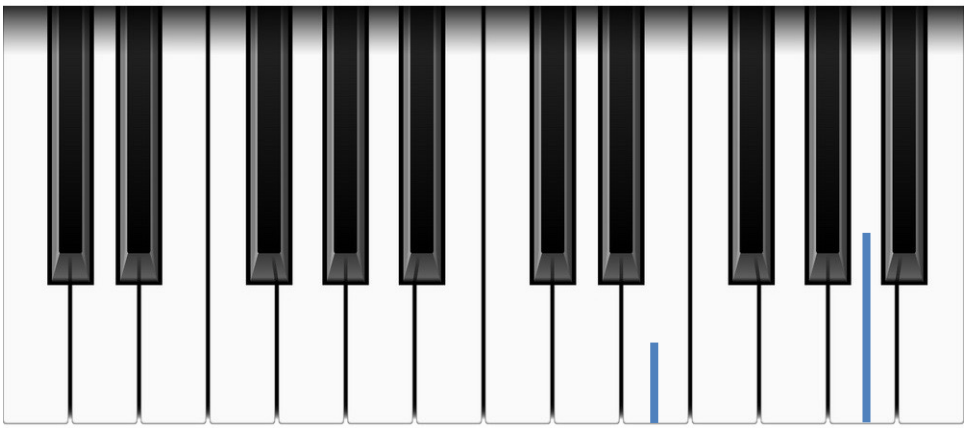
Being Upside Down Sounds Really Weird!



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SSB is Always Tuned by Ear

- But you do need to get the choice of sideband correct
- We do upper on higher bands (20m and above)
- We do lower on lower bands (40m, 80m, 160m)

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FM

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FM Modulation is More Complicated

- We still need to transmit both frequency and amplitude
- But FM output power *does not* change
- We encode *both* amplitude and frequency with just frequency!
- Let's start with a simpler case

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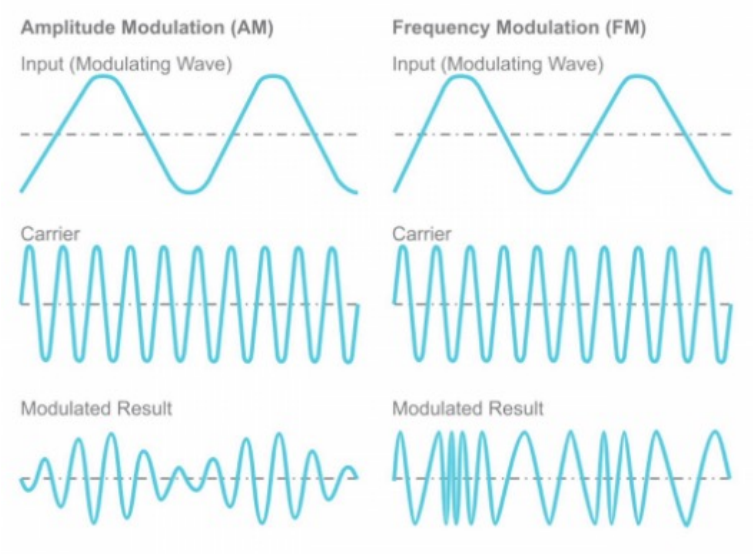
AM vs. FM



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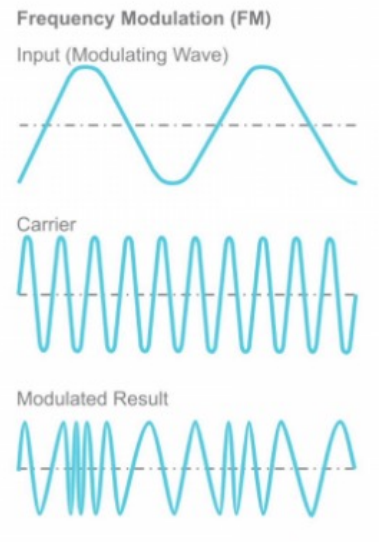
Frequency Modulation



The information you want to transmit - such as your voice

The radio frequency you want to use

The signal that comes out of the radio

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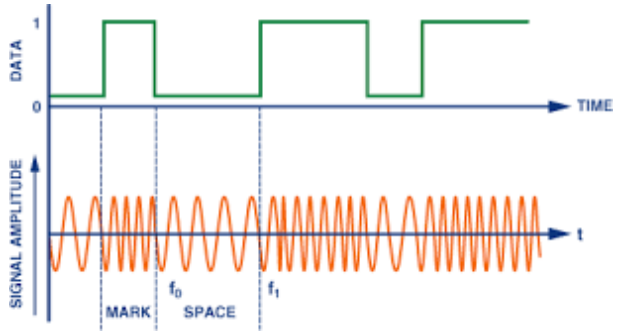
FSK Modulation

- Only 2 amplitudes in the data
- Output jumps between two frequencies
- Max deviation is twice the higher deviation [1 in this case]



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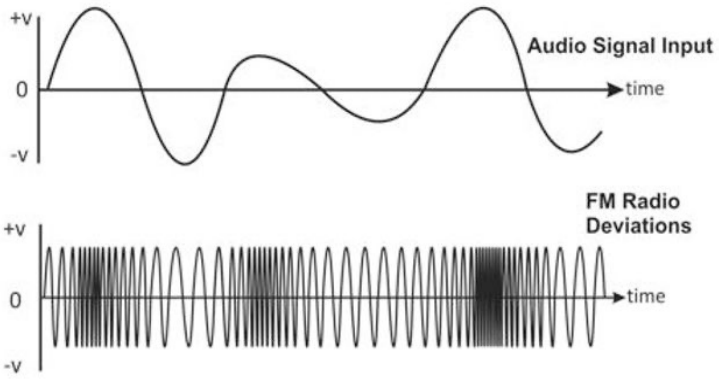
FM Audio Modulation

- Both amplitude and frequency change the deviation
- By how much?
- "Peak Deviation"
- The amount that amplitude changes frequency



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Why Use Different Types of Modulation

- AM?
  - Just say no! It's too inefficient
- SSB?
  - Most efficient transmission of voice
- CW?
  - Just showing off?
  - Very efficient
  - Great for noisy conditions and weak signals
- FT8/JS8Call/etc/etc
  - Even more efficient than CW and can work when nothing else will
- FM?
  - Nearly cell phone quality
  - VHF and above

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The Secret is in the Bandwidth

- CW: 150 Hz
- SSB: 3 KHz
- FM: 10-15 KHz
- Fast Scan TV: 6 MHz

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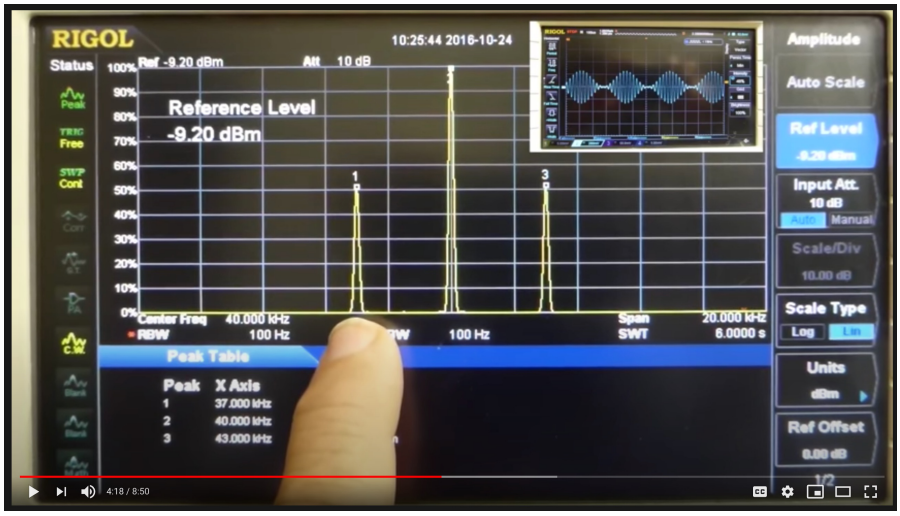
Modulation Demo

- https://www.youtube.com/watch?v=W7Z



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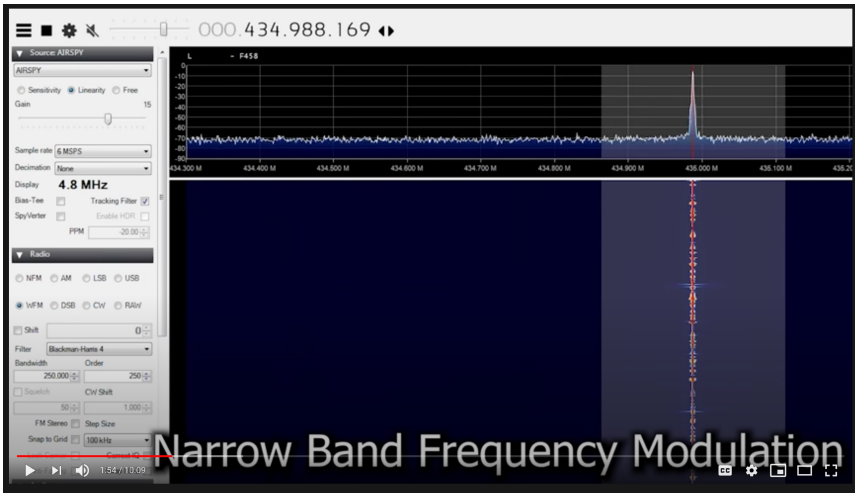
More Fun With Modulation

- https://www.youtube.com/watch?v=Ru2UOSwRzt4



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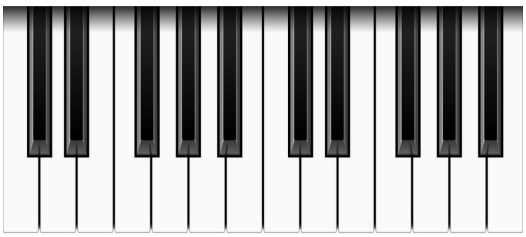
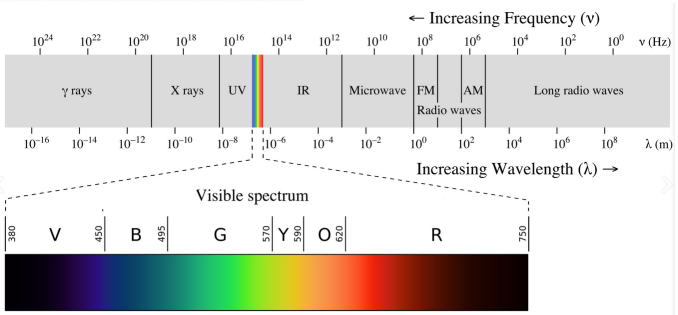
The Frequency Domain





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Deviation

- How Much Something Was Changed
- In our case, a frequency
- Carrier is *deviated* by modulation
- More deviation uses more bandwidth
- Kind of Modulation Changes the Math

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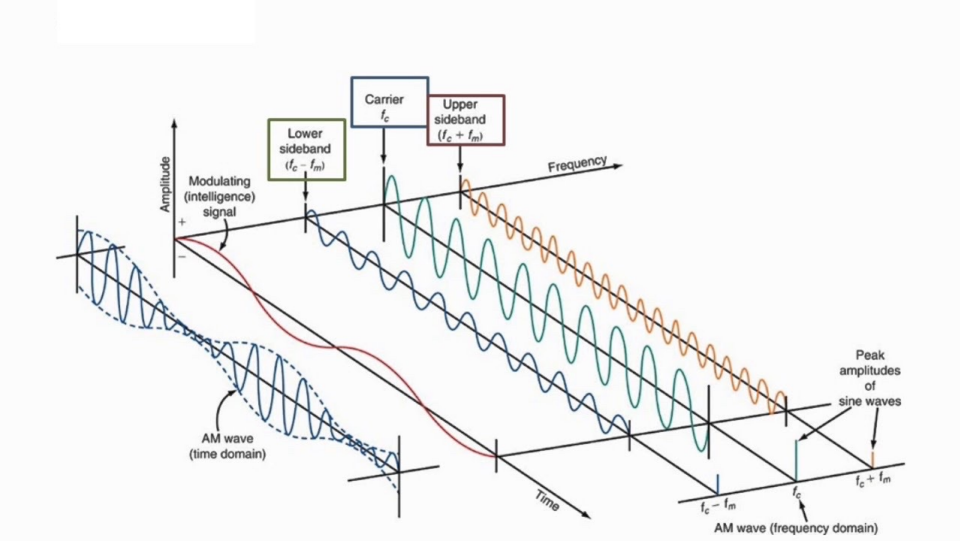
Time & Frequency Shown Together



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