

NARCC Technical Committee

Revisiting Coordination Issues
And Tech Specs

Feb 2014

Agenda

- Coordination Essentials
- Technical Guidelines

Coordination Essentials

- Considerations for getting a coordination
- Obtaining coordination
- Maintaining a coordination
- Losing Coordination

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”

Obtaining Coordination

- How do you get a Coordination?
 - Find a pair
 - Build the box
 - Heed “best practice”
 - Get it on the air as intended per power, antenna, coverage
 - Apply on-line as-is (power, feedline, antenna...)
 - Pending/wait 60-days
 - Cooperate with peers and Coordinator to resolve issues
 - No issues

Maintaining Coordination

- How do you maintain a Coordination
 - Above plus...
 - Annual data updates
 - System is still there, active, functional as-is/was
 - Don't move it, aka no moves that significantly shift coverage area, especially co-channel systems (Coordinated, Recognized or Pending)
 - Proper maintenance notifications
 - No interference complaints from other repeater Org Reps
 - No complaints relative to the FCC or other government entities

Dropping Coordination

- How do you lose a coordination?
 - Suspended
 - Non-compliant with technical or coverage criteria
 - Off-freq, over-dev, spurious, move/coverage change
 - Interference complaints from other Org Reps
 - Known interference or mitigation issues via the FCC or other government entities
- Dropped/Abandoned Coordination
 - Non-existent > 60 days without maintenance letter
 - Deliberate notice of abandonment

Coordination Stages

- Pending – 60-day window from applications
 - Meets criteria for coordination, awaiting comments/issues
- Uncoordinated but known (not coordinated by NARCC)
 - Includes in-band-plan systems within repeater sub-bands
 - (i.e., occupying splinter in simplex or low-power, weak, satellite allocations = not recognized)
- Coordinated = good job!!!
- Suspended
 - Pending application that does not yet meet criteria; off-air >60 days w/o maintenance notice, interference complaints

Test Cases

- Eric's Repeater Coordination
 - Coverage area determination

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
- Commercial service is how we got here...
 - AM wasn't optimum thus adopting SSB then FM
 - Remember static, barely useful squelch, audio quality fades of AM (CB or otherwise)
 - Surplus commercial equipment provides the opportunities for better performance, reliability and communications (most repeaters ARE used comm.)
- We expect/demand high-quality and performance and that demands good reliable technical practices.

Current Technical Guidelines

- None documented or clearly defined as a specific criteria for or against coordination and retention
 - +/- 4 KHz deviation
 - -100 dBm coverage 'benchmark'
- No specific documentation on applying/allowing 12.5 KHz spacing at 440
- Not a good mentor or facilitator of "best practice"
 - Good clear documentation and references needed
- "Best practice" is not well-received under guise of 'experimentation' vs. "in-production" use

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
- <http://www.itu.int/rec/R-REC-M/en>

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 but ***stay in it.***
- The risks of uncontrolled emissions and box ‘position’ are nuisance-to-harmful interference (i.e., *not* exercising best practice)

Block Edge Mask

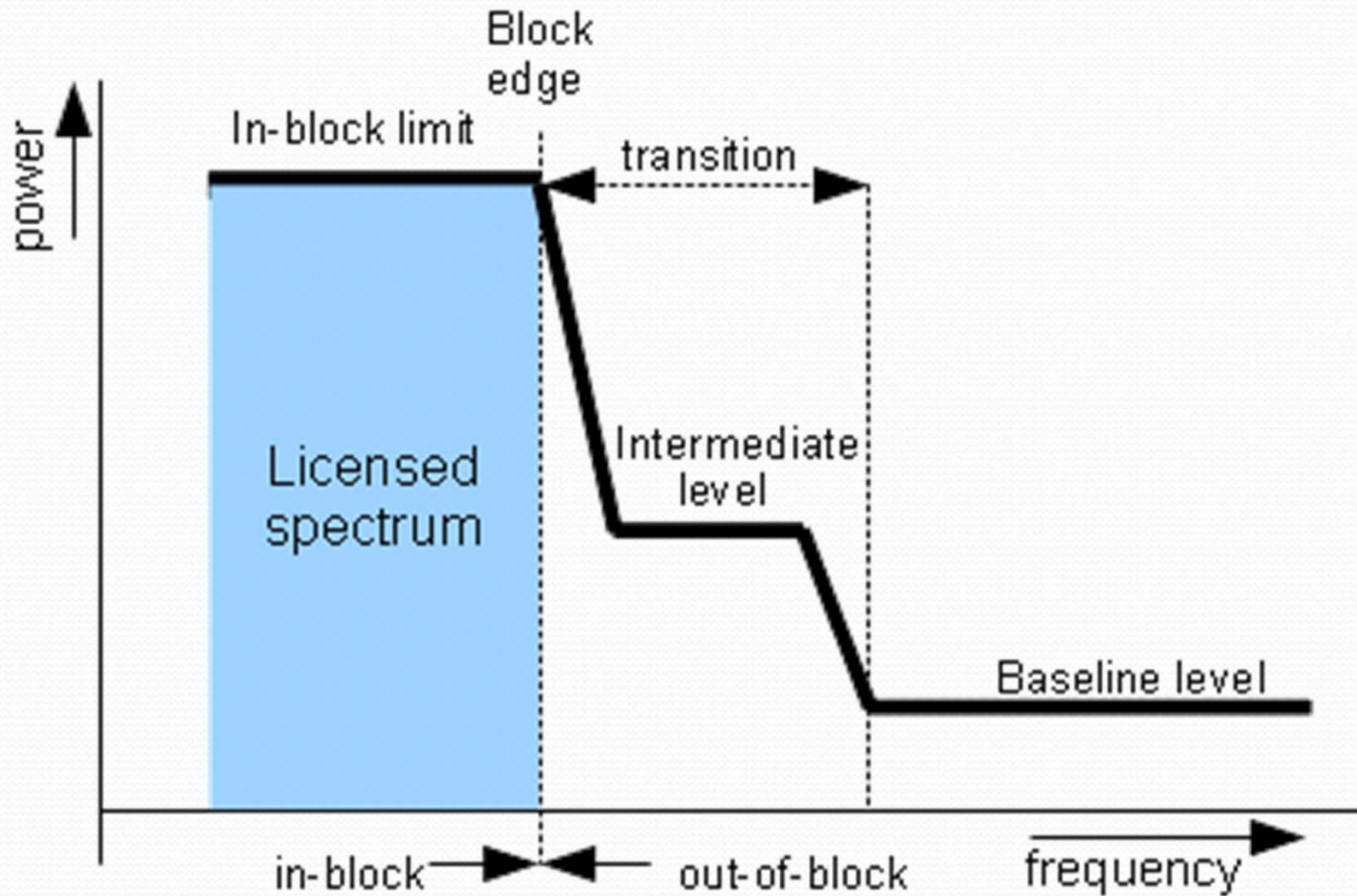
A block edge mask is a transmitter spectrum mask that applies at the edge of a contiguous licensed block of spectrum and is *designed to offer sufficient protection from interference to any anticipated receiving system in an adjacent frequency block.*

The emissions of all transmitters operating within a licensed block must comply with this block edge mask, regardless of the bandwidth of such transmitters.

On one side of this frequency boundary is the in-block power limit and on the other side is the out-of-block spectrum mask. The out-of-block component of the BEM itself consists of a baseline level and, where applicable, intermediate levels which describe the transition from the in-block level to the baseline out-of-block level as a function of frequency. This is illustrated in the figure on the next page.

A block edge mask *doesn't define the means by which the radio transmitter meets the BEM.* Usually, a spectrum emission mask (SEM) is defined by standardization organizations.

Block Edge Mask - Graphic



FM Bandwidth (ITU M.478-5)

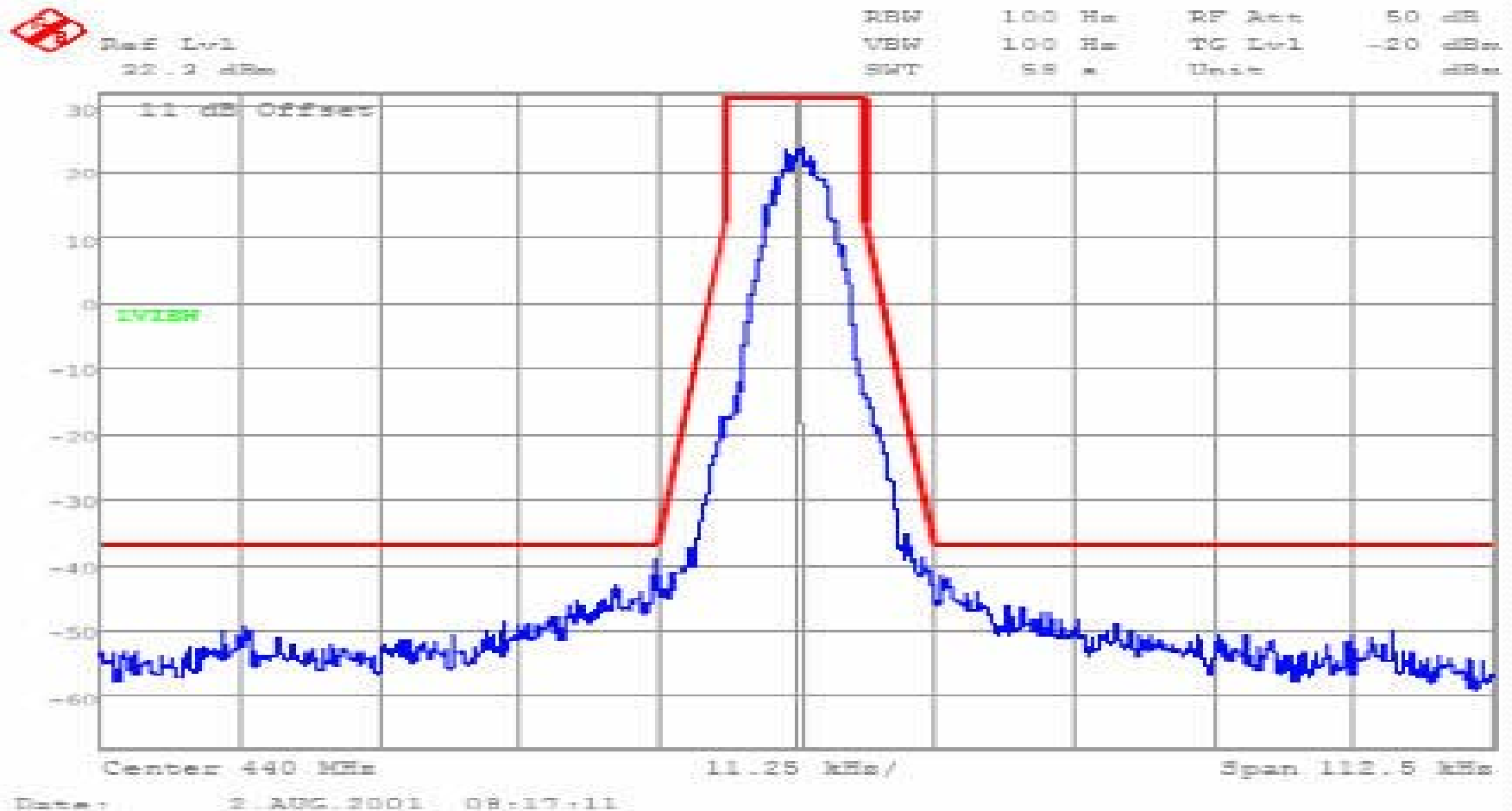
Channel Bandwidth for emission F3E

- 30 and 25 kHz channel separations: 16 kHz
- 20 kHz channel separation:
 - Max. deviation @ 4 = 14 KHz
 - Max. deviation @ 5 = 16 KHz
- 12.5 kHz channel separation: OBW= 8.5 kHz
- 15 kHz channel separation: OBW = 11 kHz

Stability Guidelines (ITU M.478-5)

	35 MHz		80 MHz		160 MHz		300 MHz		450 MHz		800 MHz		900 MHz	
Channel spacing (kHz)	kHz ⁽¹⁾	ppm	kHz ⁽¹⁾	ppm	kHz ⁽¹⁾	ppm	kHz ⁽¹⁾	ppm	kHz ⁽¹⁾	ppm	kHz ⁽¹⁾	ppm	kHz ⁽¹⁾	ppm
20, 25 and 30	0.43	12	0.96	12	0.8	5	1.5	5	2.25	5	–	2.5 (M)(B) 1.5 (B)	2.7	2.5
12.5	–	–	1.0	12	0.8	5	–	–	1.35	3	–	–	1.35	1.5 (M)(B) 0.1 (B)

Emission Mask - Example



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

LIMITS

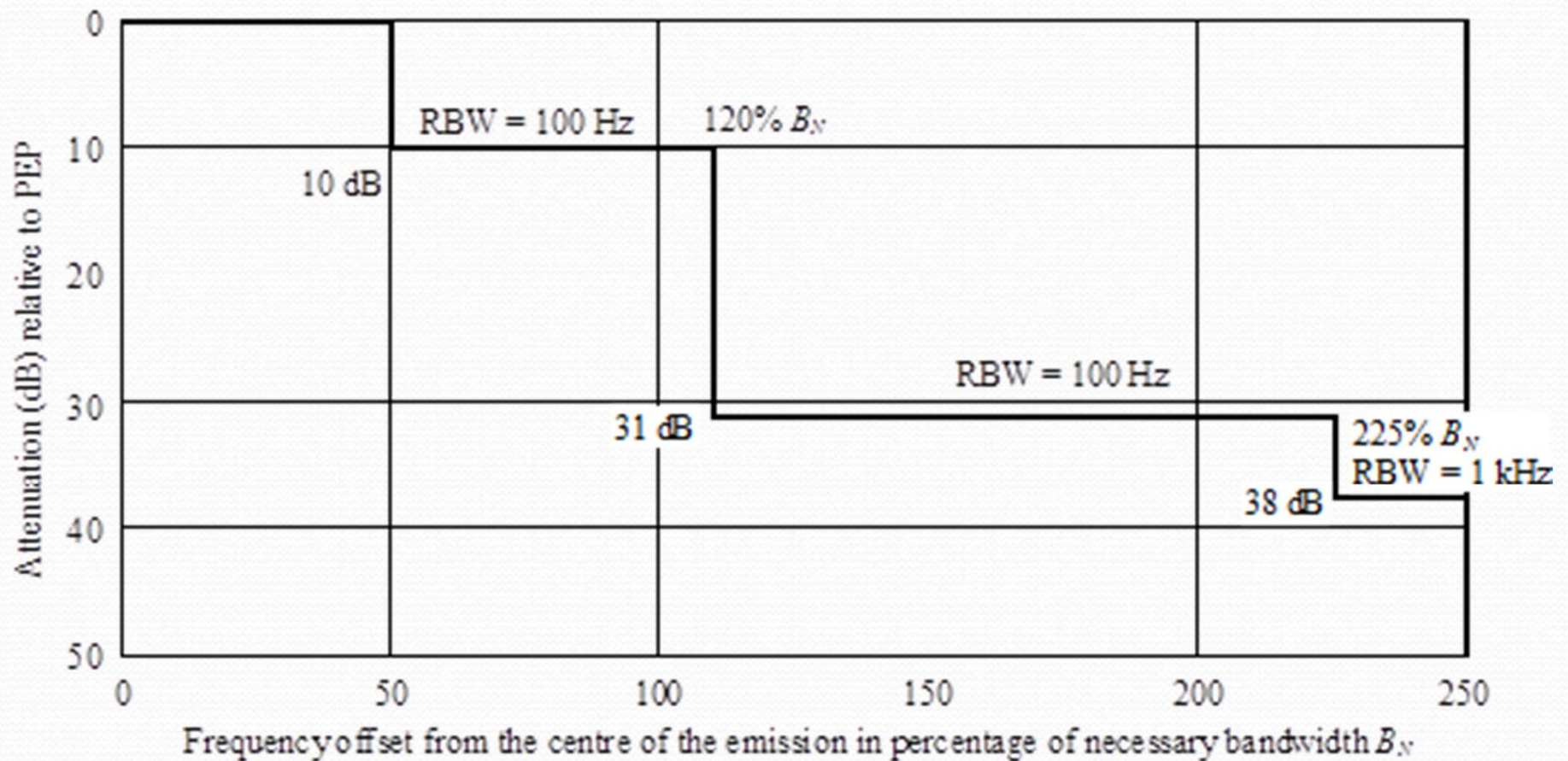
SUBCLAUSE § 90.210

Emission Mask D – 12.5 kHz channel bandwidth

Emission Mask < 30 MHz (ITU)

FIGURE 30

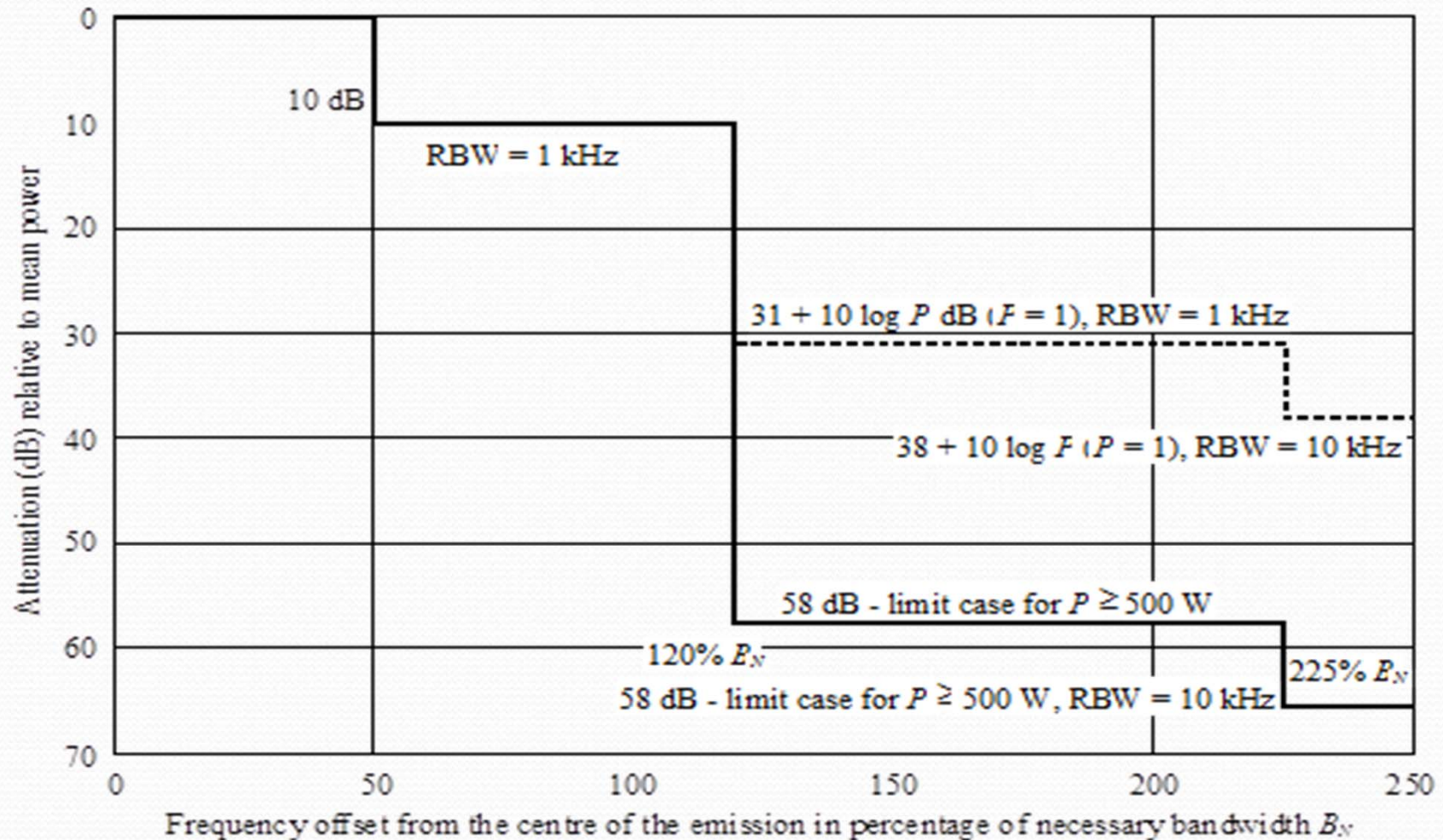
Stations operating below 30 MHz in the normal or narrow-band cases of Recommendation ITU-R SM.1539



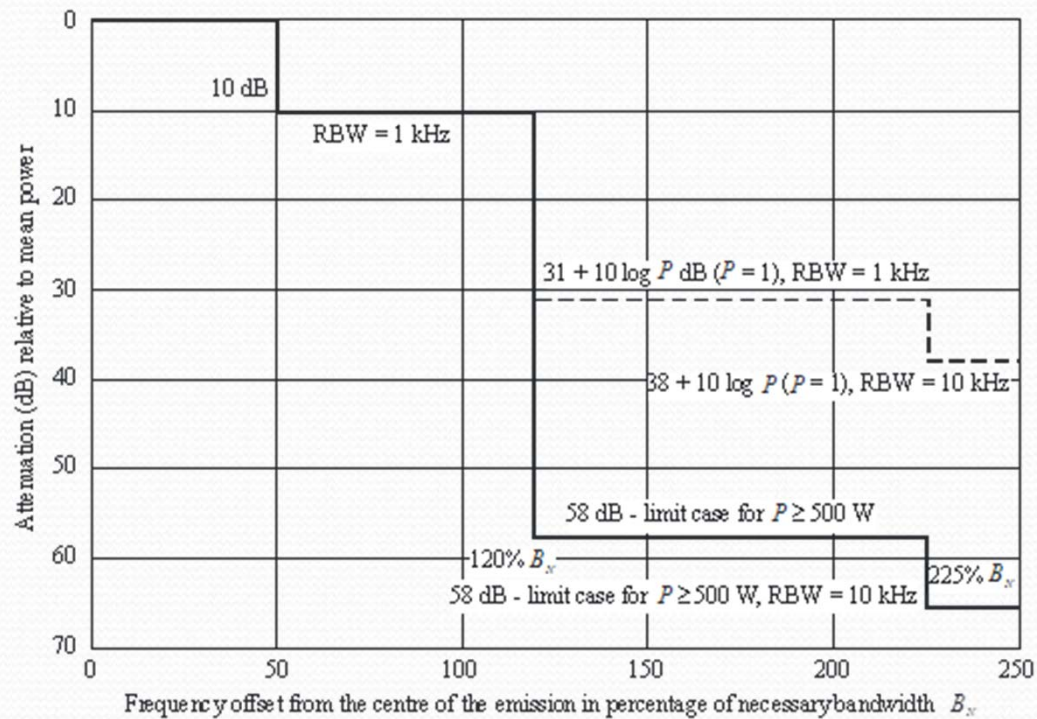
Emission Mask > 30 MHz

FIGURE 32

Stations operating above 30 MHz in the normal or narrow-band cases of Recommendation ITU-R SM.1539

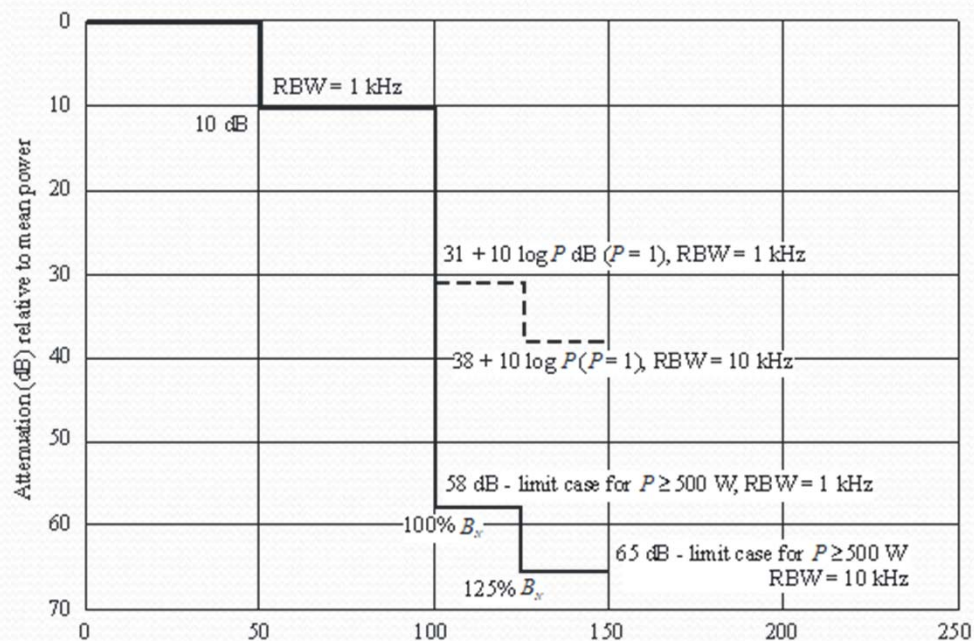


Stations operating above 30 MHz in the normal or narrow-band cases of Recommendation ITU-R SM.1539



SM.1541-34

Stations operating above 30 MHz in the wideband cases of Recommendation ITU-R SM.1539



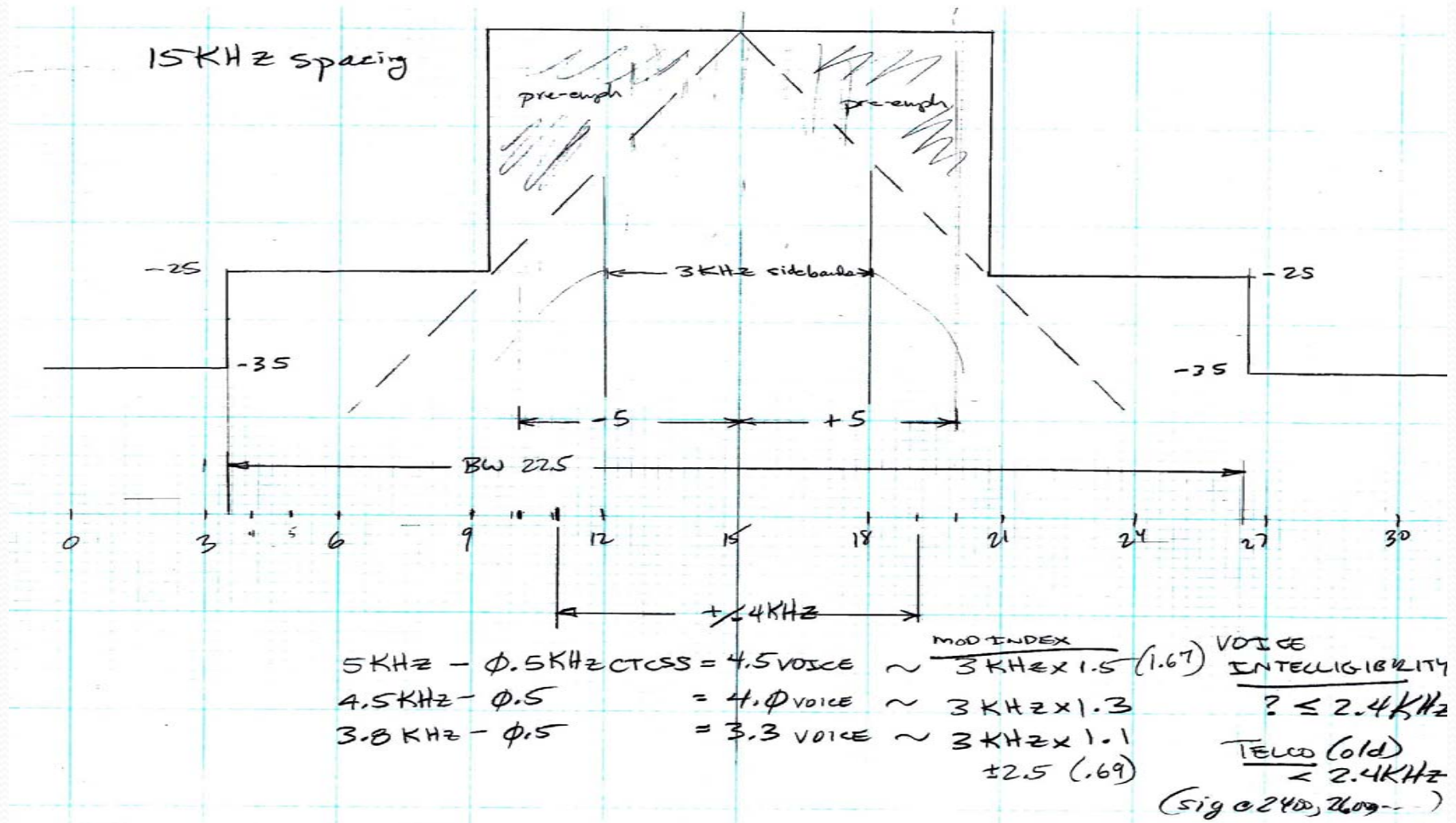
Frequency offset from the centre of the emission in percentage of necessary bandwidth B_n to which the separation value given in Recommendation ITU-R SM.1539 is to be added to obtain the actual frequency offset.

PEP: peak envelope power (W) supplied to the antenna transmission line in accordance with RR No. 1.157.

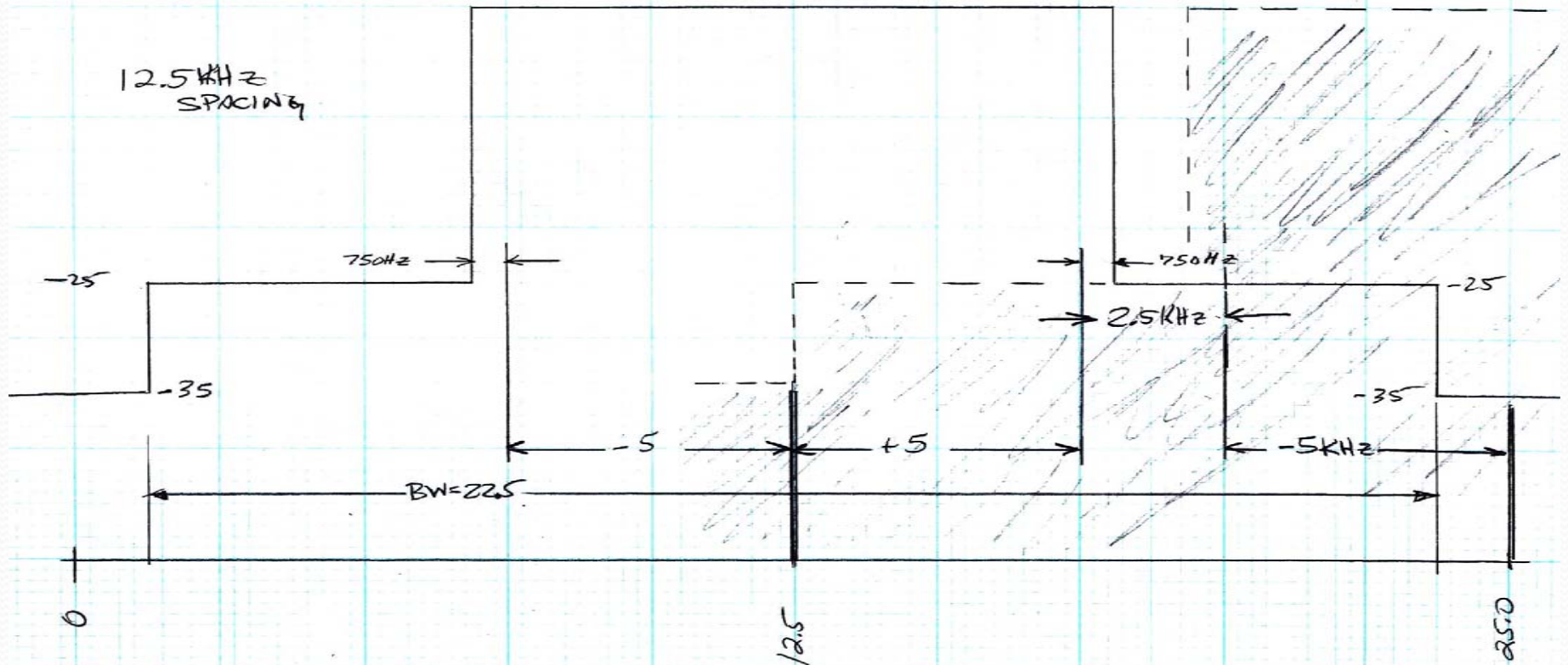
P: mean power (W) supplied to the antenna transmission line in accordance with RR No. 1.158

SM.1541-35

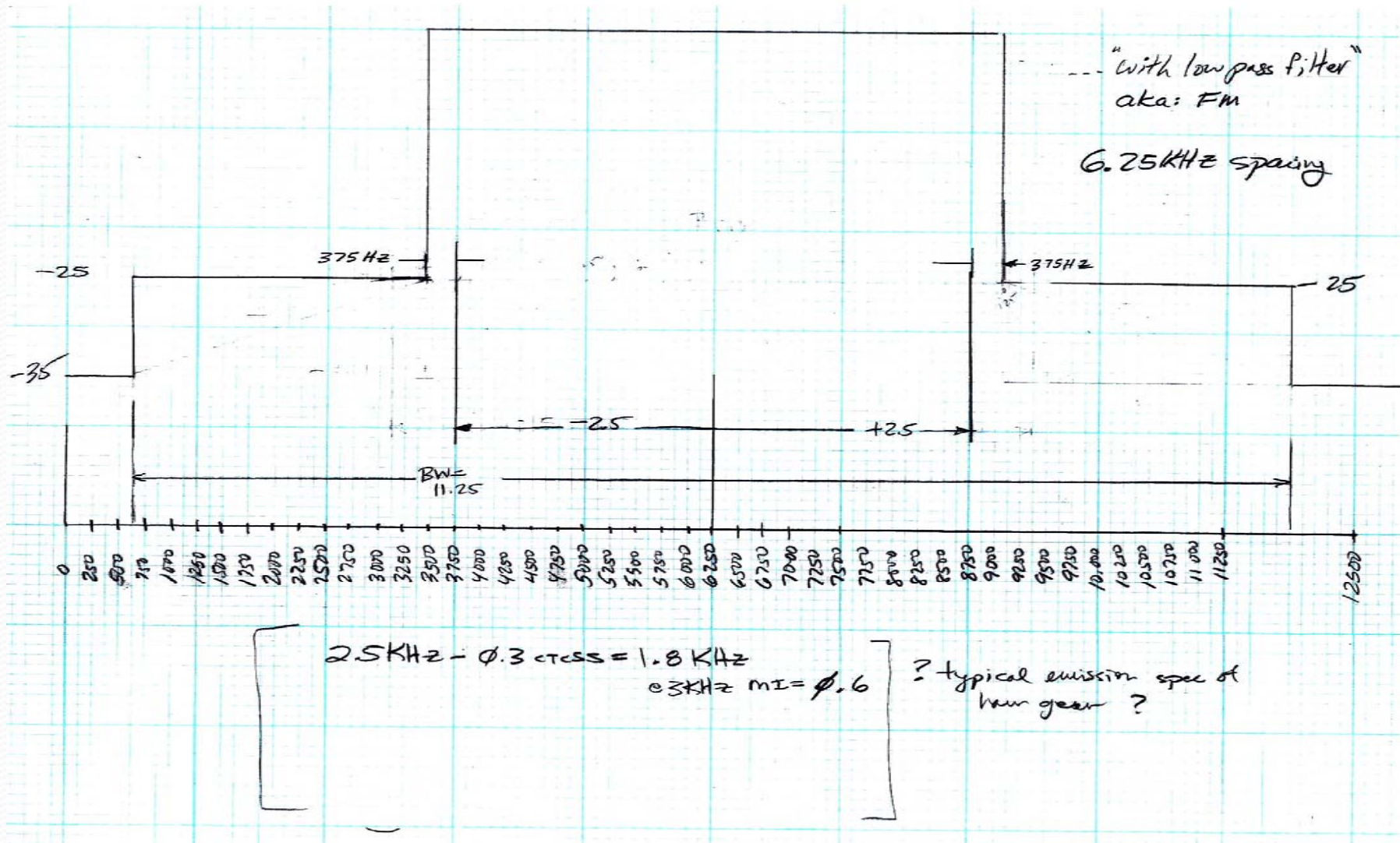
Emission Masks – 15 KHz



Emission Masks – 12.5 KHz



Emission Masks – 6.25 KHz



Deviation Options

Voice Dev.	CTCSS / DCS Dev	Max Dev	High Voice Freq	Mod Index	High Voice Freq	Mod Index
5.0	0.5	5.5	3.0	1.67	2.4	2.08
4.5	0.5	5.0	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
3.5	0.5	4.0	3.0	1.17	2.4	1.46
3.5	0.3	3.8	3.0	1.17	2.4	1.46
3.3	0.5	3.8	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
2.25	0.25	2.5	3.0	0.75	2.4	0.94

Frequency Stability

<u>Stability</u>	<u>Low Limit</u>	<u>On-Channel</u>	<u>High Limit</u>	<u>Drift</u>
2.5 PPM	146.51963	146.52000	146.52037	+/-370 Hz
0.00025%				
	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	+/-2.2 KHz
10 PPM	146.51853	146.52000	146.52147	+/-1.47KHz
0.001%				
	444.99555	445.00000	445.00445	+/-4.5 KHz

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

Coverage Area

- Generally, NARCC 'regions':
 - **Central Coast** – San Luis Obispo, Monterey, Santa Cruz
 - **East Bay** – Contra Costa, Alameda, Solano
 - **North Bay** – Marin, Sonoma, Napa, Solano, San Francisco
 - **North Coast** – Del Norte, Humboldt, Mendocino, Sonoma
 - **North East** – Modoc, Lassen, Plumas
 - **Sacramento Valley** – Siskiyou, Trinity, Tehama, Glenn, Colusa, Butte, Yolo, Sutter, Placer, Nevada, Sacramento, El Dorado,
 - **San Joaquin Valley** – San Joaquin, Amador, Calaveras, Stanislaus, Tuolumne, Merced, Mariposa, Madera, Fresno, Kings, Tulare, Mono
 - **South Bay** – Santa Clara, San Mateo, Alameda, Santa Cruz
 - **Tahoe** – Alpine, El Dorado, Tuolumne, Mono, Placer
 - **West Bay** – San Mateo, San Francisco
- Considerable overlap especially from ridges and broad valleys that span multiple 'regions'

Signal Levels

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

Signal Levels

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

Poll: Occupied BW/Emission Mask

- Deviation is readily measurable for analog to determine within Emission Mask established for +/-5 KHz and +/-2.5 KHz deviation channels.
- Deviation +/- 5.0 KHz (4.5 + 0.5 tone)
 - 20 KHz spacing 29 and 50 MHz
- Deviation +/- 4.0 KHz (3.5 + 0.5) - or - (3.3 + 0.5)
 - 20 KHz spacing 144-148, 20 and 25 KHz spacing 420-450
- Deviation +/- 3.8 KHz (3.5 + 0.3) - or - (3.5 + 0.3)
 - 15 KHz spacing 144-148, 12.5 KHz spacing 430-450

Poll: 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

Poll: Coverage

- -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.)

Poll: Tone Protection

- CTCSS / DCS on repeater receiver only
- CTCSS / DCS on repeater receiver *and* transmitter

Summary

The \$64k question:

Can and will the membership seriously consider, respectfully debate, come to an understanding of basic and essential technical guidelines, and eventually make a majority community decision to move forward with?

- Does anyone need extra time or help to understand the data presented and its benefits?

Bibliography

- <http://www.itu.int/rec/R-REC-M/en>
- M.1740: Guide to the application of ITU-R texts related to the amateur and amateur-satellite services
- M.1544: Minimum qualifications of radio amateurs