

# NARCC Technical Committee

## Revisiting Coordination Issues And Tech Specs

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# Coordination Considerations

- “Best practice”
  - “Good equipment”
  - Frequency stability
  - CTCSS/DCS input and output
  - Minimal power/coverage area to maintain reasonable communication (not S-1, not S-2, no marginal spots...)
  - Within occupied bandwidth/emission mask
    - Contain your audio spectrum and deviation
- **47CFR97.305**: “the mean power of any spurious... between 30-225 Mhz must be at least 60dB below the mean power of the fundamental”

# Technical Guidelines

- Technical Considerations
- Current Technical Guidelines
- Possible Technical Guidelines
- Emission Masks / Occupied Bandwidth
- Deviation Options for Analog
- Frequency Stability and Impact
- Coverage Area and Signal Levels
- Surveying Technical Preferences

# Benefits of Technical Guides

- Less ambiguous considerations for coordination
- Promote technical and amateur radio best practices, especially critical in a crowded environment
- Understand and improve transmitted and received signal characteristics/system performance
- Prevent issues and mitigate as needed
  - Non-, nuisance-, harmful- interference
  - Government regulations and circumstances
- Accommodate new technologies without compromising existing
- You demand we do a better job, which requires better information, guidelines and cooperation.

# Where Do Guidelines Come From?

- We didn't make this up: science, math and physics
- Comm. Act/Part 97: not updated to current technologies and expectations – we need something
- Part 90 and 95
  - Commercial service is how we got here...
  - Many hams were pioneers in commercial services
- TSB-88 broad coverage analog and digital specs
- Expected “service quality” by users

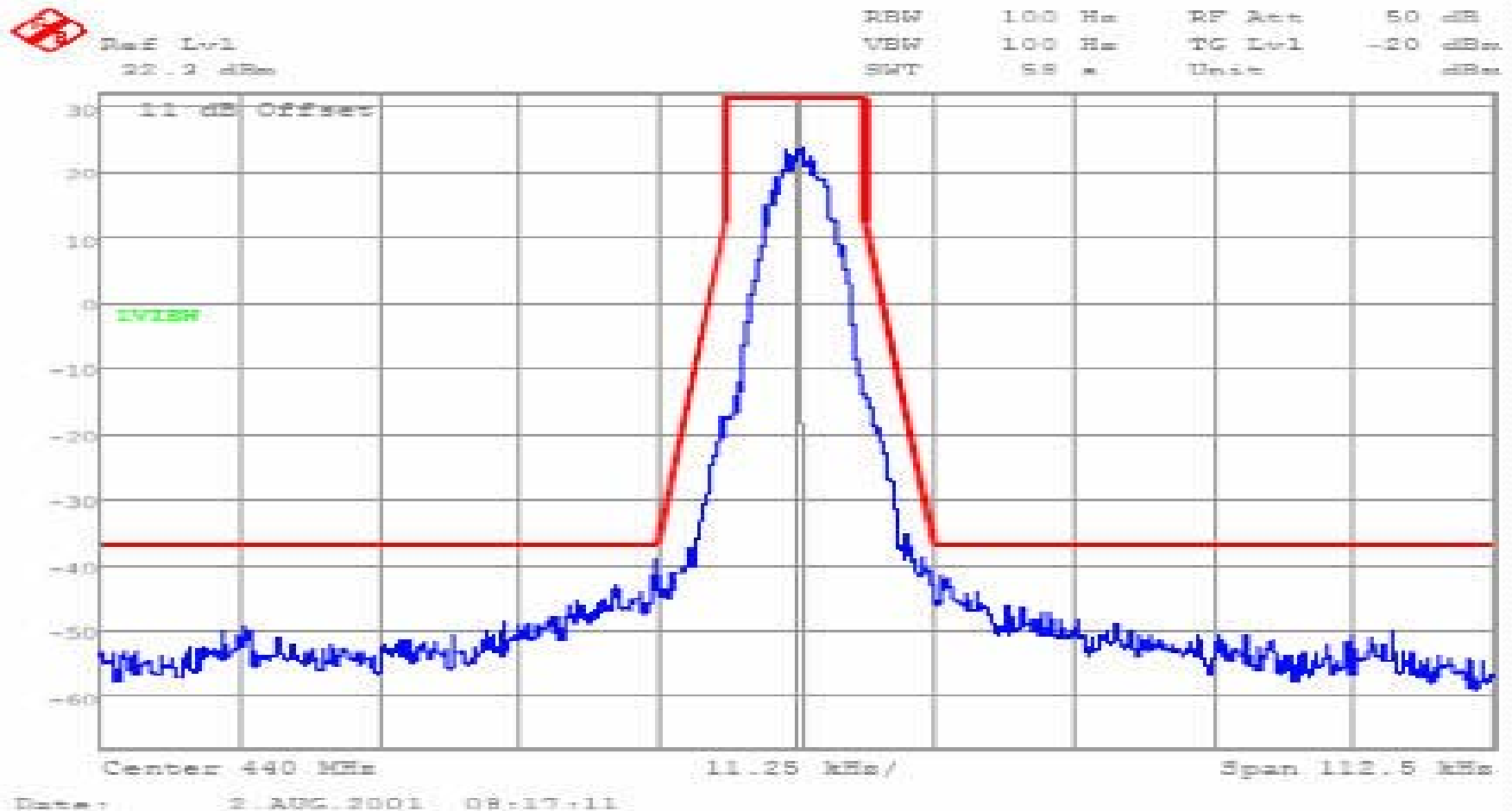
# Possible Technical Guidelines

- Deviation / Occupied Bandwidth / Emission Mask
  - “the box” your signal should stay within
  - Spurious, sidebands (all modes have this to some extent)
  - Guard-band / channel edges
  - Affects adjacent channel spillover
- Frequency stability / tolerance
  - Keeping “the box” in its place
  - Emission may be in “the box” but the box should not shift
- Coverage Area

# Emission Mask

- One way to represent emission mask is occupied bandwidth (excerpt from NIST presentation):
- “Occupied bandwidth is the portion of the spectrum which contains 99% of the emitted energy (.5% of the remaining is above and .5% is below the occupied bandwidth)
- Establish a box/fence – put whatever you want in it (FM, DMR, Fusion, NXDN, P25) but ***stay in it.***
- The risks of uncontrolled emissions and box ‘position’ are nuisance-to-harmful interference (i.e., *not* exercising best practice)

# Emission Mask - Example



measured with normal Test modulation : Pseudo random data stream max. 8kBit/s

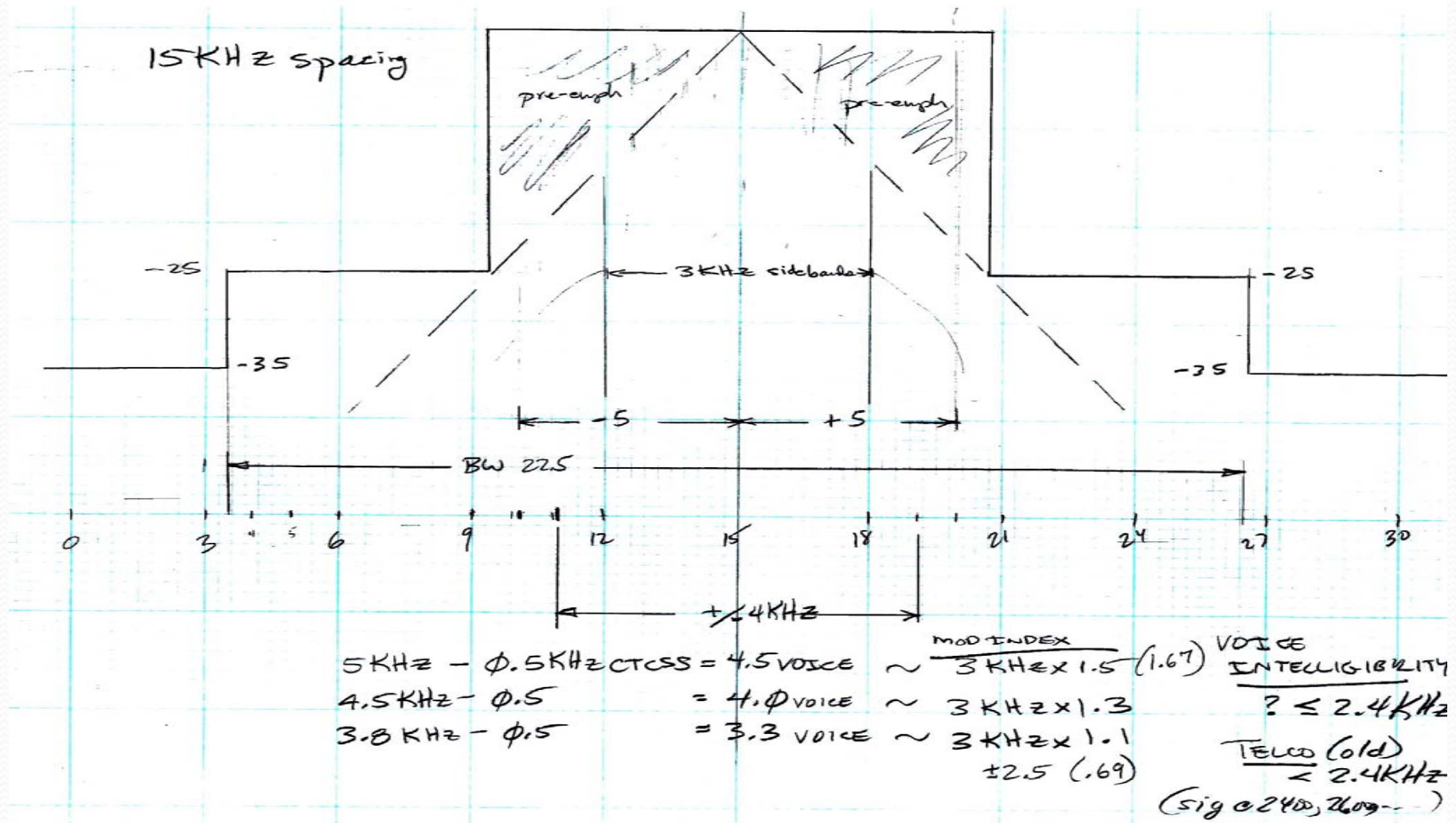
**LIMITS**

**SUBCLAUSE § 90.210**

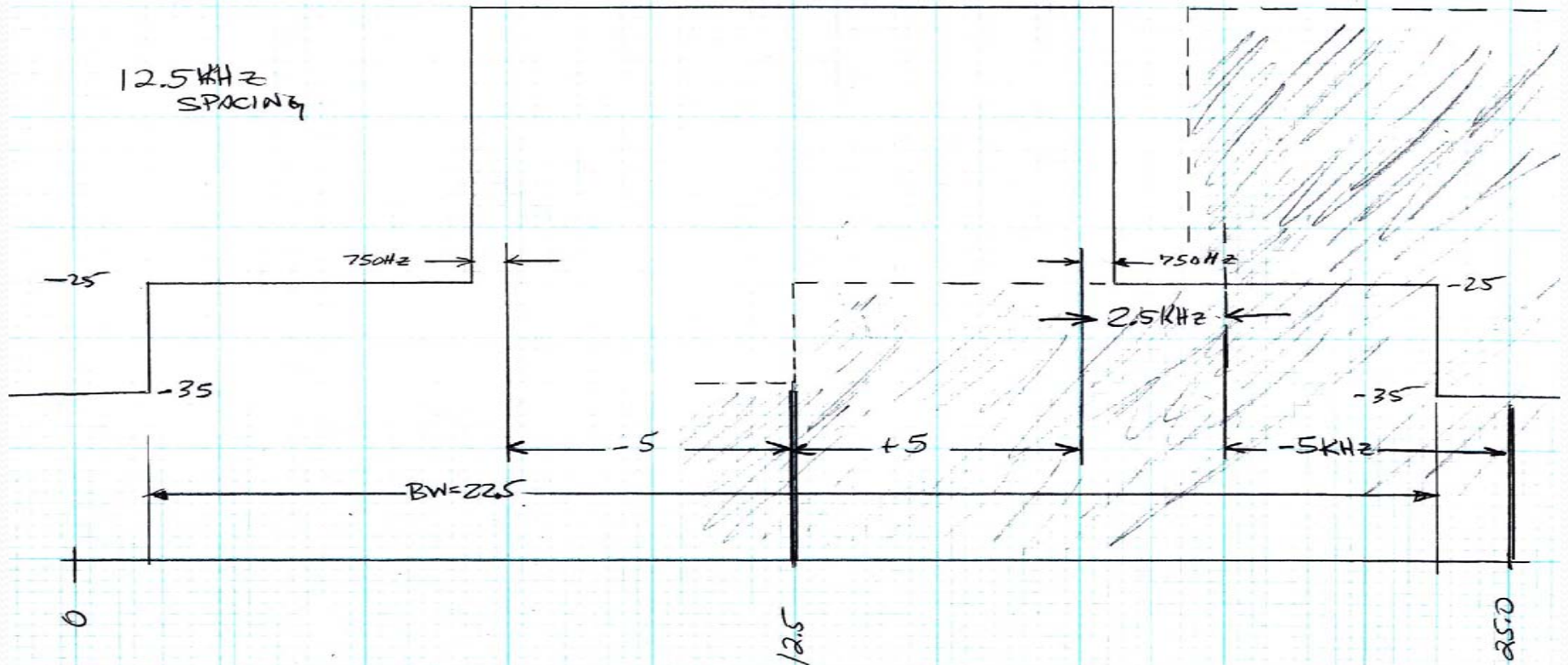
**Emission Mask D – 12.5 kHz channel bandwidth**



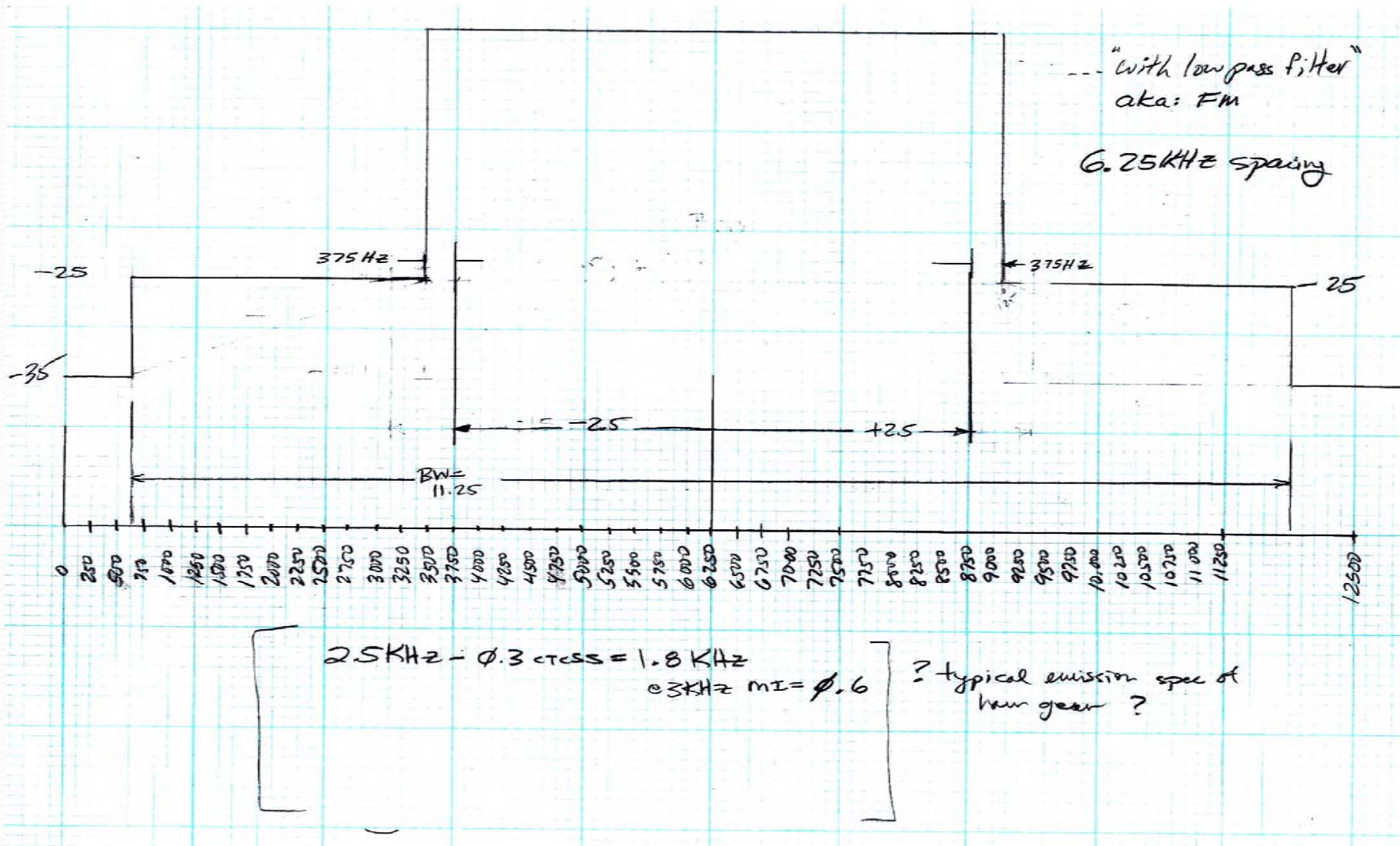
# Emission Masks – 15 KHz



# Emission Masks – 12.5 KHz Spacing



# Emission Masks – 6.25 KHz Spacing



# Deviation Options

Voice Dev.	CTCSS / DCS Dev	Max Dev	High Voice Freq	Mod Index	High Voice Freq	Mod Index
<b>5.0</b>	<b>0.5</b>	<b>5.5</b>	3.0	1.67	2.4	2.08
<b>4.5</b>	<b>0.5</b>	<b>5.0</b>	3.0	1.50	2.4	1.88
4	0.4	4.4	3.0	1.33	2.4	1.67
3.8	0.4	4.2	3.0	1.27	2.4	1.58
<b>3.5</b>	<b>0.5</b>	<b>4.0</b>	3.0	1.17	2.4	1.46
<b>3.5</b>	<b>0.3</b>	<b>3.8</b>	3.0	1.17	2.4	1.46
<b>3.3</b>	<b>0.5</b>	<b>3.8</b>	3.0	1.10	2.4	1.38
3	0.3	3.3	3.0	1.00	2.4	1.25
2.5	0.3	2.8	3.0	0.83	2.4	1.04
<b>2.25</b>	<b>0.25</b>	<b>2.5</b>	3.0	0.75	2.4	0.94 <sub>12</sub>

# Frequency Stability

<u>Stability</u>	<u>Low Limit</u>	<u>On-Channel</u>	<u>High Limit</u>	<u>Drift</u>
<b>2.5 PPM</b>	146.51963	146.52000	146.52037	+/-370 Hz
<b>0.00025%</b>				
	444.99889	445.00000	445.00111	+/-1.1 KHz
5 PPM	146.51927	146.52000	146.52073	+/-730 Hz
0.0005%				
	444.99778	445.00000	445.00223	<b>+/-2.2 KHz</b>
10 PPM	146.51853	146.52000	146.52147	<b>+/-1.47KHz</b>
0.001%				
	444.99555	445.00000	445.00445	<b>+/-4.5 KHz</b>

# Frequency Stability Impact

- Protective deviation/channel edge for +/- 5KHz deviation is 750 Hz
- Guard-band of dev-edge to dev-edge is 2.5 KHz
- 5 and 10 ppm stability can cause co-channels to overlap if they drift toward each other
- Splatter/sidebands can exceed “the box” and result in nuisance or harmful interference
- 2.5 ppm stability reduces/eliminates overlap, *retains adjacent channel protection*
- Base/repeater TX stability is always regarded more important than mobile/portables

# Signal Levels

## Desired/Intended Coverage vs. 'Interference'

<u>S-reading</u>	<u>μV (50Ω)</u>	<u>dBm</u>	<u>dB above 1uV</u>
<b>S9+10dB</b>	<b>160.0</b>	<b>-63</b>	<b>44</b>
<b>S9</b>	<b>50.2</b>	<b>-73</b>	<b>34</b>
<b>S8</b>	<b>25.1</b>	<b>-79</b>	<b>28</b>
<b>S7</b>	<b>12.6</b>	<b>-85</b>	<b>22</b>
<b>S6</b>	<b>6.3</b>	<b>-91</b>	<b>16</b>
<b>S5</b>	<b>3.2</b>	<b>-97</b>	<b>10</b>
<b>S4</b>	<b>1.6</b>	<b>-103</b>	<b>4</b>
<b>S3</b>	<b>0.8</b>	<b>-109</b>	<b>-2</b>
<b>S2</b>	<b>0.4</b>	<b>-115</b>	<b>-8</b>
<b>S1</b>	<b>0.2</b>	<b>-121</b>	<b>-14</b>

# Signal Levels

- Average ham mobile for general reference:
  - 0.1-0.16  $\mu\text{V}$  (S1) to open squelch (what's your squelch level?)
  - 0.2-0.3  $\mu\text{V}$  12 dB quieting / 0.3-0.5  $\mu\text{V}$  20 dB quieting
- -100 dBm (3.0  $\mu\text{V}$ ) is clearly and S4 to S5 signal level
  - May be deemed as interference
- -105 dBm (1.8  $\mu\text{V}$ ) is clearly high S3 to S4 signal
  - May be deemed as interference
- -110 dBm (0.8  $\mu\text{V}$ ) is high S2-S3 signal
  - May be obvious nuisance interference (beat note, squelch sputter)
- -115 dBm (0.4  $\mu\text{V}$ ) is S2 signal
  - May be nuisance interference (beat note, squelch sputter)
- -120 dBm (0.2  $\mu\text{V}$ ) is S1 signal level
  - Noise level, some squelch sputter possible



# Signal Concentration/Density

- When is S-x / -xyz dBm signal really nuisance or harmful interference?
- How do you characterize / measure it?
- How big is the affected area to be considered nuisance vs. harmful interference?
  - 1 square meter
  - 1 acre
  - 1 square mile
  - 5 square miles
  - City? County ? NARCC 'region' ?

# Signal Concentration/Density

- Define 'nuisance' interference
  - Below the capture ratio/effect (harmful) level !!
    - Harmful: where it becomes >X% difficult to 100% impossible to effectively extract meaningful communication content.
  - How much beat/heterodyne effect is tolerable?
    - -30 dB audible level difference from clear communications
    - -20 dB audible level difference from clear communications
    - -10 dB audible level difference from clear communications
    - At what level do those symptoms appear for **your** receiver?
- Mitigate
  - CTCSS/DCS
  - Use RF squelch setting if available in user radio (S2?)

# Signal Concentration/Density

- Define 'harmful' interference
  - Above the capture ratio/effect level !!
  - Where it becomes  $>X\%$  difficult to 100% impossible to effectively extract meaningful communication content.
  - What is the capture ratio for your receiver?

# Signal Concentration/Density

**“The Number”:**

Somewhere between the

**[ harmful interference/capture level ]**

and

**[ (some degree of nuisance interference level)**

**for**

**(y-minimum-nuisance-area) ]**

is **“a number”**

**Find ‘x’ (clue: it is not on this page)**

# TX Frequency Accuracy

- Analog or digital (D-Star, P25, DMR, etc.)
- Stability not readily measurable but off-frequency condition is. Criteria is whether fundamental is on-frequency within:
- 2.5 PPM @ 15KHz spacing or less
- 5 PPM @ 20KHz spacing

# Coverage/Service Area

- -110 dBm ~ S3
- -115 dBm ~ S2-S3
- -120 dBm ~ S1-S2
- Optional cooperative overlap allowed if co-channel agreement – to a degree/level agreed by both. (Capture effect typically negates nuisance interference.)

# Radio Service Comparisons

- [http://utahvhfs.org/dstar\\_testing.html](http://utahvhfs.org/dstar_testing.html)
- [http://utahvhfs.org/dstar\\_channel\\_spacing.html](http://utahvhfs.org/dstar_channel_spacing.html)
  - Analysis of D-Star's "non-digital" transmission and effect on bandwidth
  - Note D-Star's modulation frequency is 4800 Hz, 1800 Hz > conventional voice FM
  - D-Star is *NOT* a "narrow-band" technology as compared to +/- 2.5 KHz FM voice, P25, etc.
- [https://www.icomamerica.com/en/landmobile/6.25FDMAInfo\\_707.pdf](https://www.icomamerica.com/en/landmobile/6.25FDMAInfo_707.pdf)
  - Icom info on FDMA/P25