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Comparison of signal levels of NDB OF and WD2XSH stations

by

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Abstract

Nondirectional beacon (NDB) OF in Norfolk, Nebraska transmits on 510 kHz, which is on the edge of the band authorized for use by WD2XSH stations. To assess the potential for interference, K0HW in Elk Point, South Dakota compared the signal levels of WD2XSH stations to that of OF from mid-November 2008 through February 2009. All measured signal levels from WD2XSH stations are sufficiently below the signal level of NDB OF that they should not cause harmful interference.

Indexing Terms

Radio, amateur
NDB
MF

1. INTRODUCTION

Nondirectional beacon (NDB) OF in Norfolk, Nebraska transmits on 510 kHz, which is on the edge of the band authorized for use by WD2XSH stations. To assess the potential for interference, K0HW in Elk Point, South Dakota compared the signal levels of WD2XSH stations to that of OF. Measurements were conducted from November 13, 2008 through February 28, 2009 at 0400 and 1200 GMT (2200 and 0600 CST). The comparisons show that WD2XSH signals should not cause harmful interference to users of NDB OF at the edge of its 15-Nmi service range.

The locations of WD2XSH stations, NDB OF, and monitor K0HW are shown in Figure 1and selected distances are given in Table 1. Of primary interest are signals from the midwest stations, /12, /15, /16, and /19. These stations have been restricted to operation from 505 to 508 kHz to ensure they do not cause harmful interference.

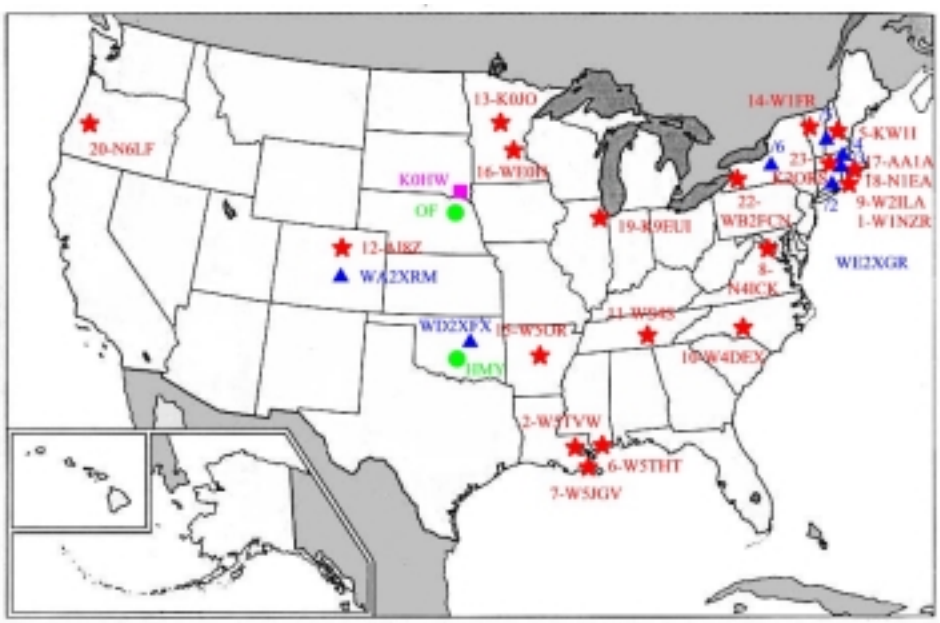

Figure 1. Locations of WD2XSH stations, NDB OF, and monitor K0HW.

STATION	DISTANCE, km	ERP, W
K0HW	117	---
/6	1490	18
/10	1635	2
/12	708	1
/13 (SK)	569	---
/15	899	5
/16	513	?
/19	762	0.25

Table 1. Distances from NDB OF to WD2XSH stations.

2. REQUIRED SIGNAL-STRENGTH MARGIN

The FAA generally regards a 15-dB difference in the levels of the signals from two NDBs on the same frequency as sufficient to prevent harmful interference [1]. As a rule of thumb, lower-power NDBs on the same frequency must be separated by 300 mi (500 km), while higher-power NDBs must be separated by 500 mi (800 km).

The FAA provides a detailed procedure for evaluating the interference potential of two NDBs. It is not perfectly clear how to apply this to other types of signals interfering with an NDB signal. The total power in a sideband of an AM signal is about 6 dB below the carrier. When the two sidebands are added together, the result is equivalent to a CW signal with the power in the carrier. Thus it appears reasonable to compare the amplitude of the NDB carrier to that of a WD2XSH CW signal.

The FAA procedure includes corrections to the permissible signal level for the difference in frequency between the two stations. The corrections for an NDB without voice (based upon Figure 11-3 of [1]) are given in Table 2. Thus a signal 2 kHz away can be at -10 dB without causing harmful interference, and a signal 4 kHz away can be at +16 dB.

Δf, kHz	ΔS, dB
1	1
2	5
3	17
4	31
5	44
6	50

Table 2. Correction to perimssible signal level for difference in frequency.

3. CORRECTION FOR SERVICE RANGE

K0HW is located 117 km (72 mi) to the northeast of NDB OF. The coordinates are given in Table 3.

STATION	LAT, °	LONG. °
K0HW	42.76424	-96.69867
OF	41.88763	-97.48028

Table 3. Coordinates.

The basic characteristics of the four classes of NDBs [1] are given in Table 4. The FAA states [2] that OF is a compass locator. It has an RF output of 10 W and a 15-Nmi (27.8-km) service radius.

CLASS	SERVICE RADIUS, Nmi	POWER, W
Compass Locator (outer marker)	15	25
MH	25	25
H	50	50
HH	75	100

Table 4. Characteristics of NDBs

The signal received by K0HW exhibits little fading and an amplitude that varies by no more than 1 dB from day to day. This signal is therefore almost entirely ground wave. The conductivity of the path from OF to K0HW is about 0.015 S/m [3]. The variation of the amplitude of the ground-wave with distance [4] is shown in Figure 3; the markers show the 15-Nmi operating radius of OF, the operating radius of an MH-class NDB (25 Nmi), and the distance of K0HW. The amplitude changes by 17.78 dB from the 27.8-km operating radius to the location of K0HW. Thus OF signal amplitudes measured by K0HW are increased by 17.8 dB to obtain the signal amplitude at the edge of the operating radius.

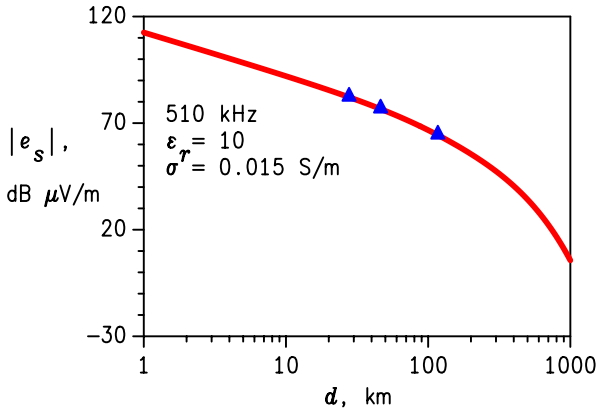

Figure 2. Variation of ground-wave signal with distance.

4. RECEIVING EQUIPMENT

Signal strength was measured by a Siemens D2006 level meter, which has an 80-Hz bandwidth. A vertical antenna (HyGain HyTower) was used to provide omnidirectional reception.

5. ANALYSIS

Transmissions were monitored from November 13, 2008 through February 28, 2009. The receiving sessions were scheduled at 0400 and 1200 GMT, which translate to 2200 and 0600 local time. Sky-wave signals are therefore excpected to be present at both monitoring periods.

The levels of signals from OF, WD2XSH stations, WE2XGR stations, and NDBs HMY (Lexington, OK) and PP (Omaha, NE) were recorded.

A given monitoring session lasted from ten to twenty minutes. During that time, the amplitude of a given signal was recorded from one to eight times. The signal levels (in dB) for each station were then averaged, resulting in one average signal-strength measurement per station per session (Appendix A).

6. RESULTS

Historgrams of the relative signal levels of the five WD2XSH stations are shown in Figure 3. The relative signal levels are obtained by first subtracting the 17.78-dB correction for distance from a given average signal level and then subtracting the corrected signal level from that of NDB OF. The signals from /6, /10, and /15 are well below the -15-dB threshold. WD2XSH/12 and /16 are also below the threshold, but by only 4 and 8 dB, respectively.

Similar histograms for two of the WE2XGR stations are shown in Figure 4. With one exception, these signals are also below the -15-dB threshold. While there was only one occurance of signal levels from WE2XGR/6 that exceeded the -15-dB threshold, several others are quite close.

Nondirectional beacons PP (513 kHz, Omaha, NE) and HMY (512 kHz, Lexington, OK) provide some insight into what is permissible. Histograms of the their relative signal levels are shown in Figure 5. Signals from PP are sometimes 2 dB above the threshold, while those from HMY are right at the threshold. However, when corrections for the frequency difference (Table 2) are included, the permissible signal levels increase by 17 dB for PP and 5 dB for HMY.

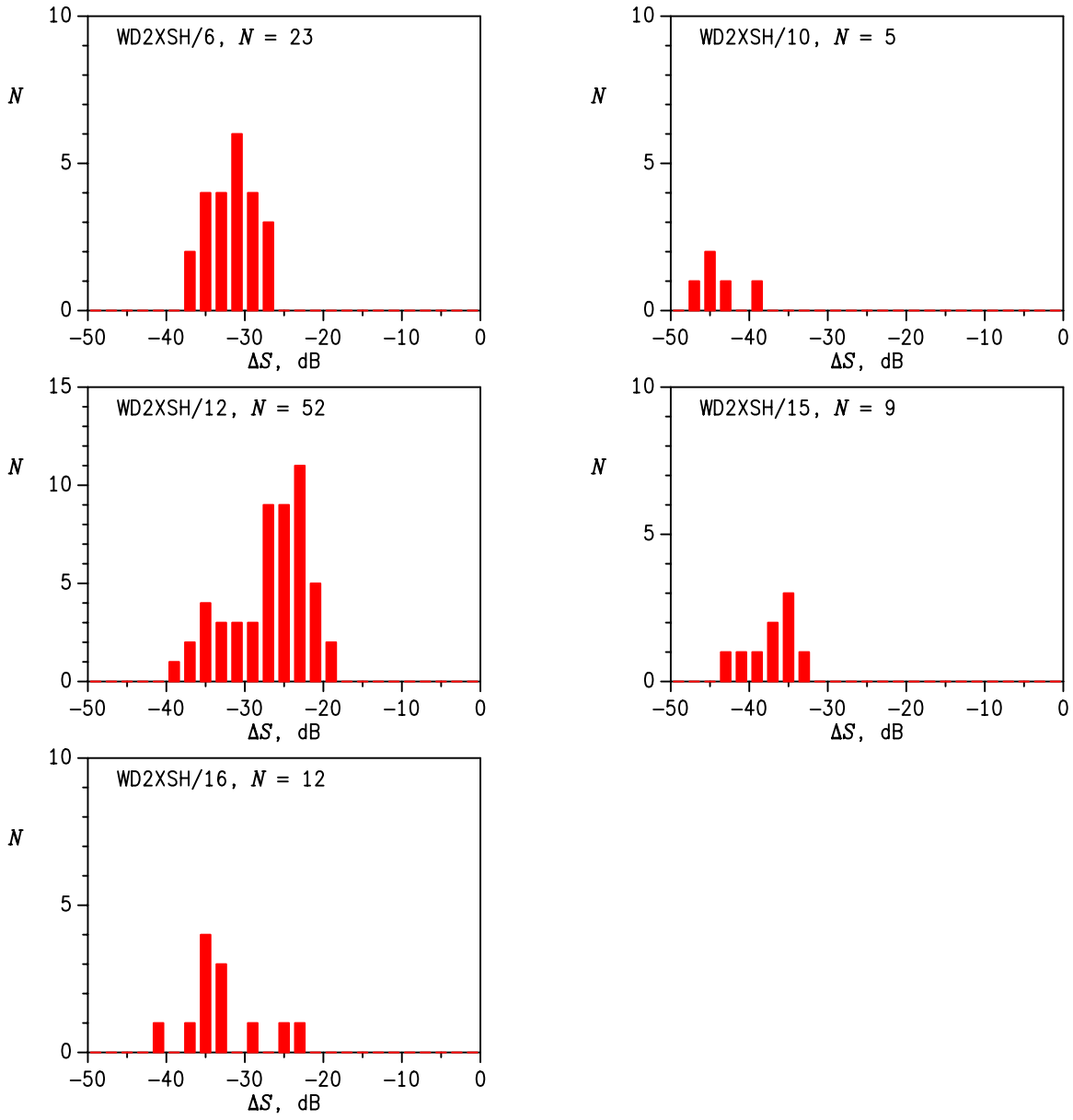

Figure 3. Histograms of relative signal levels of WD2XSH stations.

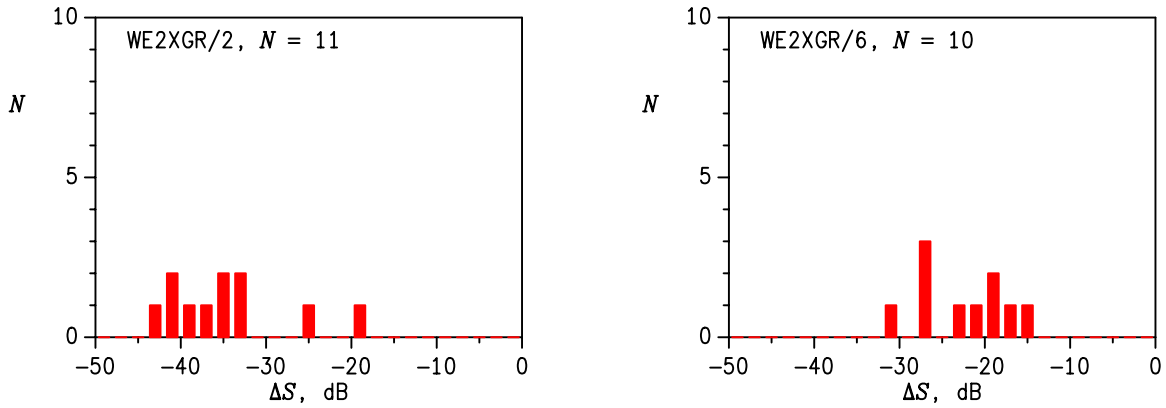

Figure 4. Histograms of relative signal levels of WE2XGR stations.

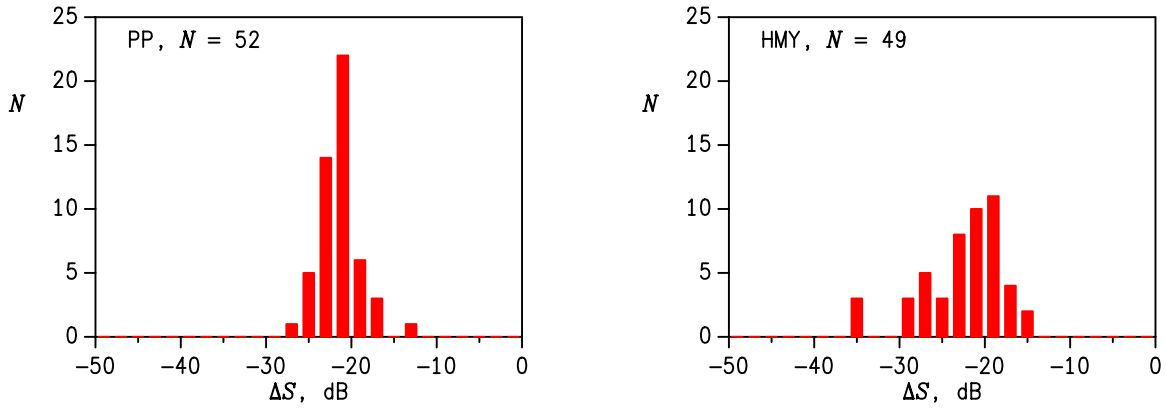

Figure 5. Histograms of relative signal levels of NDBs PP and HMY.

7. CONCLUSIONS

All observed signals from WD2XSH stations were below the threshold considered to be harmful interference.

The signals from WD2XSH stations outside the midwest are sufficiently below the threshold that their operation in 508-510 kHz should not cause harmful interference.

The signals from WD2XSH/15 are also sufficiently below the threshold that it could operate in 508-510 kHz with its present ERP.

The signals from WD2XSH/12 and /16 are also below the threshold, but only barely.

The signals from WE2XGR stations are generally below the threshold. However, on one occasion signals from WE2XGR/6 exceeded the threshold, and their levels have been close on

several other occasions. A reduction in power by 3 dB is recommended for night-time operation between 508 and 512 kHz.

NDB OF coexists with signals at -13 to -15 dB from NDBs 2 and 3 kHz away (HMY and PP). Consequently, amateur operation at similar levels and separations should not pose a problem.

8. REFERENCES

[1] "Spectrum Management Regulations and Procedures Manual," Order 6050.32B, Federal Aviation Administration, Washington, DC, Nov. 17, 2005. [E-438]

[2] H. Dietz, W5GHZ, March 23, 2009

[3] P. H. Lee, *Vertical Antenna Handbook*. Port Washington, NY: Cowan Publishing Company, 1974.

[4] L. Boithias, *Radiowave Propagation*. New York: Wiley, 1987.

APPENDIX A. SIGNAL-LEVEL COMPARISONS

DATE	TIME	OFC	PP	HMY	/6	/10	/12	/15	/16	XGR/2	XGR/6
081113	1200	-94					-103.7				
081114	0400	-94			-112.5				-110.0	-120	
081118	1200	-93.5					-100				
081118	0400	-93.2			-108.0		-97.8			-117.0	-91
081120	1200	-93					-108.7				
081121	0400	-97	-102		-111.5			-113.5			-101.7
081125	1200	-98.5	-102			-120.0		-117			
081126	0400	-93.3	-99		-107.7	-120.0		-111	-110		
081127	1200	-93.5	-101	-97.5			-102.6	-118.5			
081128	0400	-94	-102	-95.5	-105.0		-100.0	-115.5			-96

DATE	TIME	OFC	PP	HMY	/6	/10	/12	/15	/16	XGR/2	XGR/6
081202	1200	-93	-98.5	-91.2				-112.5	-109.3		
081203	0400	-92.3	-96.7	-97	-111.0		-99.0		-108.0	-115.0	-106.0
081205	0400	-92.5	-97	-92.5	-103.5		-98.7	-108.5	-109.5		
081209	1200	-91.5	-97	-109			-110.7				
081210	0400	-92.5	-97	-92.3			-96.4				
081211	1200	-93.5	-97	-103.5			-113	-117.0			
081212	0400	-93.7	-98.5	-95.7	-107.0		-101.8	-110.0	-101.0		
081216	1200	-92.0	-96	-98.5			-105.2		-107.8		
081217	0400	-92.0	-93	-110	-103.5		-95.7		-111.3	-110	
081218	1200	-92.5	-95.5	-96.5			-97.4		-108.8		
081219	0400	-92.9	-96.5	-95.5	-107.0		-98.5			-108.3	
081223	1200	-89.5	-98.5	-101.0			-105.8				
081223	0400	-89.5	-91.5	-95.0	-106.2		-97.0			-104.0	
081225	1200	-93.0	-95.0	-96.0			-101.6				
081226	0400	-93.7	-97.7	-101.3	-111.7		-103.4				
081230	1200	-94.0	-97.5	-93.5		-123.5	-104.0		-118.0		
081231	0400	-93.5	-96.0	-95.5		-120.0	-98.5		-105.0		-103.0

DATE	TIME	OFC	PP	HMY	/6	/10	/12	/15	/16	XGR/2	XGR/6
090101	1200	-93.0	-97.0	-97.5		-117.3	-101.2				
090102	0400	-94.0	-99.5	-98.0	-105.0		-98.5			-115.0	-102.5
090105	0400	-93.0	-96.0	-90.0	-111.0		-100.0		-98.0	-101.0	
090105	1200	-93.0	-98.0	-94.0			-110.5				
090111	0400	-94.0	-96.0	-95.0			-115.0			-112.0	-96.0
090111	1200	-95.0	-102.0	-101.0			-106.2				
090113	1200	-93.5	-97.5	-98.5			-101.2				
090114	1200	-92.0	-95.5	-97.5	-108.0		-100.8				
090115	1200	-92.5	-95.3	-91.5			-109.0				
090116	0400	-92.5	-96.5	-93.0	-106.0		-98.5			-111.0	
090120	0400	-93.5	-95.5	-100.5			-109.2				
090121	0400	-93.5	-96.5	-94.5	-103.5		-100.0				-93.0
090122	1200	-94.0	-98.0	-95.0			-99.6				
090123	0400	-93.7	-100.5	-111.7	-106.0		-97.0				
090127	1200	-92.5	-96.5	-103.5			-103.0				
090128	0400	-93.5	-96.5	-104.5	-106.5		-97.0				-102.0
090129	1200	-93.0	-95.5	-103.0			-107.0				
090130	0400	-93.5	-98.0	-96.5	-110.0		-103.0				-96.5
090203	1200	-94.0	-93.5	-94.5			-95.7				
090204	0400	-93.0	-92.0	-96.0	-103.0		-109.5				
090205	1200	-92.0	-88.0	-101.0			-95.2				
090206	0400	-94.0	-93.0	-97.0	-102.7		-95.0			-96.0	
090210	1200	-91.0	-94.7	-96.7			-106.4				
090211	0400	-91.0	-98.5	-100.0			-98.0				
090212	1200	-91.5	-94.0	-92.5			-103.7				
090213	0400	-91.0	-97.0	-95.5	-104.2		-100.7				
090218	0400	-92.0	-94.0	-95.0			-97.5				
090224	1200	-91.0	-94.5	-100.5			-104.1				
090226	1200	-91.5	-97.0	-92.0			-101.0				
090227	0400	-93.0	-98.0	-96.0			-98.0				