Basics of HF Operating

Bands, modes, propagation, on-air procedures, and using rig controls to get the most out of your HF transceiver

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What Are The HF Bands?

- **Ten Frequency Ranges Between 1.8 and 30 MHz**
  - 160 Meters … 1.8 to 2.0 MHz
  - 80 Meters … 3.5 to 4.0 MHz
  - 60 Meters … 5330.5 to 5403.5 kHz (5 Specific Channels)
  - 40 Meters … 7.0 to 7.3 MHz
  - 30 Meters … 10.1 to 10.150 MHz
  - 20 Meters … 14.0 to 14.350 MHz
  - 17 Meters … 18.068 to 18.168 MHz
  - 15 Meters … 21.0 to 21.450 MHz
  - 12 Meters … 24.890 to 24.900 MHz
  - 10 Meters … 28.0 to 29.7 MHz

Why So Many Bands?

- Each HF band has particular propagation characteristics:
  - Long-range vs. Short-range
  - Daytime vs. Nighttime
  - Summer vs. Winter
  - Top vs. Bottom of Sunspot Cycle
- Also:
  - Noise Levels
  - Types of QSOs Found Most Often

“Lower” vs “Higher” Bands

- Generally Speaking:
  - Lower Bands (160-40 Meters)
    - Better in Winter than Summer
    - Better at Bottom of Sunspot Cycle
    - Local/Regional Daytime -- DX at Night
  - Higher Bands (30-10 Meters)
    - Better in Summer Than Winter
    - Better at Top of Sunspot Cycle
    - DX Day and Night (at top of cycle)
    - DX Day - Closed at Night (bottom of cycle)

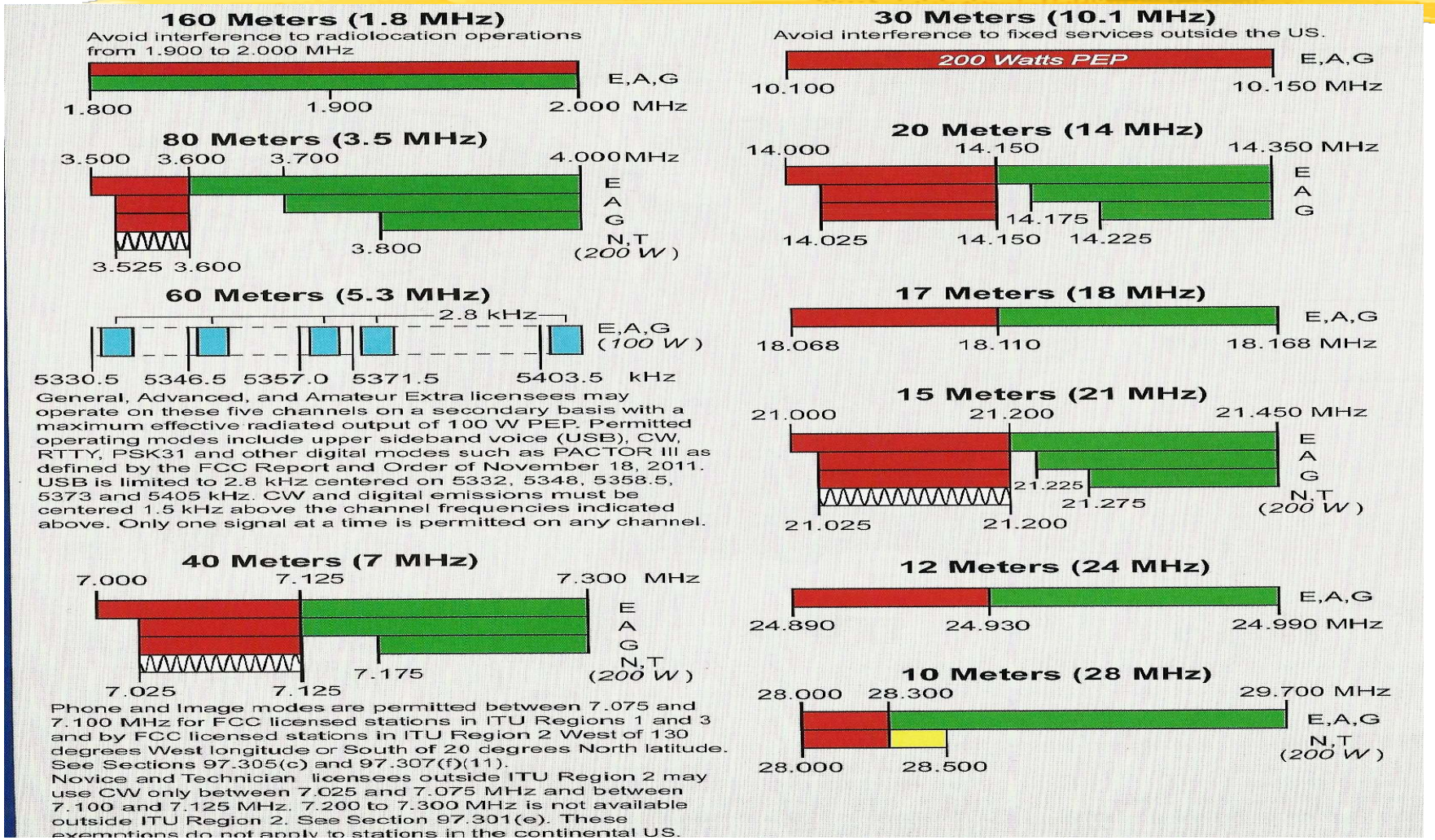
HF Sub-Bands

- Each HF Band is divided into frequency ranges for specific:
  - Modes -- cw, digital/data, phone
  - License Classes
    - Novice / Technician
    - General
    - Advanced
    - Extra

HF Sub-Bands by Mode

- **CW**
  - Permitted on **any** frequency on **any** band
  - Generally found in lowest part of each band
- **Digital/Data**
  - Permitted in lowest part of each band
  - Generally found just above cw
- **Phone**
  - Permitted in the upper 1/2 to 3/4 of each band
    - LSB on 40 Meters and below
    - USB above 40 Meters

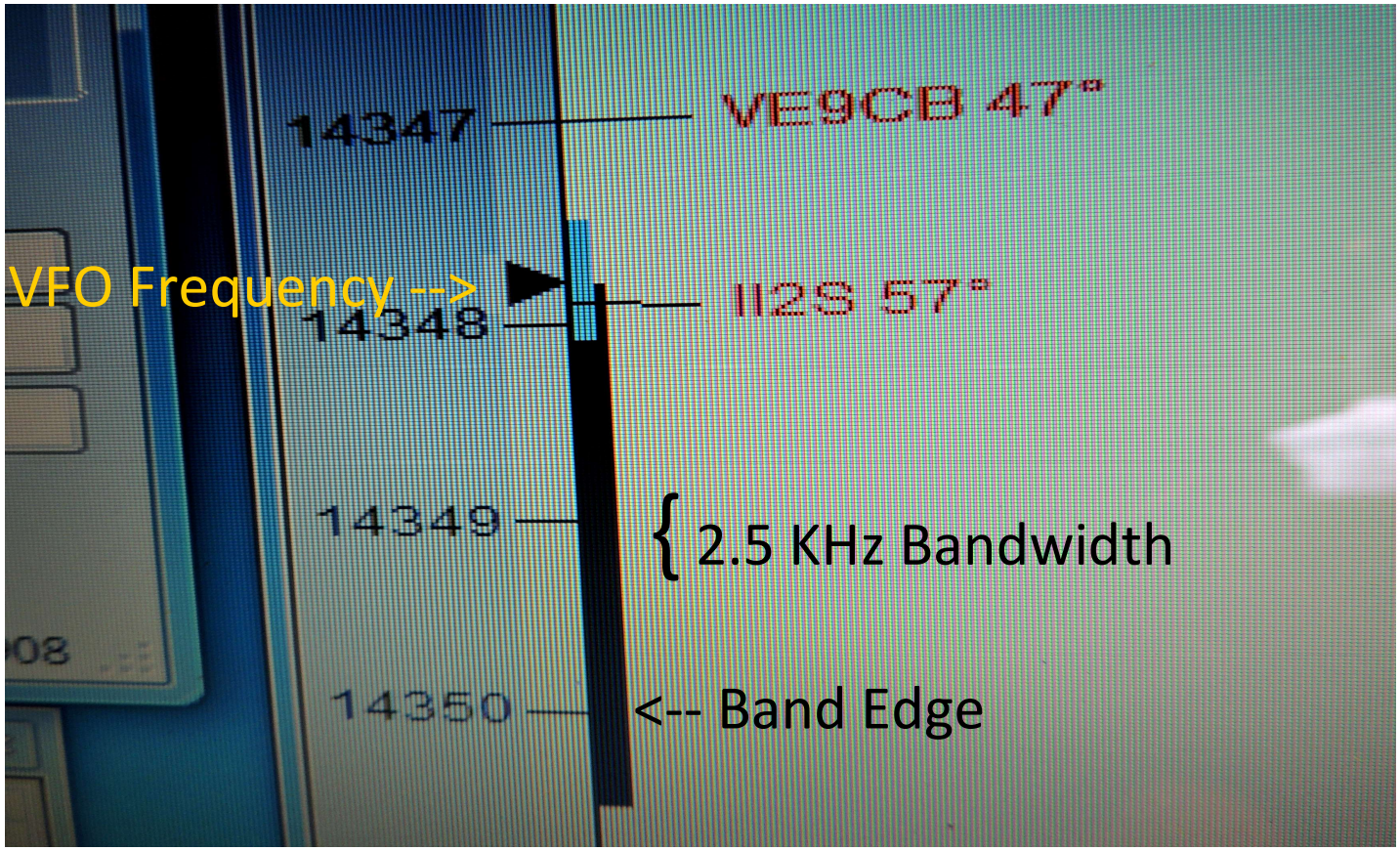
HF Sub-Bands by License



Be Aware of Band and Sub-Band Edges

- On SSB, Bandwidth typically is 2.5 - 3 KHz
  - Therefore … stay at least 3 KHz from the edge of band or sub-band
  - On LSB … 3 KHz **ABOVE** the bottom edge
  - On USB … 3 KHz **BELOW** the top edge
- Examples:
  - **Bottom** of 40-Meter General Phone Sub-Band is 7.175 MHz. Transmit **no lower** than 7.178 MHz.
  - **Top** of 20-Meter Phone Band is 14.350 MHz. Transmit **no higher** than 14.347 Mhz.

Out of Band!


14347
VE9CB 47°
VFO Frequency -->
14348
II2S 57°
14349
{ 2.5 KHz Bandwidth
14350
<-- Band Edge

What Modes Where On Each Band

The Considerate Operator's Frequency Guide

The following frequencies are generally recognized for certain modes or activities (all frequencies are in MHz) during normal conditions. These are not regulations and occasionally a high level of activity, such as during a period of emergency response, DXpedition or contest, may result in stations operating outside these frequency ranges.

Nothing in the rules recognizes a net's, group's or any individual's special privilege to any specific frequency. Section 97.101(b) of the Rules states that "Each station licensee and each control operator must cooperate in selecting transmitting channels and in making the most effective use of the amateur service frequencies. No frequency will be assigned for the exclusive use of any station." No one "owns" a frequency.

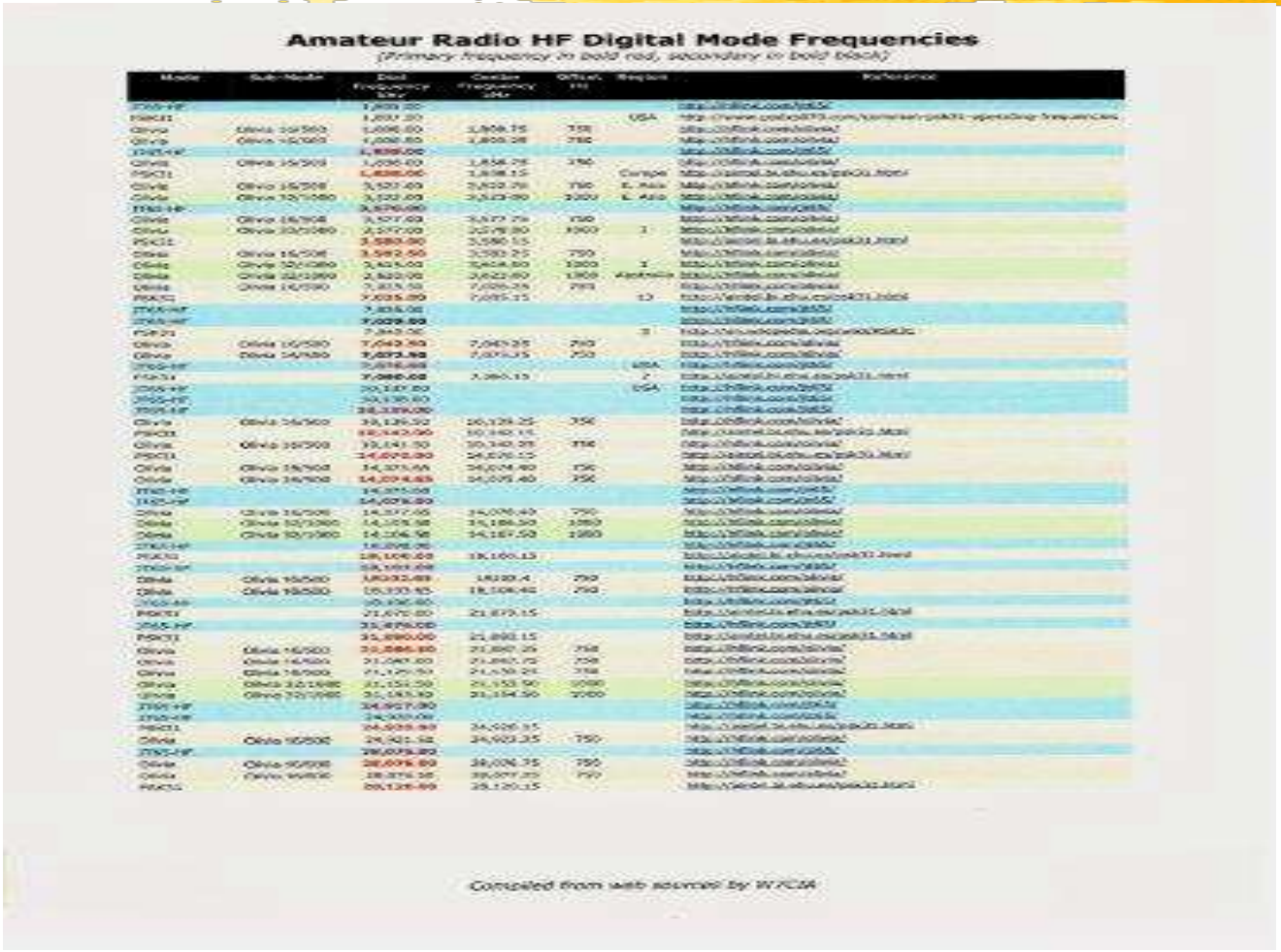
It's good practice — and plain old common sense — for any operator, regardless of mode, to check to see if the frequency is in use prior to engaging operation. If you are there first, other operators should make an effort to protect you from interference to the extent possible, given that 100% interference-free operation is an unrealistic expectation in today's congested bands.

Frequencies	Modes/Activities
1.800-2.000	CW
1.800-1.810	Digital Modes
1.810	CW QRP calling frequency
1.843-2.000	SSB, SSTV and other wideband modes
1.910	SSB QRP
1.995-2.000	Experimental
1.999-2.000	Beacons
3.500-3.510	CW DX window
3.560	QRP CW calling frequency
3.570-3.600	RTTY/Data
3.585-3.600	Automatically controlled data stations
3.590	RTTY/Data DX
3.790-3.800	DX window
3.845	SSTV
3.885	AM calling frequency
3.985	QRP SSB calling frequency
7.030	QRP CW calling frequency
7.040	RTTY/Data DX
7.070-7.125	RTTY/Data
7.100-7.105	Automatically controlled data stations
7.171	SSTV
7.173	D-SSTV
7.285	QRP SSB calling frequency
7.290	AM calling frequency
10.130-10.140	RTTY/Data
10.140-10.150	Automatically controlled data stations
14.060	QRP CW calling frequency
14.070-14.095	RTTY/Data
14.095-14.0995	Automatically controlled data stations
14.100	IBP/NCDXF beacons
14.1005-14.112	Automatically controlled data stations
14.230	SSTV

Frequencies	Modes/Activities
14.233	D-SSTV
14.236	Digital Voice
14.285	QRP SSB calling frequency
14.286	AM calling frequency
18.100-18.105	RTTY/Data
18.105-18.110	Automatically controlled data stations
18.110	IBP/NCDXF beacons
18.162.5	Digital Voice
21.060	QRP CW calling frequency
21.070-21.110	RTTY/Data
21.090-21.100	Automatically controlled data stations
21.150	IBP/NCDXF beacons
21.340	SSTV
21.385	QRP SSB calling frequency
24.920-24.925	RTTY/Data
24.925-24.930	Automatically controlled data stations
24.930	IBP/NCDXF beacons
28.060	QRP CW calling frequency
28.070-28.120	RTTY/Data
28.120-28.189	Automatically controlled data stations
28.190-28.225	Beacons
28.200	IBP/NCDXF beacons
28.385	QRP SSB calling frequency
28.680	SSTV
29.000-29.200	AM
29.300-29.510	Satellite downlinks
29.520-29.580	Repeater inputs
29.600	FM simplex
29.620-29.680	Repeater outputs

ARRL band plans for frequencies above 28.300 MHz are shown in The ARRL Repeater Directory and on www.arrl.org.

Digital Mode
“Watering Holes”



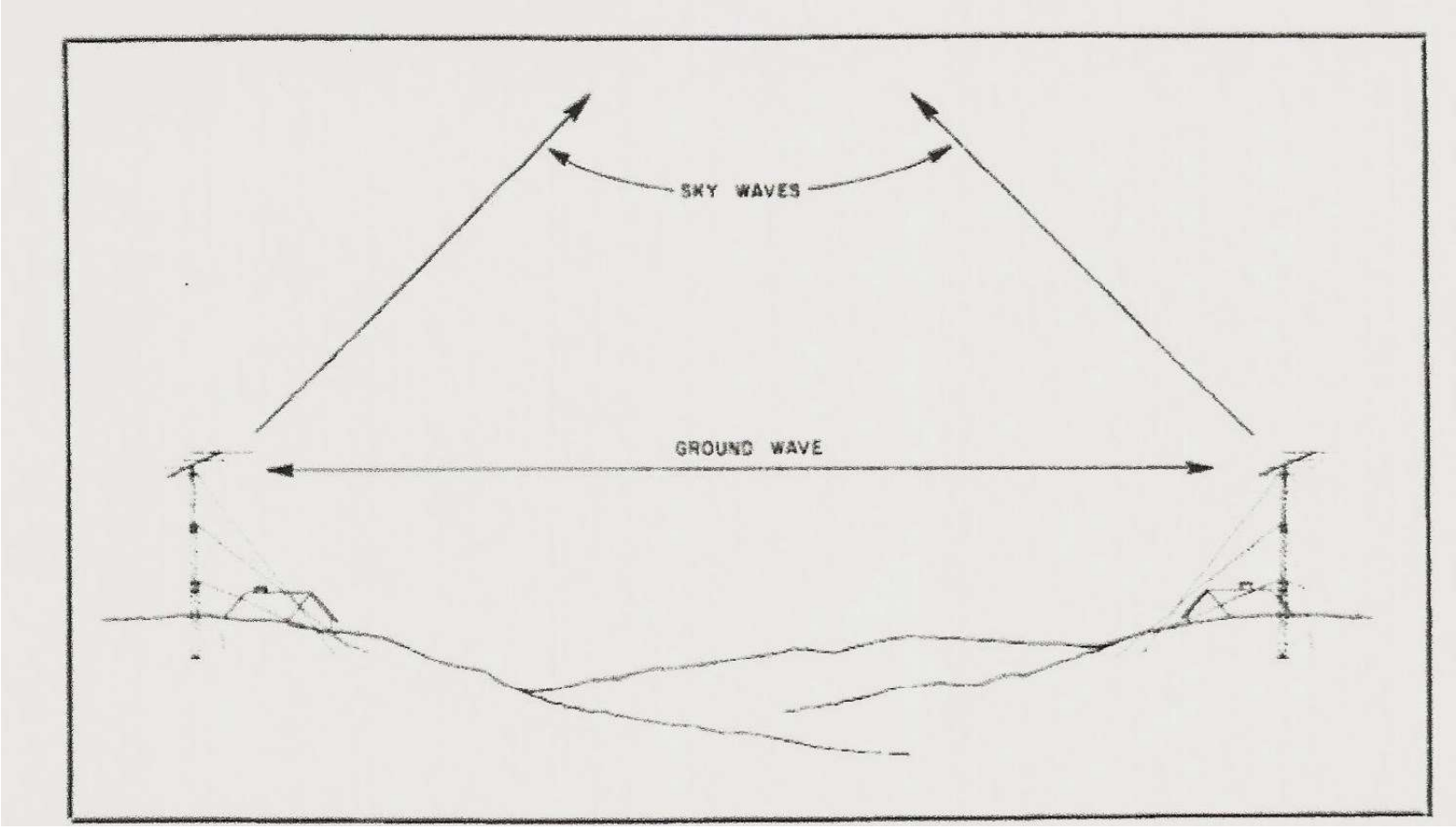
Amateur Radio HF Digital Mode Frequencies

(Primary frequency in bold red, secondary in bold black)

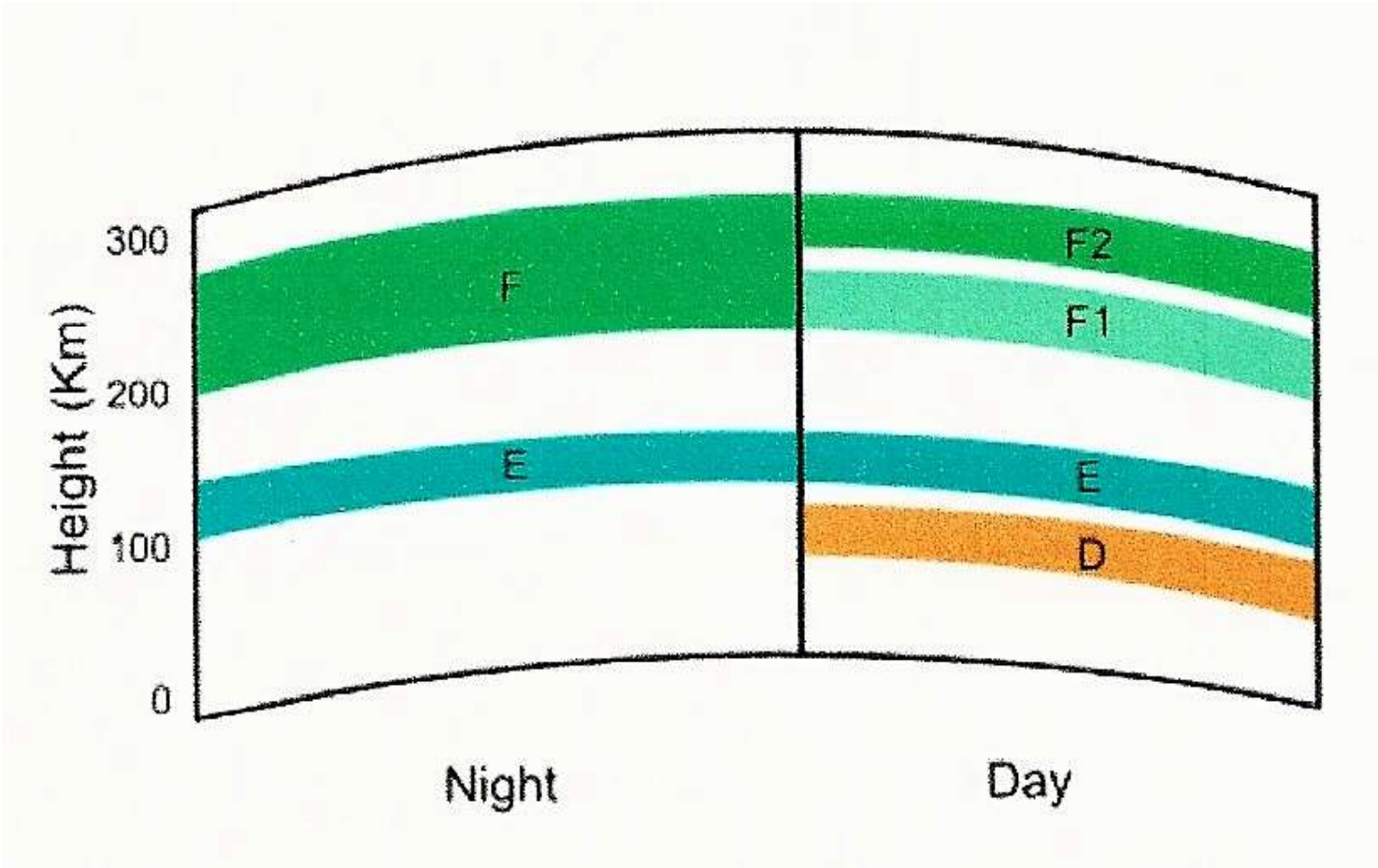
Mode	Sub-Mode	Dial Frequency kHz	Center Frequency kHz	Offset Hz	Region	Reference
JT65-HF		1,838.00				http://physics.princeton.edu/pulsar/K1JT/
PSK31		1,837.00			USA	http://www.psk31.com/tutorial/psk31-operating-frequencies
Olivia	Olivia 16/500	1,836.00	1,838.75	750		http://fldigi.com/node/
Olivia	Olivia 16/500	1,836.00	1,838.25	750		http://fldigi.com/node/
JT65-HF		1,838.00				http://physics.princeton.edu/pulsar/K1JT/
Olivia	Olivia 16/500	1,836.00	1,838.75	750		http://fldigi.com/node/
PSK31		1,838.00	1,838.15		Europe	http://ham.te.chiba-u.ac.jp/psk31.html
Olivia	Olivia 16/500	3,577.00	3,579.75	750	E. Asia	http://fldigi.com/node/
Olivia	Olivia 32/1000	3,577.00	3,579.50	1000	E. Asia	http://fldigi.com/node/
JT65-HF		3,576.00				http://physics.princeton.edu/pulsar/K1JT/
Olivia	Olivia 16/500	3,577.00	3,577.75	750		http://fldigi.com/node/
Olivia	Olivia 32/1000	3,577.00	3,579.50	1000	1	http://fldigi.com/node/
PSK31		3,580.00	3,580.15			http://ham.te.chiba-u.ac.jp/psk31.html
Olivia	Olivia 16/500	3,582.50	3,580.25	750		http://fldigi.com/node/
Olivia	Olivia 32/1000	3,405.00	3,404.50	1000	1	http://fldigi.com/node/
Olivia	Olivia 32/1000	3,820.00	3,820.50	1000	Alaska	http://fldigi.com/node/
Olivia	Olivia 16/500	7,035.50	7,035.25	750		http://fldigi.com/node/
PSK31		7,035.00	7,035.15		1?	http://ham.te.chiba-u.ac.jp/psk31.html
JT65-HF		7,076.00				http://physics.princeton.edu/pulsar/K1JT/
JT65-HF		7,078.00				http://physics.princeton.edu/pulsar/K1JT/
FSK31		7,043.00			1	http://ch1ehq.ch/pipermail/digitalradio/
Olivia	Olivia 16/500	7,040.50	7,040.25	750		http://fldigi.com/node/
Olivia	Olivia 16/500	7,073.50	7,073.25	750		http://fldigi.com/node/
JT65-HF		7,076.00			USA	http://physics.princeton.edu/pulsar/K1JT/
FSK31		7,080.00	7,080.15		2	http://ham.te.chiba-u.ac.jp/psk31.html
JT65-HF		10,137.00			USA	http://physics.princeton.edu/pulsar/K1JT/
JT65-HF		10,138.00				http://physics.princeton.edu/pulsar/K1JT/
JT65-HF		10,139.00				http://physics.princeton.edu/pulsar/K1JT/
Olivia	Olivia 16/500	10,139.50	10,139.25	750		http://fldigi.com/node/
PSK31		10,142.00	10,140.15			http://ham.te.chiba-u.ac.jp/psk31.html
Olivia	Olivia 16/500	10,141.50	10,140.25	750		http://fldigi.com/node/
PSK31		14,070.00	14,070.15			http://ham.te.chiba-u.ac.jp/psk31.html
Olivia	Olivia 16/500	14,071.50	14,074.40	750		http://fldigi.com/node/
Olivia	Olivia 16/500	14,074.00	14,075.40	750		http://fldigi.com/node/
JT65-HF		14,076.00				http://physics.princeton.edu/pulsar/K1JT/
JT65-HF		14,078.00				http://physics.princeton.edu/pulsar/K1JT/
Olivia	Olivia 16/500	14,077.00	14,076.40	750		http://fldigi.com/node/
Olivia	Olivia 32/1000	14,074.00	14,186.50	1000		http://fldigi.com/node/
Olivia	Olivia 32/1000	14,174.00	14,187.50	1000		http://fldigi.com/node/
JT65-HF		14,076.00				http://physics.princeton.edu/pulsar/K1JT/
PSK31		18,100.00	18,100.15			http://ham.te.chiba-u.ac.jp/psk31.html
JT65-HF		18,102.00				http://physics.princeton.edu/pulsar/K1JT/
Olivia	Olivia 16/500	18,097.00	18,098.4	750		http://fldigi.com/node/
Olivia	Olivia 16/500	18,173.00	18,108.40	750		http://fldigi.com/node/
JT65-HF		21,076.00				http://physics.princeton.edu/pulsar/K1JT/
PSK31		21,070.00	21,073.15			http://ham.te.chiba-u.ac.jp/psk31.html
JT65-HF		21,076.00				http://physics.princeton.edu/pulsar/K1JT/
PSK31		21,080.00	21,080.15			http://ham.te.chiba-u.ac.jp/psk31.html
Olivia	Olivia 16/500	21,084.00	21,082.25	750		http://fldigi.com/node/
Olivia	Olivia 16/500	21,087.00	21,082.75	750		http://fldigi.com/node/
Olivia	Olivia 16/500	21,170.50	21,170.25	750		http://fldigi.com/node/
Olivia	Olivia 32/1000	21,151.50	21,153.50	1000		http://fldigi.com/node/
Olivia	Olivia 32/1000	21,183.50	21,184.50	1000		http://fldigi.com/node/
JT65-HF		24,917.00				http://physics.princeton.edu/pulsar/K1JT/
JT65-HF		24,919.00				http://physics.princeton.edu/pulsar/K1JT/
PSK31		24,919.00	24,920.15			http://ham.te.chiba-u.ac.jp/psk31.html
Olivia	Olivia 16/500	24,921.50	24,920.25	750		http://fldigi.com/node/
JT65-HF		24,971.00				http://physics.princeton.edu/pulsar/K1JT/
Olivia	Olivia 16/500	28,076.00	28,076.25	750		http://fldigi.com/node/
Olivia	Olivia 16/500	28,076.00	28,077.25	750		http://fldigi.com/node/
PSK31		28,120.00	28,120.15			http://ham.te.chiba-u.ac.jp/psk31.html

Compiled from web sources by W7CIM

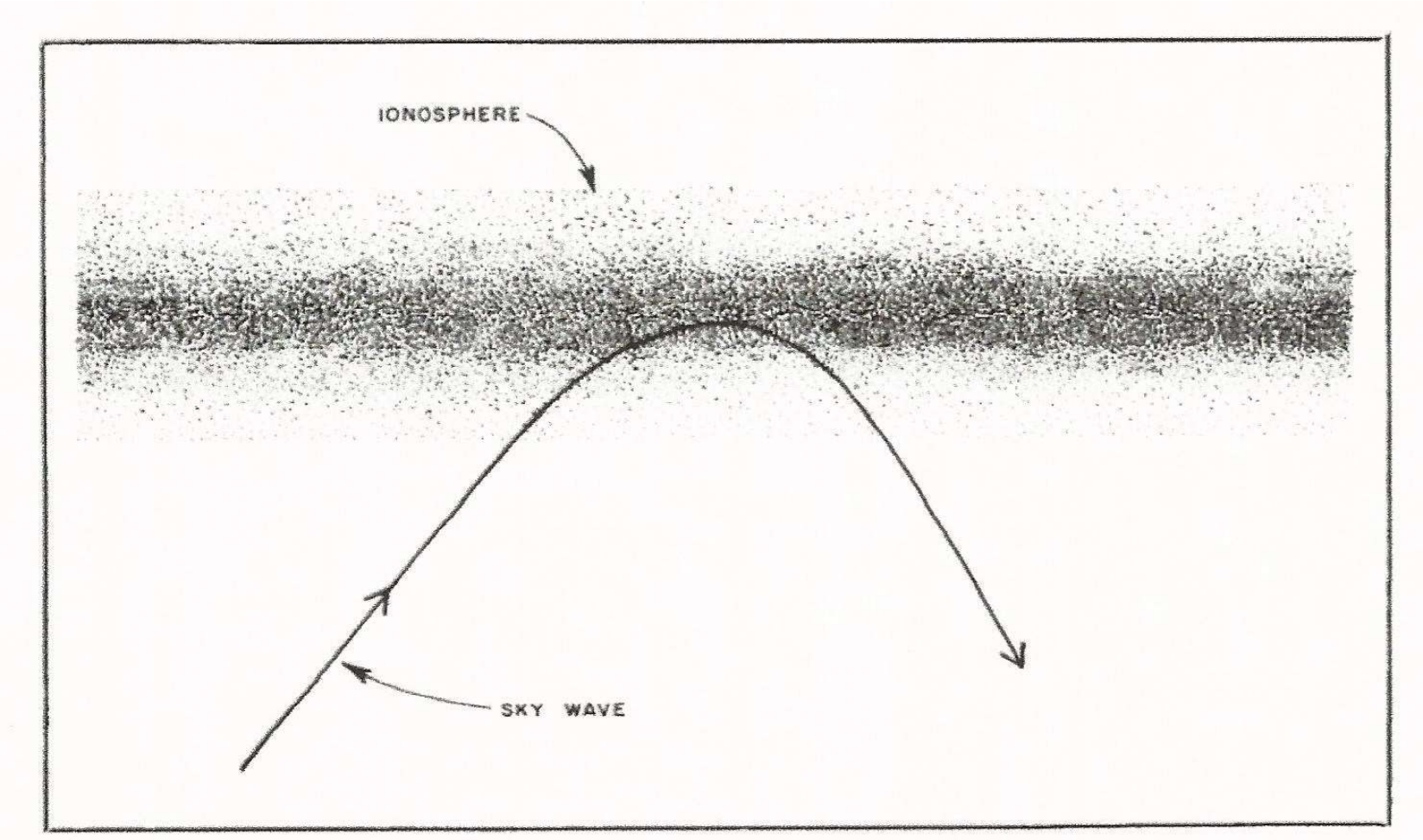
HF Propagation:
Ground Wave / Sky Waves



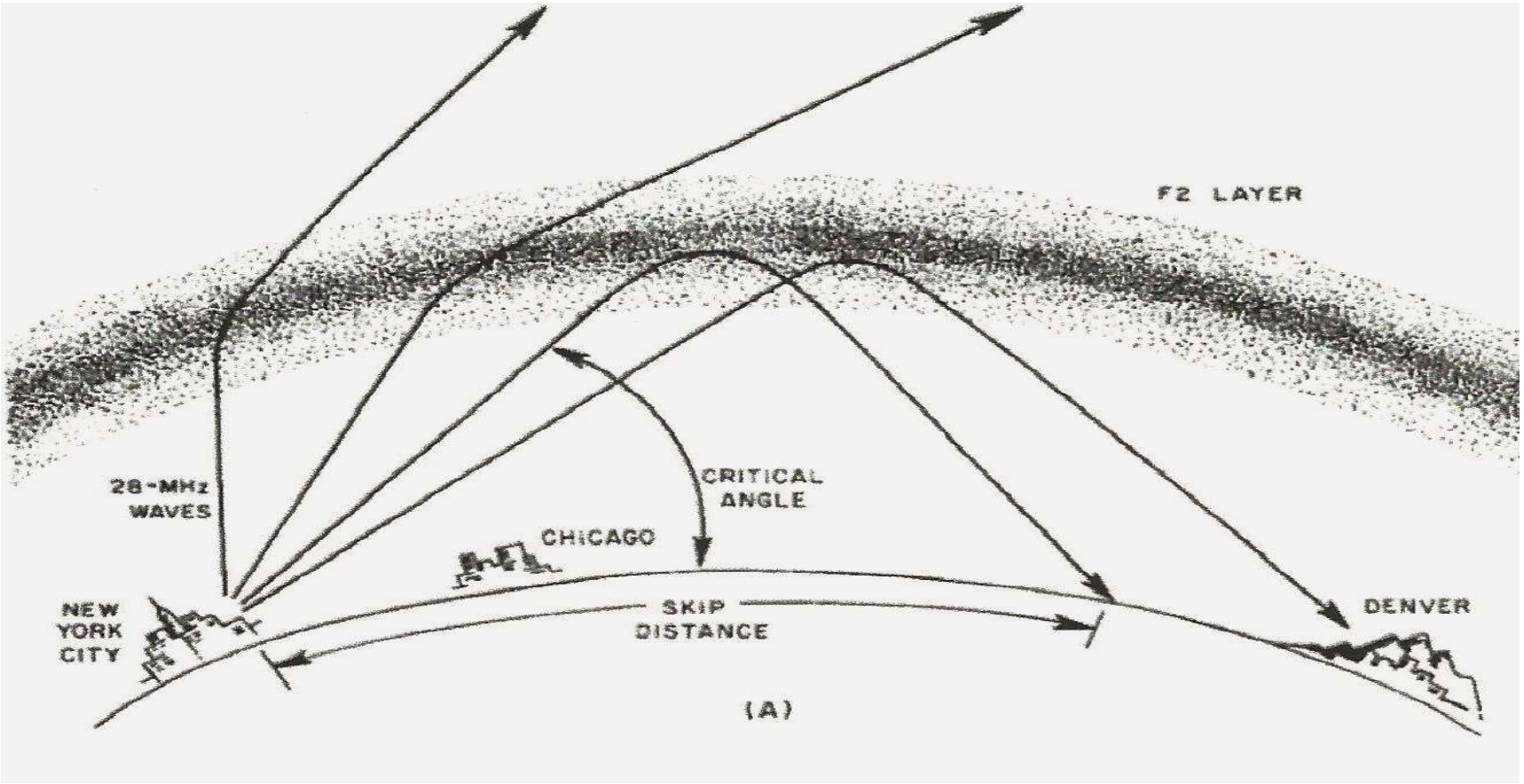
HF Propagation: The Ionosphere Layers



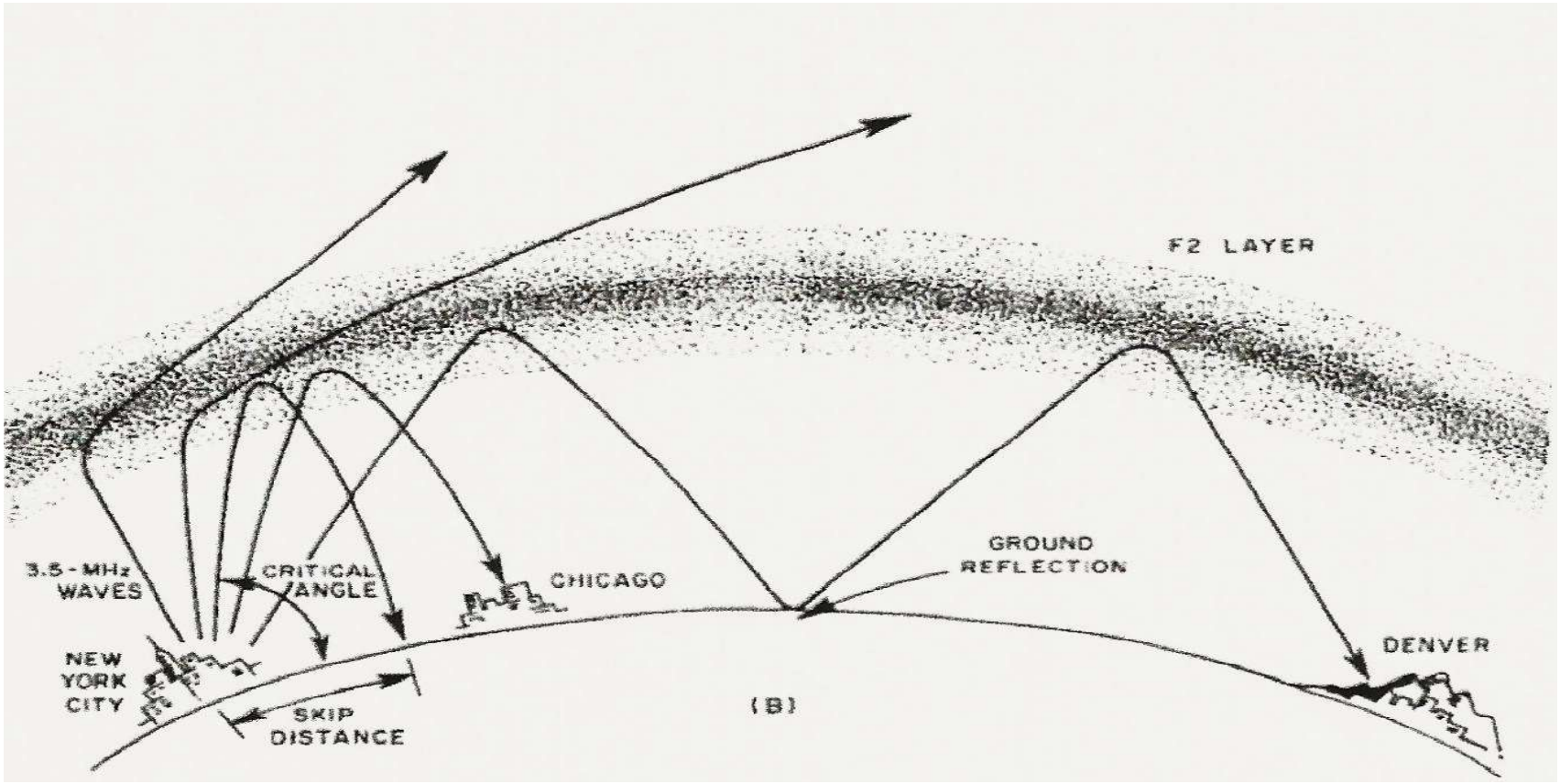
The Ionosphere Can Refract Sky Waves



Sky Wave Refraction: Long-Distance "Skip"



Multi-Hop Propagation

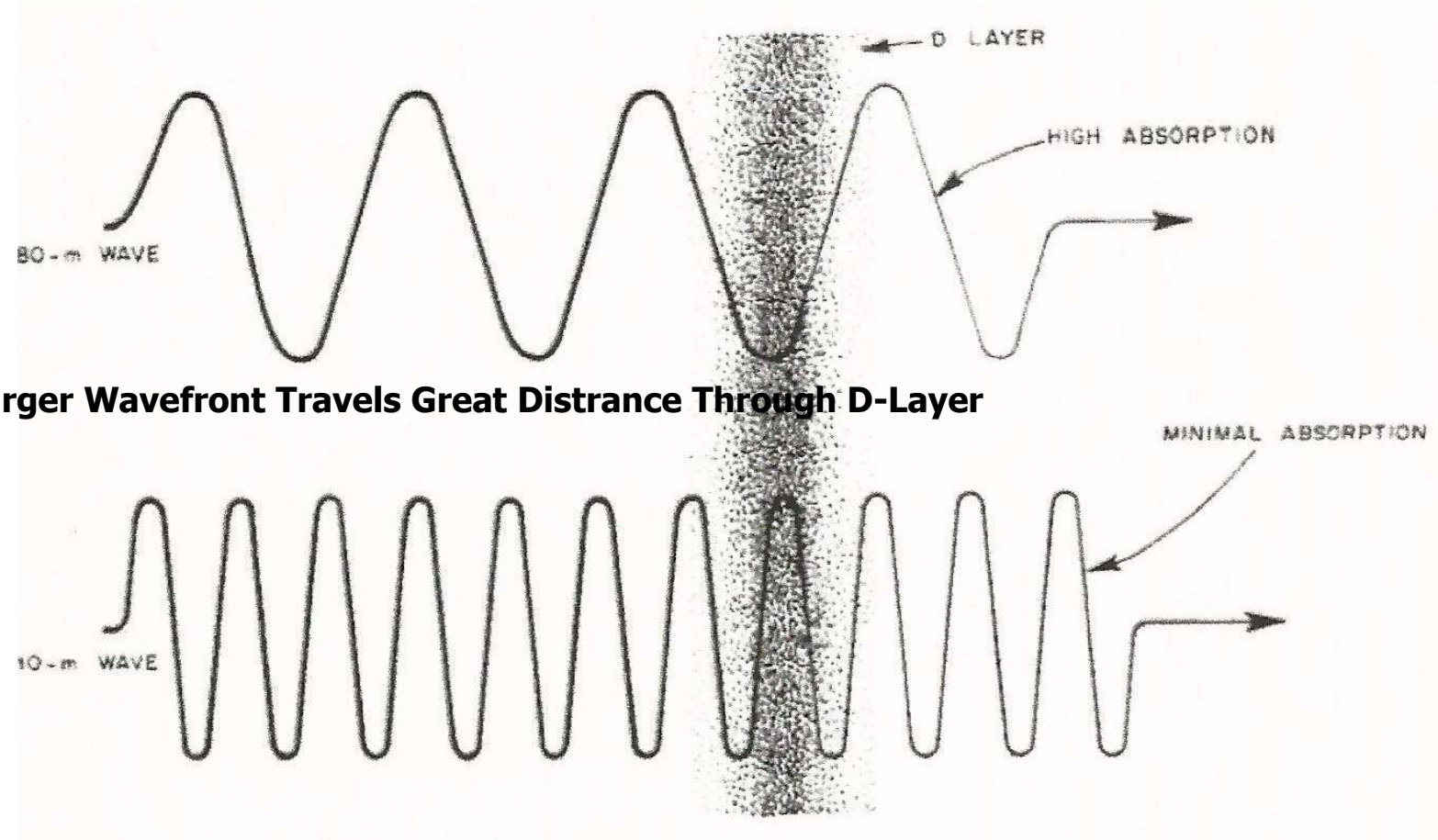


Which Bands When?

- Lower Frequency Bands
  - 160, 80, 60, 40 Meters
    - Ground Wave Daytime (Local / Regional)
    - Sky Wave Nighttime (DX)
- Upper Frequency Bands
  - 30, 20, 17, 15, 10 Meters
  - Both Ground Wave & Sky Wave Day and Night (When Open)

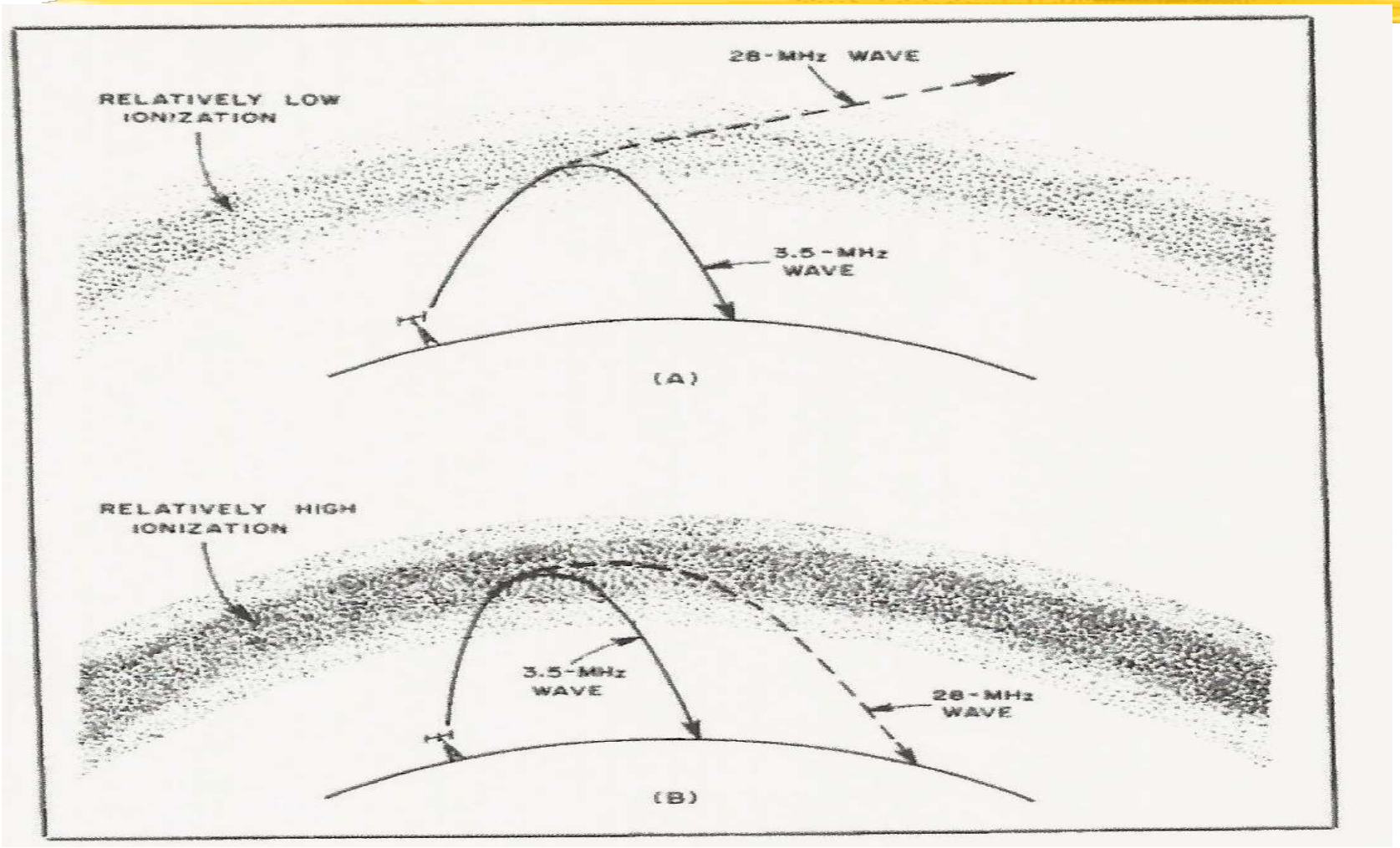
D-Layer Absorption

Lower Frequency = Higher Absorption



Larger Wavefront Travels Great Distrance Through D-Layer

Frequency and Ionization Level

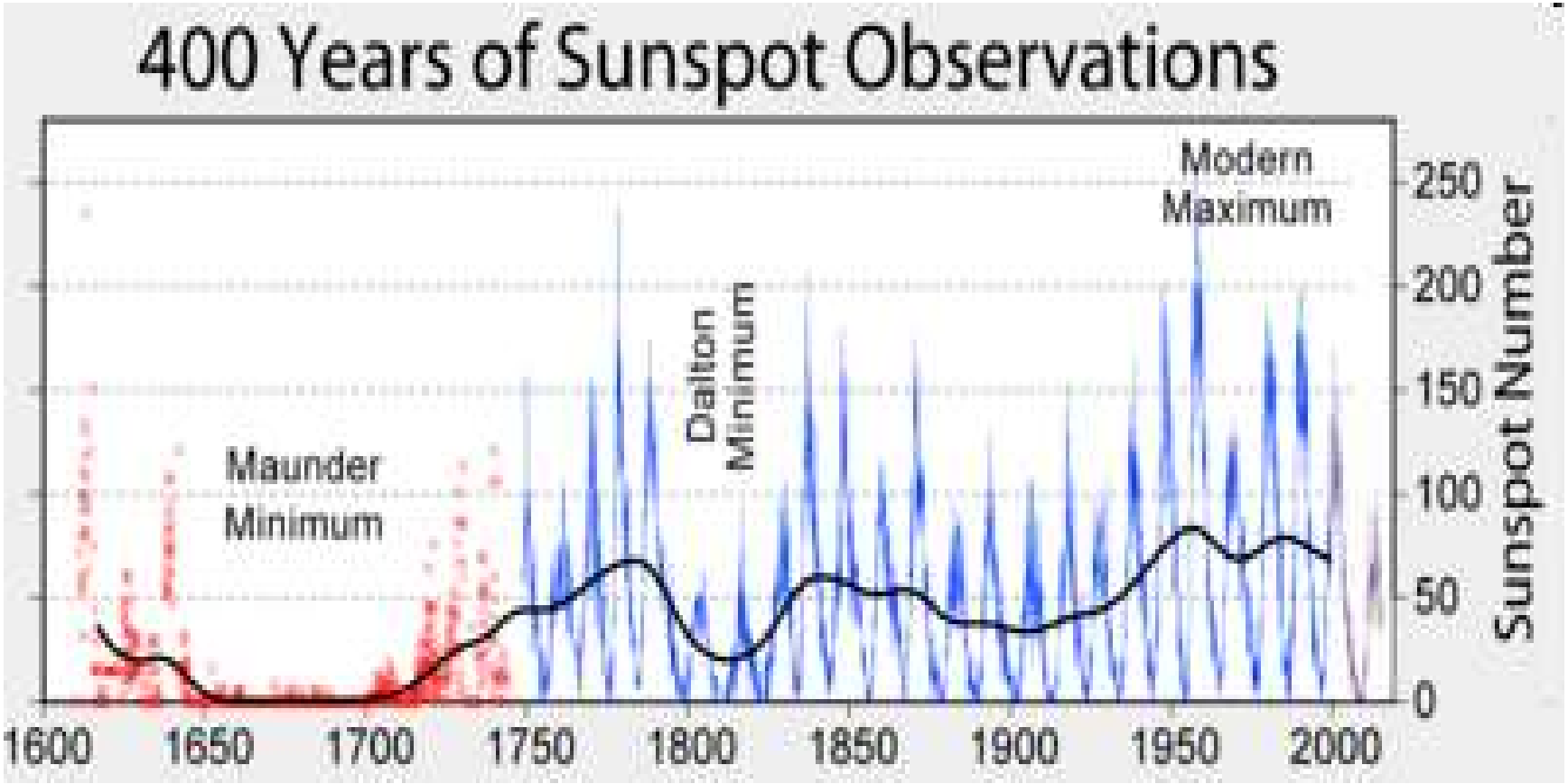


Sky Wave & Sunspots

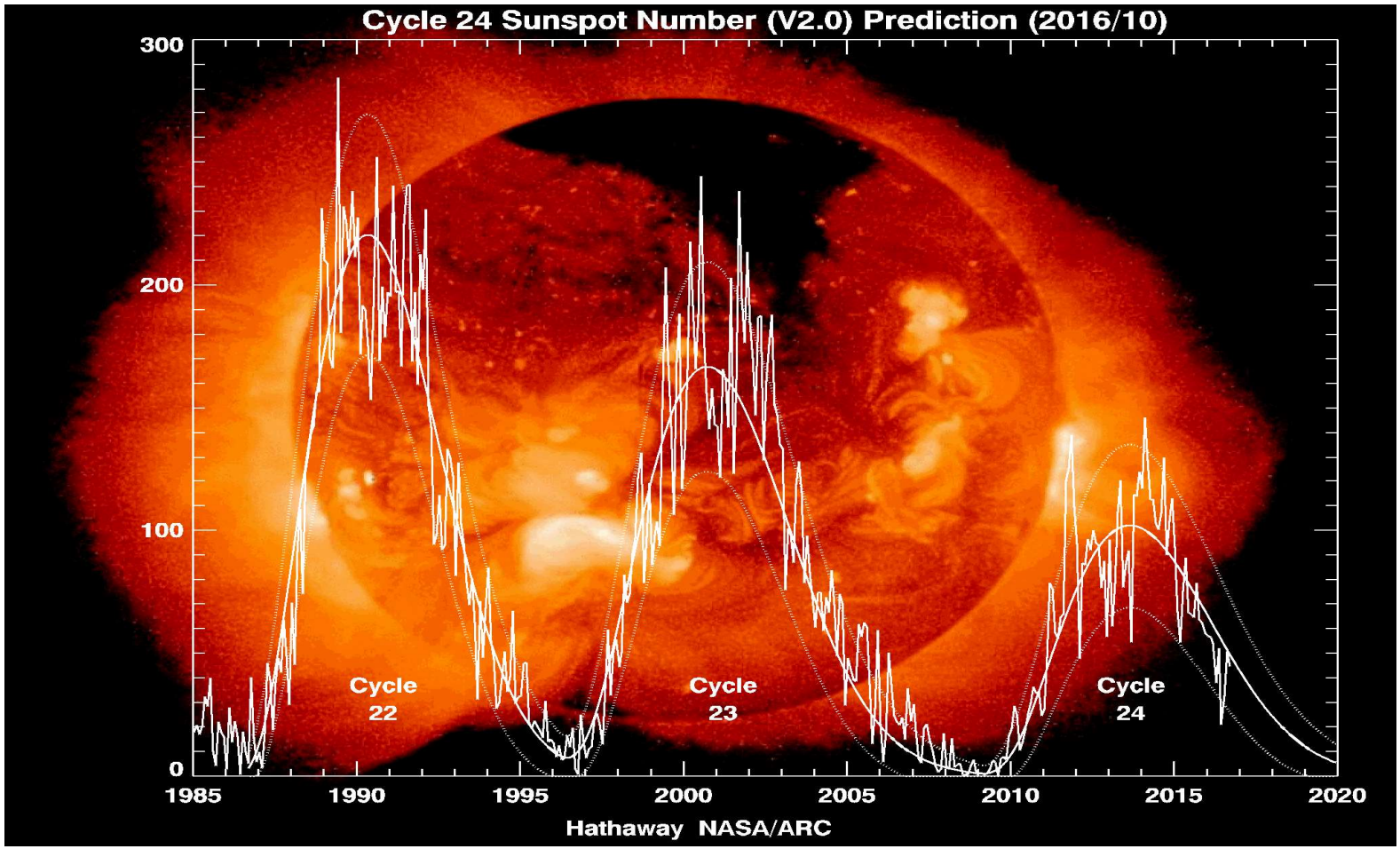
- Ionization Determined by **Sunspot Activity**
  - More Sunspots = More Ionization
  - More Ionization = More DX at Higher Frequencies

- **Sunspots Rise and Fall in 11-Year Cycles**
  - Discovered in 1843 by Samuel Heinrich Schwabe, who retrospectively started a numbering scheme with 1755-1766 as Cycle #1

Modern Sunspot Maximum Was 1959 - Peak of Cycle 19

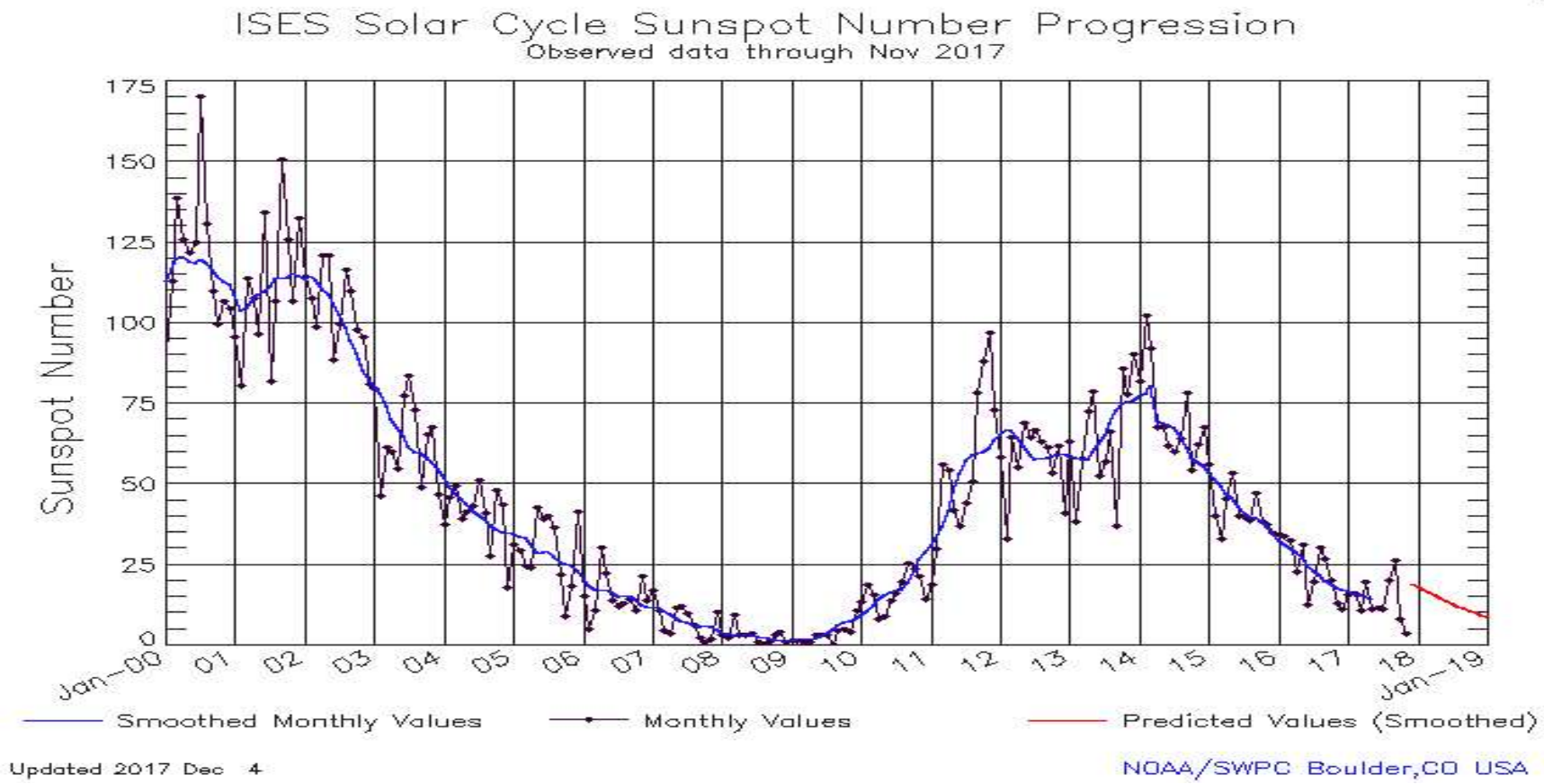


Currently, We Are Approaching The End (Bottom) of Cycle 24



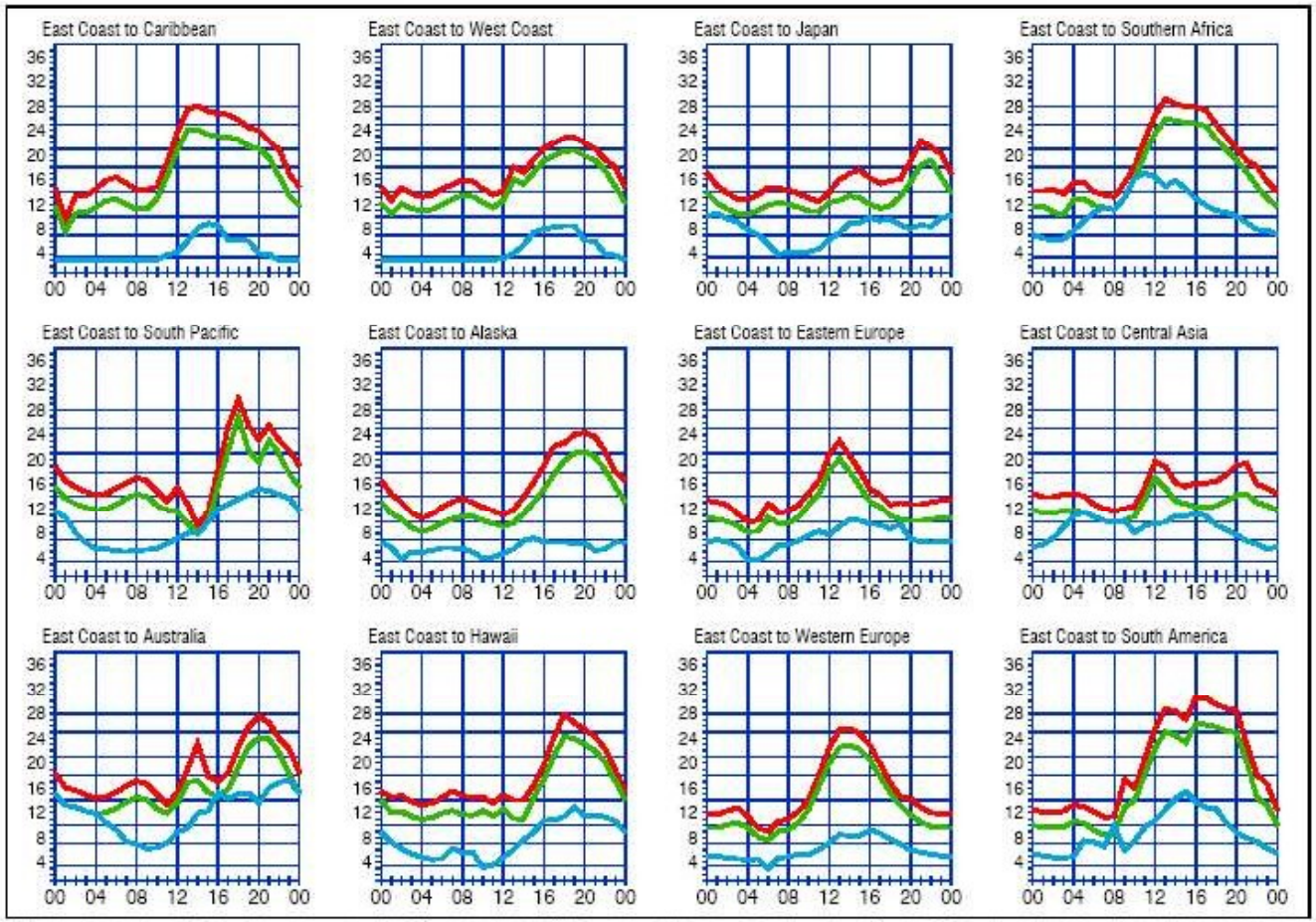
End of Cycle 24
Start of Cycle 25

Expected in 2019 or 2020



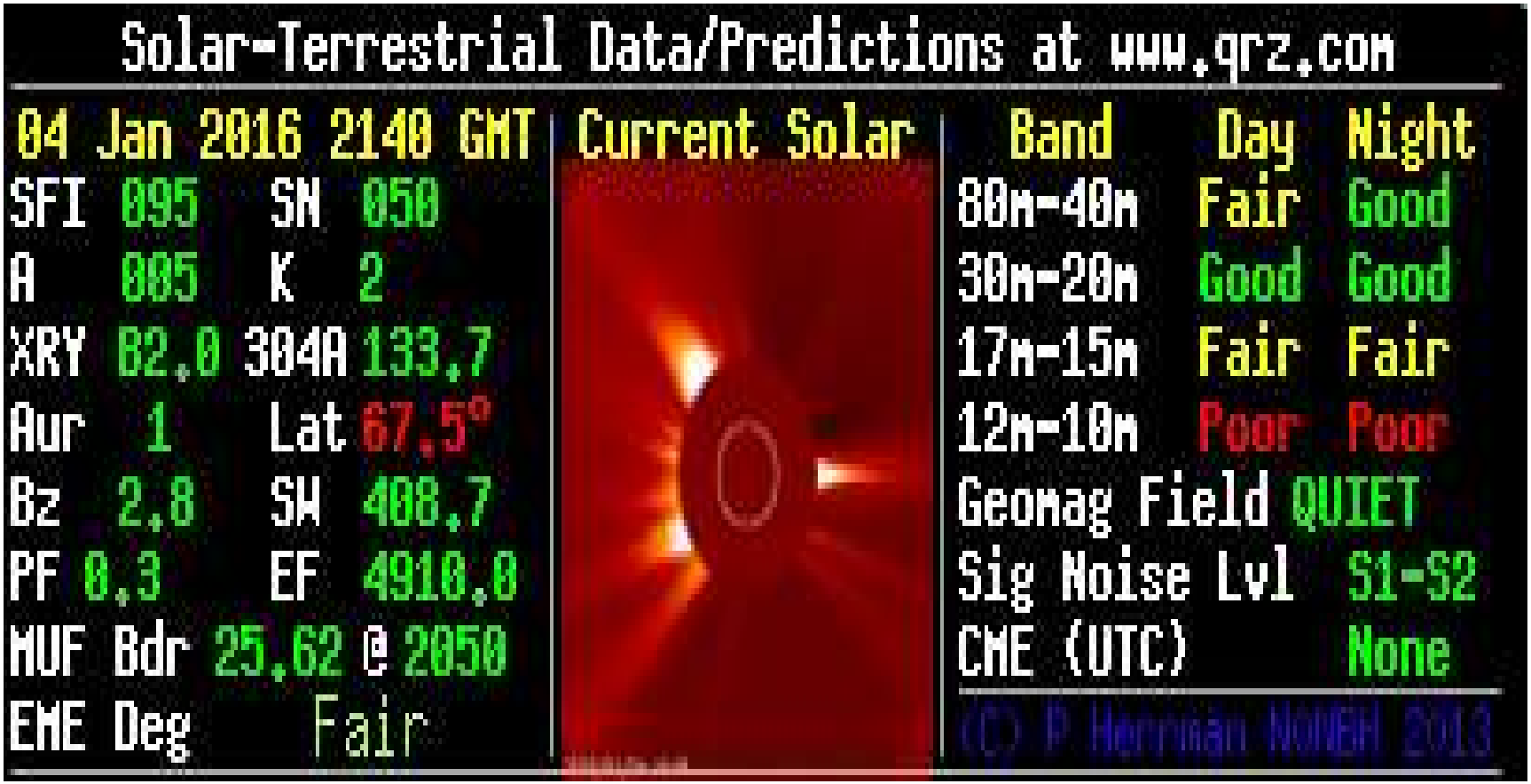
How Do I Know Which Band To Use?

http://www.arrl.org/qst/propcharts/

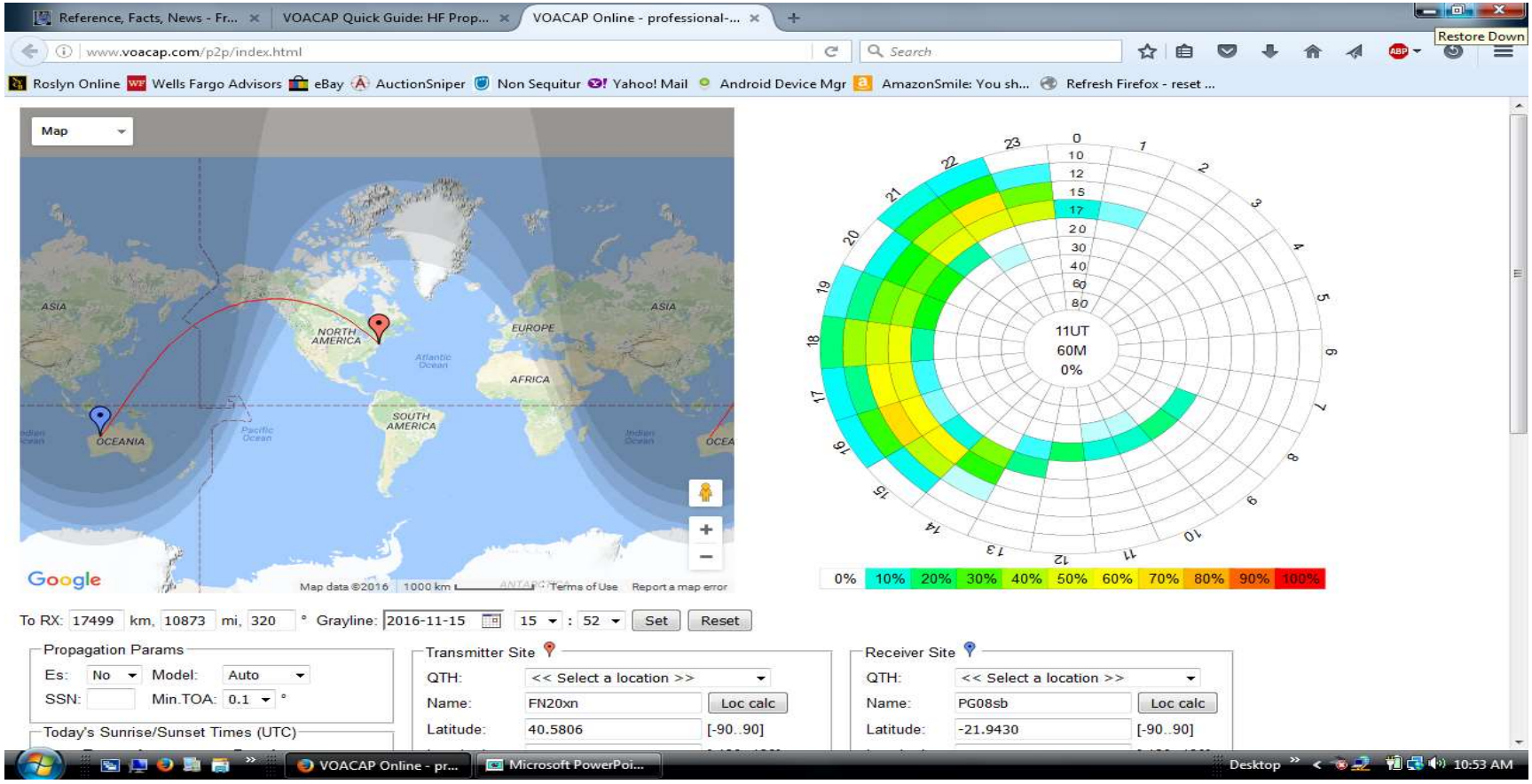


When are the bands open? These charts, generated using CAPman, show probabilities for average HF propagation in the month of **January 2007** for the paths indicated. The horizontal axes show Coordinated Universal Time (UTC), and the vertical axes frequency in MHz. On 10% of the days of this period, the highest frequencies propagated will be at least as high as the upper red curves (HPF, highest possible frequency) and on 50% of the days they will be at least as high as the green curves (MUF, classical maximum usable frequency). The blue curves show the lowest usable frequency (LUF) for a 1500-W CW transmitter. For SSB or a lower transmitter power, the LUF will be somewhat higher than the blue curves indicate. See Oct 1994 *QST*, pp 27-30, and Feb 1995 *QST*, pp 34-36, for more details. The predictions assume an observed 2800-MHz solar flux value of 73. This is a Very **Low** level of solar activity. See the detailed propagation tables on *The ARRL Antenna Book CD-ROM*.

Solar Conditions Vary Day-to-Day … Even Hour-to-Hour

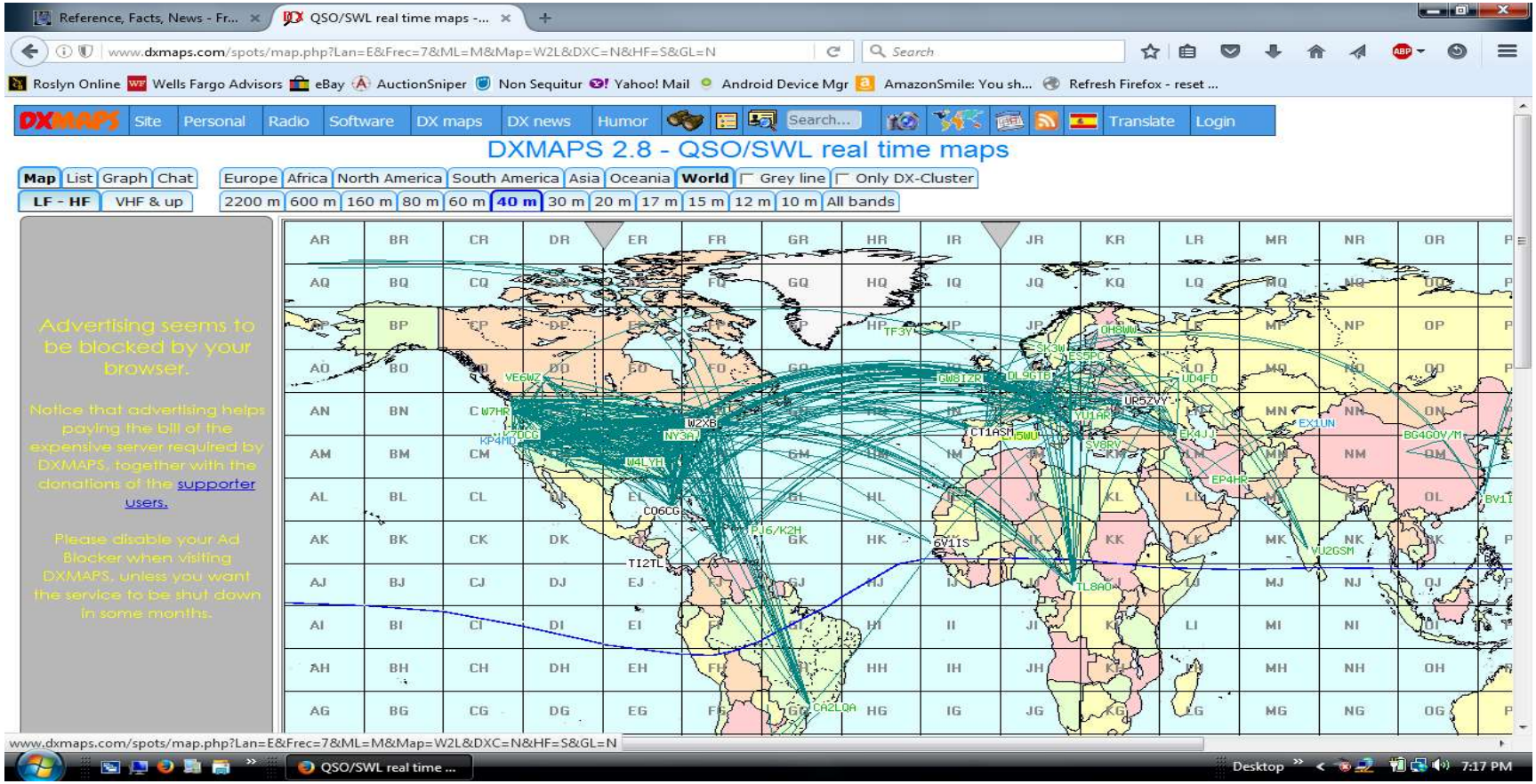


Propagation Calculators



http://www.voacap.com

Real-Time Path Views



http://www.dxmaps.com/spots/map.php

Making Contacts

- Proactively:
  - Call CQ
    - Tune The Band
      - Get a "feel" for conditions and activity
    - **LISTEN** for a clear frequency
      - **ASK** "Is the Frequency in use?"
        - QRL? On CW
      - Because of how HF propagation works you often hear only one side of a QSO. So what appears to be a clear frequency may be occupied by a QSO in which you're not hearing one (or more) of the stations involved

Typical CQ Format

- On Phone:
  - CQ, CQ, CQ calling CQ 20 meters. This is KS2G calling. Kilo Sierra Two Golf, KS2G near New York City calling CQ 20 meters. Hello CQ, CQ, CQ calling CQ 20 meters and standing by for a call.

- On CW / RTTY:
  - CQ CQ DE KS2G KS2G CQ CQ DE KS2G KS2G K

Making Contacts

- Respond to CQ's
  - "Casual" Contacts
    - Phone: W2HF This is KS2G OVER
    - CW/RTTY: W2HF DE KS2G K
  - DX Pile-Ups & DXpeditions
    - Just Give Your Callsign
      - Phonetically on Phone
    - Is the DX Station Operating "Split?"

Operating “Split”

- Split-Frequency Operation
  - Transmit and Receive on Different Frequencies
  - Like the “offset” of repeater input/output
- Most DXpeditions Operate “Split”
  - DX Station Will Say “Up 5” or “Up 5 to 10”
    - He’s listening 5 or 5-to-10 KHz up from his transmit frequency
  - DX Station on 14.160 MHz Will Say “200 to 225”
    - He’s listening 14.200 to 14.225 MHz
- Learn how to use your rig’s dual VFO’s

Working Contests

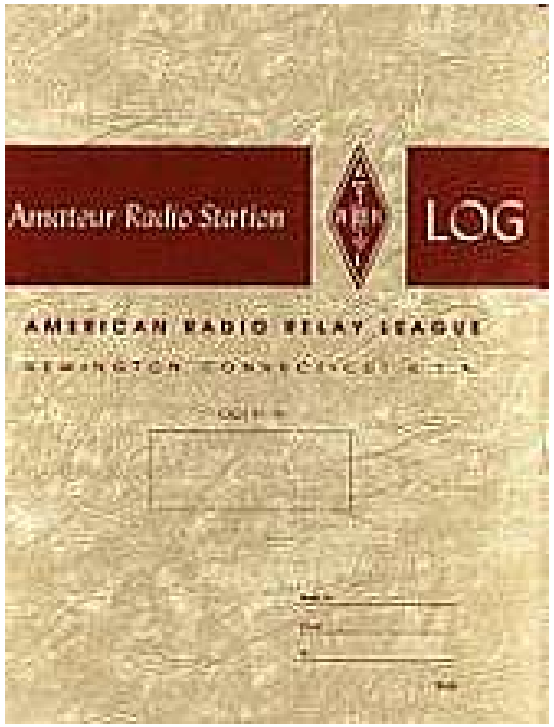
- Competitive Operating:
  - Work as many stations as possible, in as many places as possible, as quickly as possible
  - Check Contest Rules For Contest "Exchange"
  - "Run" -- call CQ
  - "Search & Pounce" -- Tune the Band and Respond to Stations That Call CQ

Logging

- No Legal Requirement To Log
- Useful Record of Operating Activity and Information Required For QLS'ing
  - Date & Time in UTC
  - Frequency Band and Mode (cw, ssb, rtty, etc)
  - Callsign
  - Signal Report
  - Notes -- Name, QTH, Equipment, etc.

Logging - “Old School”

- On Paper:

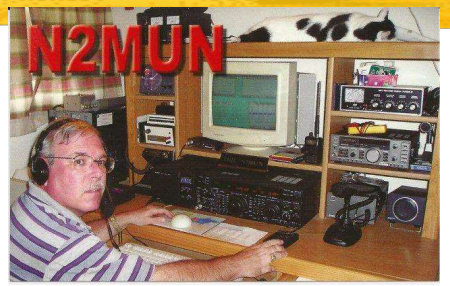


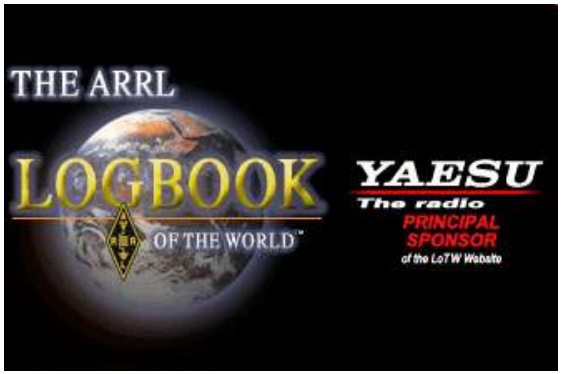
Computer Logging

- General Purpose Loggers:
  - DXLAB
  - DX 4 WIN
  - DXKeeper
- Specialized Contest Loggers:
  - N1MM-Plus
  - WriteLog

QSLing: Confirmation of Contacts

- Direct - Printed Cards
  - SASE or "Green Stamps"
- QSL Managers
- QSL Bureaus
  - ARRL Outgoing QSL Service
  - 2nd District Incoming QSL Bureau
    - North Jersey DX Association
    - Purchase Return-Envelope "Credits"
- Electronic
  - ARRL Logbook of the World (LoTW)
  - eQSL
  - Club Log





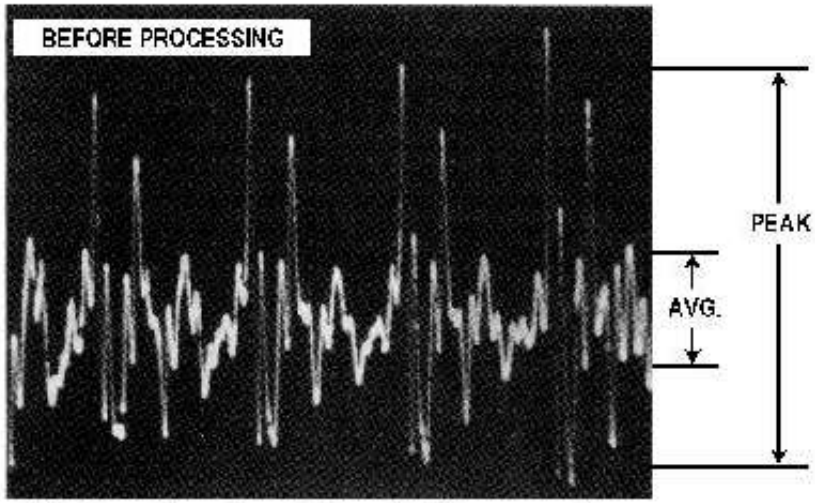
Operating Awards

Getting The Most Out Of Your HF Transceiver

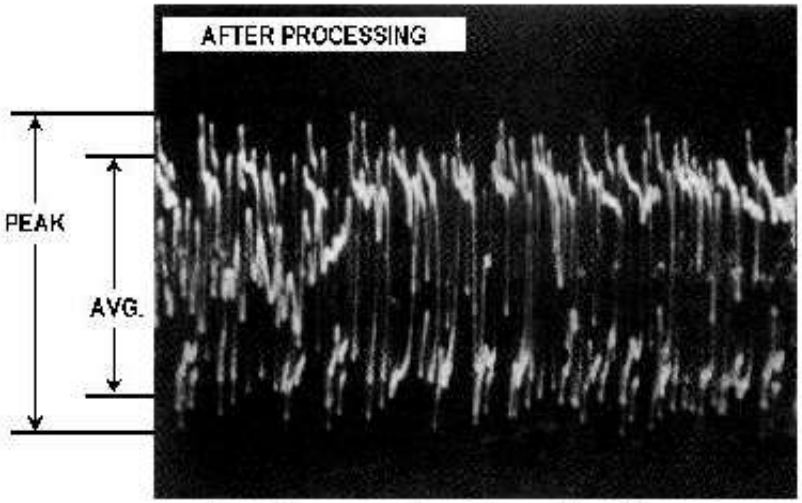
- Transmitter Controls:
  - RF Power Output - cw, digital, ssb
  - Microphone Level
    - Speech Processing / Compression
      - Increases Average RF Power & Adds "Punch" To Audio
      - Observe ALC (Automatic Level Control) Limit
    - Transmit Audio Equalization
      - Control "Highs" & "Lows" For Maximum Intelligibility
    - Transmit Audio Monitor
      - Listen To Yourself As You Transmit
    - Ask For Audio Reports From Stations You Work

Speech Processing

Also Known As Audio Compression
Increases SSB "Talk Power"



Actual speech waveform photograph with no processing, as it exists at the TX mike input. Note the very high peak amplitude when compared to the average levels.



Correctly processed speech waveform. The average amplitude *relative to the peaks* is now much higher. This is a dramatic increase in the average power output, but without the risk of distortion because the peaks have been limited by diode clipping.

Transmitter Keying Controls

- VOX (Voice Operated Transmit)
  - Transmitter is Keyed By Sensing Speech
    - Sensitivity / Delay (Hang) Time / Anti-VOX
- CW Break-In
  - Automatic Switching Between Transmit & Receive
  - Full Break-In (QSK)
    - Switches from transmit to receive immediately when key contacts open
  - Semi-Break-In
    - When key contacts open, switch to receive is delayed by a set duration (usually controlled by VOX setting)

Automatic Antenna Tuner

- Automatically “matches” out-of-resonance antenna impedance to 50 ohms
- Maintains Full Transmitter Power Output
  - Modern Solid-State Transmitters “Fold-Back” (Lower) Output Power to Mismatched Antenna Loads To Prevent Damage To Final Output Power Transistors

Receiver Audio Controls

- AF Gain
  - Audio Frequency Gain - Volume Control
- RF Gain
  - Radio Frequency Gain
  - Manually Adjusts Receiver Sensitivity
  - Usually Left at Maximum in Conjunction With AGC
- AGC - Automatic Gain Control
  - Automatically Adjusts Receiver Sensitivity In Response To Changes In Signal Strength
  - “Fast” Response For CW / “Slow” Response For SSB

Receiver Sensitivity Controls

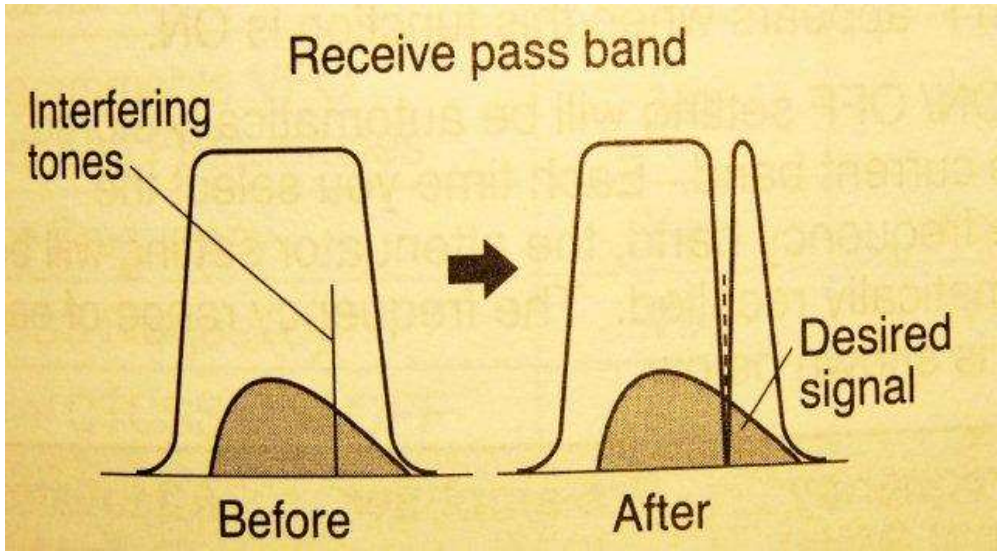
- RF Attenuator
  - Reduces Receiver Sensitivity By A Set Amount
- RF Preamp
  - Increases Receiver Sensitivity By A Set Amount
- Squelch
  - Mutes Receiver When No Signal Is Present
  - Leave “Wide Open” Except For FM

Receiver Tuning Controls

- RIT
  - Receiver Incremental Tuning
  - "Clarifier" on Yaesu Radios
    - Changes Receive Frequency Without Changing Transmit Frequency
- XIT
  - Transmitter Incremental Tuning
    - Changes Transmit Frequency Without Changing Receive Frequency
    - Sometimes can be used for "split" in the absence of dual VFO's

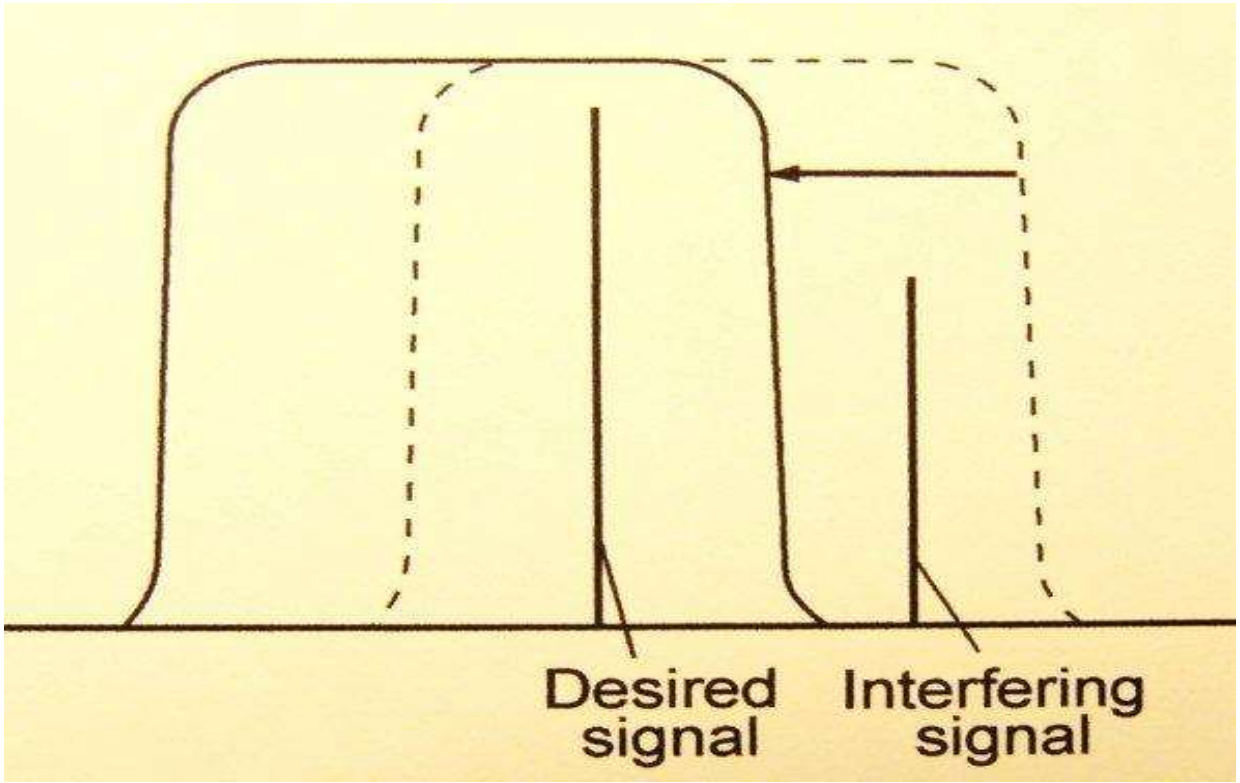
Interference Controls

- Noise Filter / Noise Reduction
  - Reduces Steady Background Noise
- Noise Blanker
  - Reduces Pulsing Background Noise
- Notch Filter
  - "Nulls" Specific Interfering Signal (e.g. Heterodynes)



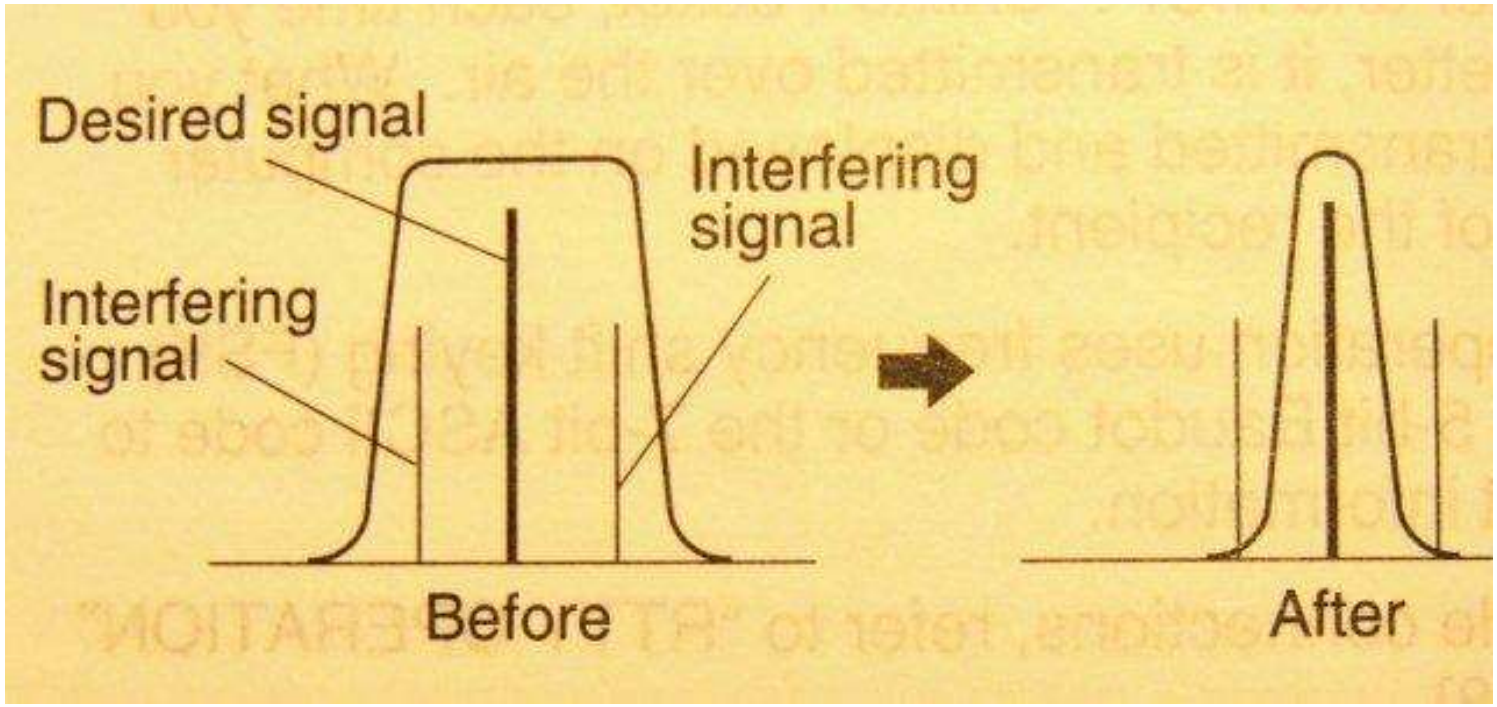
Bandwidth Controls

- IF Shift
  - Shifts Center Frequency of Pass Band



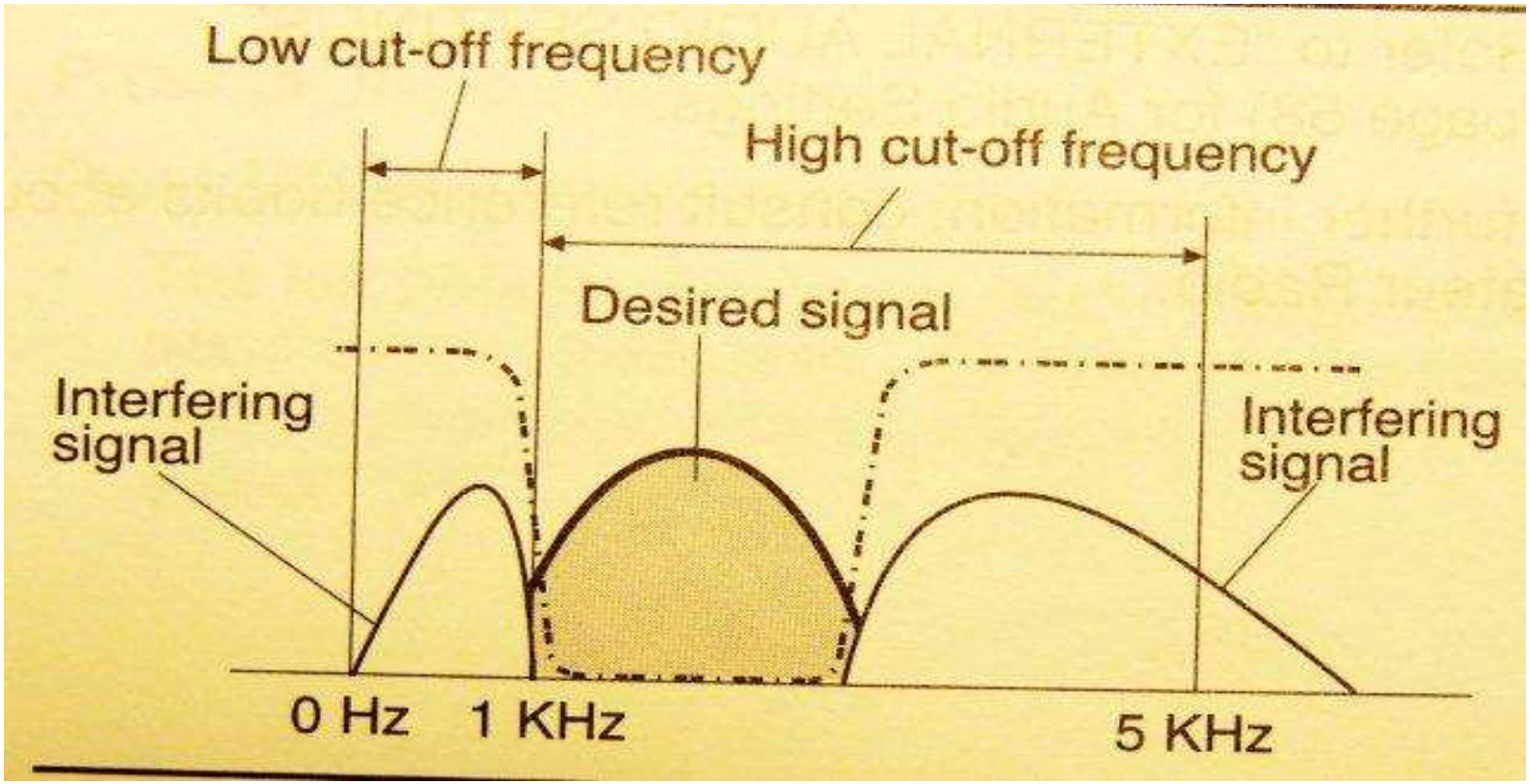
Bandwidth Controls

- Wide / Narrow (DSP & Roofing) Filters
  - Fixed Bandwidth (CW & FSK)



Bandwidth Controls

- Variable Bandwidth Filters



Quick Review:

- Propagation Characteristics
- Be aware of band edges
- Check daily solar conditions
- DX Summit site
- In a SSB contest just send your call - The DX station will send back your call and then the contest exchange

Radio Review:

- Getting the most out of your HF transceiver
  - Speech processing (Punch)
  - Audio Equalization
  - Interference control
  - Noise filter/noise reduction
  - Bandwidth IF Shift
  - Pull that weak signal out of the mud
  - Reduce RF gain increase AF gain

Final Words:

- Learn how to use Split
  - Good videos on YouTube
- Working a contest
  - Before contest check rules
  - WA7BNM contest resource,ARRL,CQ
  - Plan your strategy
  - Class, time allocation,GOAL!
- Antenna Tuner vs Antenna characteristics

73, CU On The Air!

Any questions?