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Effect of Small Frequency Changes on the Radiation Patterns of MF (AM) Directional Antennas

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EFFECT OF SMALL FREQUENCY CHANGES ON THE RADIATION PATTERNS OF MF (AM) DIRECTIONAL ANTENNAS

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The pressure to provide additional full-time facilities in the AM (standard broadcasting) band in the United States resulted in a rulemaking petition filed with the Federal Communications Commission (FCC) by the National Telecommunications and Information Administration (NTIA). The petition proposed the reduction of the AM channel spacing from 10 to 9 kHz. According to the suggested frequency allocation plan, the maximum frequency change required for any standard AM broadcast station would be ±4 kHz. At the Institute for Telecommunication Sciences, in addition to investigation of several impacts which would result from the change, a study was conducted both theoretically and experimentally to determine the magnitude of the radiation pattern changes that would be caused by a ±4 kHz frequency change for stations using directional antenna arrays. The dollar cost to broadcasters because of the proposed change is directly tied to the engineering costs that would be required in achieving compliance with directional arrays. Additionally, a computer study of the 1430 kHz regional channel, using standard patterns for all occupants of the channel, was conducted to determine the effects of a ±4 kHz frequency change on the interference levels suffered by co-channel stations. The results of the study demonstrate that the effects of small frequency changes on the radiation patterns of directional antenna arrays are greater in practice than theoretical predictions would indicate, but that required pattern corrections could probably be quickly and easily effected.

Key Words: AM broadcast band; allocation bandwidth; directional antennas; frequency allocations

1. INTRODUCTION

Because of the number of requests for additional full-time facilities in the AM (standard broadcast) band, different means for providing additional channel space have been considered. Proposals for the addition of new channels by extending the high frequency limit of the present AM broadcast band (535 to 1605 kHz) have not been popular because existing radio receivers

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do not cover the extended range, and the time required for replacement of existing receivers because of obsolescence would be too long to justify the expenditure for new broadcast stations in the extended portion of the band.

Twelve new channels could be provided in the spectrum space presently occupied by the AM standard broadcast band by the simple expedient of changing the allocation channel spacing from 10 to 9 kHz. This reduced channel spacing is already in use in other regions of the world (ITU regions 1 and 3), but not in the Americas (region 2). This scheme for increasing the number of AM channels has had the support of a portion of the broadcast industry and was the subject of a rulemaking petition filed with the Federal Communications Commission (FCC) by the National Telecommunications and Information Administration (NTIA). A suggested allocation plan is shown in Table 1. According to this plan, the maximum frequency change required of any presently operating broadcast station is 4 kHz. It will be noted that some broadcast stations would not be required to change their frequency, some would be required to move 1 kHz, some 2 kHz, some 3 kHz, and some 4 kHz.

Studies have been conducted to determine what effect the change in allocation bandwidth would have on adjacent channel interference with existing receivers and what changes in receiver characteristics would be desirable with the reduced channel widths.

The frequency change for broadcast stations employing omnidirectional antennas would be a simple operation of changing the crystals in the transmitter and monitoring equipment to crystals for the new frequency, some slight retuning of the transmitter and antenna matching network, and a new measurement of antenna impedance, though the current antenna measurements would cover the new frequency.

In the case of broadcast stations which use directional antenna arrays (of which there are a great many) either for the protection of other stations on the same frequency or to achieve a desired coverage area, the problem is more complex. The desired radiation pattern for an array is determined by the orientation of the array, the spacing between the elements of the array, and the ratios of the currents and phase relationships between the elements. With changes in frequency, the electrical heights of the radiators and the electrical spacing between the elements of the array will be different than the parameters used by the designer of the array. The electrical lengths of transmission lines will be different and will contribute different phase

Table 1. Proposed 9 kHz Frequency Allocation Plan

Present f kHz	Nearest New * f kHz	Δf kHz	Present f kHz	Nearest New * f kHz	Δf kHz	Present f kHz	Nearest New * f kHz	Δf kHz
540	540	0	900	900	0	1260	1260	0
550	549	-1	910	909	-1	1270	1269	-1
560	558	-2	920	918	-2	1280	1278	-2
570	567	-3	930	927	-3	1290	1287	-3
580	576	-4	940	936	-4	1300	1296	-4
	585			945			1305	
590	594	+4	950	954	+4	1310	1314	+4
600	603	+3	960	963	+3	1320	1323	+3
610	612	+2	970	972	+2	1330	1332	+2
620	621	+1	980	981	+1	1340	1341	+1
630	630	0	990	990	0	1350	1350	0
640	639	-1	1000	999	-1	1360	1359	-1
650	648	-2	1010	1008	-2	1370	1368	-2
660	657	-3	1020	1017	-3	1380	1377	-3
670	666	-4	1030	1026	-4	1390	1386	-4
	675			1035			1395	
680	684	+4	1040	1044	+4	1400	1404	+4
690	693	+3	1050	1053	+3	1410	1413	+3
700	702	+2	1060	1062	+2	1420	1422	+2
710	711	+1	1070	1071	+1	1430	1431	+1
720	720	0	1080	1080	0	1440	1440	0
730	729	-1	1090	1089	-1	1450	1449	-1
740	738	-2	1100	1098	-2	1460	1458	-2
750	747	-3	1110	1107	-3	1470	1467	-3
760	756	-4	1120	1116	-4	1480	1476	-4
	765			1125			1485	
770	774	+4	1130	1134	+4	1490	1494	+4
780	783	+3	1140	1143	+3	1500	1503	+3
790	792	+2	1150	1152	+2	1510	1512	+2
800	801	+1	1160	1161	+1	1520	1521	+1
810	810	0	1170	1170	0	1530	1530	0
820	819	-1	1180	1179	-1	1540	1539	-1
830	828	-2	1190	1188	-2	1550	1548	-2
840	837	-3	1200	1197	-3	1560	1557	-3
850	846	-4	1210	1206	-4	1570	1566	-4
	855			1215			1575	
860	864	+4	1220	1224	+4	1580	1584	+4
870	873	+3	1230	1233	+3	1590	1593	+3
880	882	+2	1240	1242	+2	1600	1602	+2
890	891	+1	1250	1251	+1			

* According to the 9 kHz spacing plan used in Regions 1 and 3.

shifts. Phase shifts in phasing and matching networks in the antenna system will also change. The greater the frequency change, the greater the change in electrical lengths and phase changes in the array. In the study, the maximum frequency change (±4 kHz) was used since this will cause the greatest change in the parameters. The purpose of this study was to determine whether existing directional antenna arrays could accommodate this amount of frequency change and still provide the required protection to co-channel stations without redesign. It was also the purpose of the study to determine the probable complexity and likely cost to broadcasters of making the frequency change.

This report deals with the theoretical studies made on several directional antenna systems and with experiments with four directional systems at three broadcast stations when the operating frequency was changed 4 kHz both above and below their normal frequency. Additionally, a computer analysis of the station-to-station interference on the 1430 kHz channel and comparison with the interference that would exist if the frequency were changed to 1426 kHz and 1434 kHz is presented.

2. THEORETICAL RADIATION PATTERNS

Radiation patterns were calculated for a number of broadcast station directional antennas at their present operating frequency and at frequencies from 1 to 4 kHz both above and below. Standard patterns were also calculated for all stations on 1430 kHz with directional antennas and for all of these stations if they were operating on 1426 kHz and 1434 kHz. The licensed design parameters for the antennas were used for the offset frequencies with only the electrical heights of the antennas and the electrical spacing between elements of the array changed to conform to the offset frequencies. Changes in the radiation patterns of all of the stations were minor.

Radiation patterns were also calculated for the four directional arrays which were measured as described in Section 3. The calculations were made at the assigned frequency and at frequencies 4 kHz above and below. Licensed field ratios and phases were used, with the spacing between elements and antenna heights changed to the electrical lengths they would be at the offset frequencies.

Table 2 shows the computed, horizontal-plane, standard pattern for Radio Station WLBH in Mattoon, Illinois. Also shown are the fields that would be

Table 2. WLBH - Standard Horizontal Plane Pattern

Azimuth	Field Strength mV/m 1166 kHz A	1170 kHz B	1174 kHz C	Ratios A/B	C/B
0	74.85	75.13	75.46	0.996	1.004
10	73.46	72.66	71.89	1.011	0.989
20	89.24	88.35	87.45	1.010	0.990
30	95.32	94.83	94.34	1.005	0.995
40	78.22	78.03	77.85	1.002	0.998
50	60.51	60.13	59.75	1.006	0.994
60	86.49	85.84	85.20	1.008	0.993
70	112.78	112.10	111.42	1.006	0.994
80	97.56	96.85	96.14	1.007	0.993
90	88.24	88.13	88.02	1.001	0.999
100	215.52	216.16	216.78	0.997	1.003
110	406.63	407.47	408.29	0.998	1.002
120	606.44	607.23	607.98	0.999	1.001
130	782.95	783.51	784.03	0.999	1.001
140	916.77	917.04	917.24	1.000	1.000
150	998.85	998.86	998.81	1.000	1.000
160	1026.35	1026.27	1026.12	1.000	1.000
170	998.85	998.86	998.81	1.000	1.000
180	916.77	917.04	917.24	1.000	1.000
190	782.95	783.51	784.03	0.999	1.001
200	606.44	607.23	607.98	0.999	1.001
210	406.64	407.47	408.29	0.998	1.002
220	215.52	216.16	216.78	0.997	1.003
230	88.24	88.13	88.02	1.001	0.999
240	97.56	96.85	96.14	1.007	0.993
250	112.78	112.10	111.41	1.006	0.994
260	86.49	85.84	85.20	1.008	0.993
270	60.51	60.13	59.75	1.006	0.994
280	78.22	78.03	77.85	1.002	0.998
290	95.32	94.83	94.34	1.005	0.995
300	89.24	88.35	87.45	1.010	0.990
310	73.46	72.66	71.89	1.011	0.989
320	74.85	75.13	75.46	0.996	1.004
330	91.30	92.47	93.70	0.987	1.013
340	99.69	101.13	102.62	0.986	1.015
350	91.30	92.47	93.70	0.987	1.013

NOTE: Maximum deviation occurs at 340° (1.5%) at 0° elevation.

produced by the array if the frequency were shifted to 1166 kHz and 1174 kHz. The ratios between the 1170 kHz fields and those at 1166 and 1174 kHz are shown in the right hand columns. Note that the maximum deviation in the fields at the offset frequencies is 1.5%.

The antenna array at Radio Station WLBH consists of four radiators arranged in a line oriented 340° true (Figure 1). The radiators are spaced 210 feet apart. The southeast radiator is 525 feet high and is used to support an FM antenna. The other three towers are 210 feet high. The design parameters for the array at 1170 kHz are as follows:

Tower	Tower Height	Spacing from Reference Tower	Bearing from Reference Tower	Phase	Field Ratio
1	90°	0°	0°	-133.1°	1
2	90°	90°	340°	76.07°	1.764
3	90°	180°	340°	-76.1°	1.493
4	225°	270°	340°	133.1°	0.578

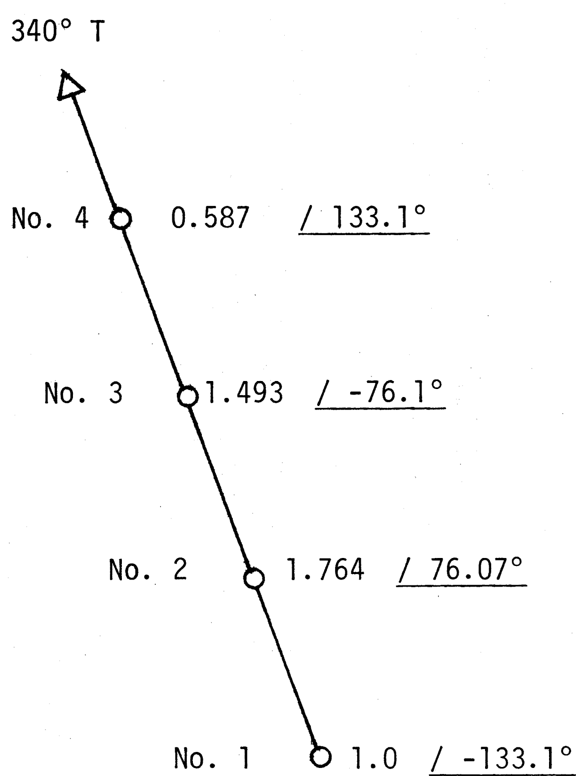
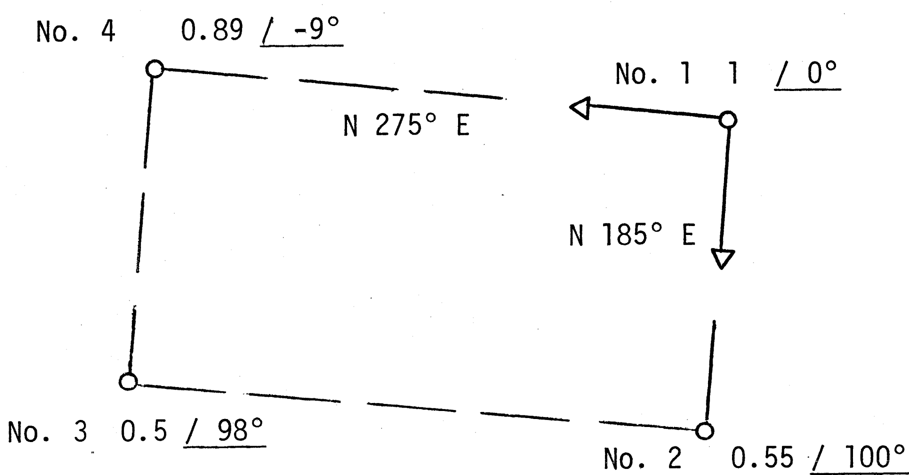


Figure 1. WLBH antenna array.

Table 3 is a similar computation of the standard radiation pattern for Radio Station KLAK in Denver, Colorado. The antenna array at Radio Station KLAK consists of four elements located essentially at the corners of a rectangle with dimensions of 325 feet by 154 feet (Figure 2). The long dimension is oriented at approximately N 95^{o} E. The northeast tower is 360 feet in height, and is used for daytime operation. It also supports an auxiliary FM antenna. The other three towers are 185 feet high. The design parameters at 1600 kHz are shown.

Tower	Tower Height	Spacing from Reference Tower	Bearing from Reference Tower	Phase	Field Ratio
1	212.5^{o}	0	0	0	1
2	109^{o}	91.242^{o}	185^{o}	100^{o}	0.55
3	109^{o}	210.4^{o}	249.3^{o}	98^{o}	0.5
4	109^{o}	189.587^{o}	275^{o}	-9^{o}	0.89



Spacing

No. 1 to No. 4 325' (190°)
No. 3 to No. 2 325' (190°)
No. 4 to No. 3 154' (90°)
No. 1 to No. 2 154' (90°)

H_1 = 360' (212.5°)
H_2, H_3, H_4 = 185' (109°)

Figure 2. KLAK antenna array.

Table 3. KLAK - Standard Horizontal Plane Pattern
Night Pattern

Azimuth	Field Strength mV/m 1596 kHz A	1600 kHz B	1604 kHz C	Ratios A/B	C/B
0	1165.57	1167.67	1169.73	0.998	1.002
10	1146.77	1148.79	1150.77	0.998	1.002
20	1033.71	1035.06	1036.37	0.999	1.001
30	846.47	846.73	846.94	1.000	1.000
40	617.97	616.94	615.87	1.002	0.998
50	386.26	384.05	381.81	1.006	0.994
60	188.41	185.52	182.61	1.016	0.984
70	76.71	76.03	75.51	1.009	0.993
80	105.27	108.14	111.07	0.974	1.027
90	131.50	134.59	137.70	0.977	1.023
100	120.04	122.65	125.28	0.979	1.021
110	85.90	87.66	89.46	0.980	1.020
120	57.08	57.38	57.74	0.995	1.006
130	65.75	64.75	63.76	1.015	0.985
140	101.85	100.80	99.76	1.010	0.990
150	156.13	155.57	155.00	1.004	0.996
160	226.74	226.91	227.08	0.999	1.001
170	298.62	299.51	300.41	0.997	1.003
180	350.00	351.27	352.74	0.996	1.004
190	365.11	366.54	367.98	0.996	1.004
200	342.31	343.38	344.45	0.997	1.003
210	294.11	294.55	294.99	0.999	1.002
220	238.79	238.57	238.23	1.001	0.999
230	188.02	187.26	186.50	1.004	0.996
240	141.82	140.66	139.50	1.008	0.992
250	98.75	97.35	95.95	1.014	0.986
260	69.93	69.02	68.16	1.013	0.988
270	68.08	68.50	69.04	0.994	1.008
280	72.11	72.81	73.65	0.990	1.012
290	80.32	79.05	77.91	1.016	0.986
300	151.96	149.00	146.05	1.020	0.980
310	299.76	297.00	294.22	1.009	0.991
320	499.17	497.32	495.43	1.004	0.996
330	720.96	720.31	719.62	1.001	0.999
340	929.51	930.10	930.65	0.999	1.001
350	1087.80	1089.39	1090.93	0.999	1.001

Note: For fields in excess of 10% of the horizontal plane rms value, the maximum deviation of 7.47% occurs at an azimuth of 70° and an elevation angle of 15°.

The maximum difference between the offset frequency fields and the 1600 kHz fields is 2.7%.

Table 4 is a computation of the nighttime pattern for Radio Station WELO in Tupelo, Mississippi. The antenna array at Radio Station WELO consists of four elements arranged in a parallelogram with dimensions of 1320 feet by 566 feet (Figure 3). The long dimension is oriented 0° true. The antennas are 305 feet high. A 500-foot tower supporting an FM antenna is located in the vicinity of the No. 1 and No. 2 towers. This tower has been detuned at 580 kHz. Shown are the design parameters at the assigned frequency of 580 kHz.

Tower	Tower Height	Spacing from Reference Tower	Bearing from Reference Tower	Phase	Field Ratio
1	64.8°	0	0	-152°	1
2	64.8°	120°	20°	0	1.6667
3	64.8°	280°	0	-152°	0.65
4	64.8°	394.9°	5.966°	0	1.0833

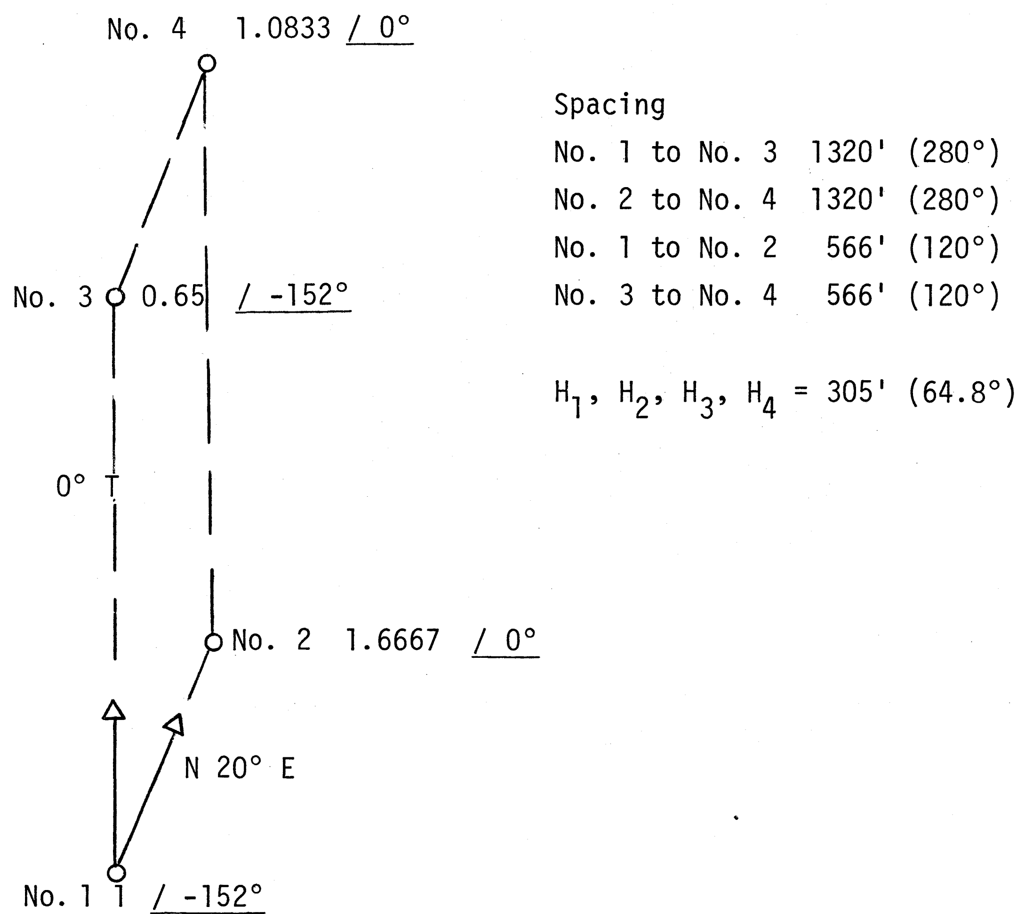


Figure 3. WELO antenna array.

Table 4. WELO - Standard Horizontal Plane Pattern
Nighttime

Azimuth	Field Strength mV/m 576 kHz A	580 kHz B	584 kHz C	Ratios A/B	C/B
0	190.38	192.65	194.81	0.988	1.011
10	192.86	195.26	197.55	0.988	1.012
20	176.23	178.83	181.33	0.986	1.014
30	139.46	142.14	144.75	0.981	1.018
40	86.82	89.09	91.34	0.975	1.025
50	49.04	48.92	48.92	1.003	1.000
60	81.56	80.18	78.78	1.017	0.983
70	116.48	115.75	114.98	1.006	0.993
80	119.00	118.70	118.38	1.003	0.997
90	97.34	96.91	96.46	1.004	0.995
100	84.48	83.61	82.74	1.010	0.990
110	84.94	83.79	82.64	1.014	0.986
120	67.94	66.45	64.96	1.022	0.978
130	46.01	45.73	45.55	1.006	0.996
140	89.41	91.45	93.47	0.978	1.022
150	154.92	157.42	159.83	0.984	1.015
160	208.95	211.34	213.61	0.989	1.011
170	243.67	245.79	247.77	0.991	1.008
180	258.63	260.61	262.42	0.992	1.007
190	254.56	256.64	258.56	0.992	1.008
200	230.43	232.83	235.09	0.990	1.010
210	184.04	186.78	189.42	0.985	1.014
220	117.84	120.40	122.94	0.979	1.021
230	69.77	69.31	69.01	1.007	0.996
240	125.41	122.76	120.11	1.022	0.978
250	199.36	197.29	195.18	1.011	0.989
260	234.06	232.68	231.26	1.006	0.994
270	214.66	213.59	212.49	1.005	0.995
280	154.22	153.11	151.98	1.007	0.993
290	84.95	83.80	82.65	1.014	0.986
300	37.52	36.60	35.70	1.025	0.975
310	21.58	21.46	21.40	1.006	0.997
320	45.74	46.92	48.11	0.975	1.025
330	90.57	92.41	94.21	0.980	1.020
340	135.74	137.87	139.93	0.985	1.015
350	170.61	172.83	174.96	0.987	1.012

Note: For any azimuth angle or elevation angle through 70°, the maximum deviation occurs at 304° azimuth and 0° elevation (2.76%).

The maximum deviation in field strength at 576 kHz and 584 kHz from that at 580 kHz is 2.5%.

Table 5 is a computation of the daytime pattern for Radio Station WELO. This array uses two elements of the four-tower nighttime array with the following design parameters at 580 kHz.

Tower	Tower Height	Spacing from Reference Tower	Bearing from Reference Tower	Phase	Field Ratio
1	64.8^{o}	0	0	0	1
2	64.8^{o}	120^{o}	20^{o}	-90^{o}	2.222

The maximum deviation of field strength at 576 kHz and 584 kHz from the value at 580 kHz is <1%.

Though the tabulations in Tables 2 through 5 are for azimuthal increments of 10^{o} for the horizontal plane standard pattern, the computations were made with azimuth increments of 2^{o} and for vertical angles from 0 to 70^{o} in 5^{o} increments. The maximum percentage deviation of the field at the offset frequencies from the field at the licensed frequency is given in the note at the bottom of the table for the nighttime arrays at KLAK and WELO. These represent very small deviations in the actual fields since they are in directions where the fields are small. It appears that wide-spaced arrays with elements not in line and with mixed tower heights are apt to produce variations of 10 to 15% in radiated fields at certain of the higher vertical angles when the frequency is shifted ±4 kHz.

3. MEASURED PATTERNS

In order to obtain some "hands on" experience with the problems that might arise in connection with the proposed change to a 9 kHz allocation bandwidth and to provide some verification of the theoretical calculations, the frequencies of three radio stations with directional antennas were changed. These stations were WLBH, 1170 kHz in Mattoon, Illinois; KLAK, 1600 kHz in Denver, Colorado; and WELO, 580 kHz in Tupelo, Mississippi.

Since the maximum frequency shift that would be required to implement the proposed 9 kHz allocation plan is ±4 kHz, and since this would result in the largest change in the electrical spacing of elements in an array, the frequency of each of the stations was changed to 4 kHz above and 4 kHz below their assigned frequency. The new frequencies were obtained from a very

Table 5. WELO - Standard Horizontal Plane Pattern Daytime

Azimuth	Field Strength mV/m 576 kHz A	580 kHz B	584 kHz C	Ratios A/B	C/B
0	250.36	250.38	250.38	1.000	1.000
10	248.18	248.12	248.03	1.000	1.000
20	247.35	247.25	247.13	1.000	1.000
30	248.18	248.12	248.03	1.000	1.000
40	250.36	250.38	250.38	1.000	1.000
50	252.90	253.05	253.18	0.999	1.000
60	254.33	254.62	254.90	0.999	1.001
70	252.86	253.28	253.70	0.998	1.002
80	246.75	247.25	247.75	0.998	1.002
90	234.70	235.21	235.71	0.998	1.002
100	216.33	216.74	217.15	0.998	1.002
110	192.40	192.63	192.86	0.999	1.001
120	165.04	165.04	165.04	1.000	1.000
130	137.65	137.44	137.23	1.002	0.999
140	114.67	114.37	114.07	1.003	0.997
150	100.47	100.30	100.14	1.002	0.998
160	96.68	96.85	97.03	0.998	1.002
170	100.37	100.89	101.44	0.995	1.005
180	106.56	107.35	108.17	0.993	1.008
190	111.52	112.48	113.45	0.992	1.009
200	113.37	114.37	115.39	0.991	1.009
210	111.52	112.48	113.45	0.992	1.009
220	106.56	107.35	108.17	0.993	1.008
230	100.37	100.89	101.44	0.995	1.006
240	96.69	96.85	97.03	0.998	1.002
250	100.47	100.30	100.14	1.002	0.998
260	114.67	114.37	114.07	1.003	0.997
270	137.65	137.44	137.23	1.002	0.999
280	165.04	165.04	165.04	1.000	1.000
290	192.40	192.63	192.86	0.999	1.000
300	216.33	216.74	217.15	0.998	1.002
310	234.70	235.21	235.71	0.998	1.002
320	246.75	247.25	247.75	0.998	1.002
330	252.86	253.28	253.70	0.998	1.002
340	254.33	254.62	254.90	0.999	1.001
350	252.90	253.05	253.18	0.999	1.001

stable commercial frequency synthesizer. At WLBH and KLAK, this frequency source was used in place of the crystal oscillator in the transmitter. At WELO, the synthesizer was used in place of the crystal in the transmitter oscillator.

The first experiment was conducted at radio station WLBH. Conduct of the tests was authorized by the FCC during the test period, 1:00 to 5:00 A.M. on the nights of July 12 and 13. The frequency of WLBH was changed to 1174 kHz on July 12, 1979, and the directional antenna was adjusted to the licensed parameters. An in-line bridge was installed at the common point and the common point impedance was returned to its 1170 kHz value at each of the offset frequencies. The power input at the common point was held constant for all of the tests on the three frequencies. Field strength readings were made at three points on each of the 12 radials used for the original proof of performance. The same points were measured during the daytime with the station operating on 1170 kHz. During the test period on July 13, the operation was repeated with the station operating on 1166 kHz with the directional antenna adjusted to the licensed parameters.

The measurements were made by three engineers, each with a field strength meter, making measurements on four of the radials. The same engineer and the same field strength meter made the measurements on the same four radials in each of the tests.

The measured field strengths and the ratios between the field strengths on the offset frequencies and the 1170 kHz fields are shown in Table 6. The differences between the offset frequency field strengths and the fields at 1170 kHz are much greater than were expected and will be discussed at the end of the section.

Adjustment of the phase and field ratios at the offset frequencies were made by the station's engineering personnel. About 1.5 hours were required to adjust the directional antenna to the licensed parameters on 1174 kHz and about 0.5 hour to obtain the licensed parameters on 1166 kHz.

The indicated field ratios and phases at WLBH for the three frequencies were as follows:

1170 kHz	Field Ratio	Phase
Tower No. 1	0.55	-110°
Tower No. 2	0.91	-152.5°
Tower No. 3	1.00	0
Tower No. 4	0.64	148.5°

Table 6. Measurements on Radio Station WLBH - 07/12 & 13/79

Point	Field Strength mV/m 1166 kHz A	1170 kHz B	1174 kHz C	Ratios A/B	C/B
		6° Radial			
8	43	51	62.5	0.843	1.226
17	19.5	27	36.5	0.722	1.352
18	10	14	19.5	0.714	1.393
		27° Radial			
9	63	56	68	1.125	1.214
17	29.5	25	27	1.180	1.080
19	19.5	18	21.5	1.083	1.194
		50° Radial			
16(MP-1)	29	25	23.5	1.160	0.940
17	22	19	16	1.158	0.842
19	13	12	12	1.083	1.000
		70° Radial			
12	65	62	52	1.048	0.839
17	35	32	24	1.094	0.750
19(MP-2)	31	28.5	23.5	1.088	0.825
		87° Radial			
12	54	58	70	0.931	1.207
18	27	25	23	1.080	0.920
X	26	23	29	1.130	1.261
		125° Radial			
15	325	320	315	1.016	0.984
17	190	180	190	1.056	1.056
18	160	150	150	1.067	1.000
		160° Radial			
MP-3	600	580	585	1.034	1.009
		233° Radial			
11	72	63	74	1.143	1.175
16	86	79	89	1.089	1.127
17	33.2	29.5	32.2	1.125	1.091
		250° Radial			
11	62.5	52.5	41.5	1.190	0.790
17	27	25.2	22.6	1.071	0.897
19	22.8	17.7	16.2	1.288	0.915
		270° Radial			
10	44	32.2	35.2	1.366	1.093
17(MP-4)	17.2	17.1	24.8	1.006	1.450
18	11	5.9	13.1	1.864	2.220
		293° Radial			
12	63	50	55.5	1.260	1.110
17	35.5	25.2	25.5	1.409	1.021
18	27	29.5	24.9	0.915	0.844
		314° Radial			
13	24	24.5	30	0.980	1.224
17	14.8	19.5	23	0.759	1.179
18	9.6	13.5	15.5	0.711	1.148
		340° Radial			
8	49	45.5	70.0	1.077	1.538
17(MP-5)	47	45.5	47.5	1.033	1.044
18	32	32.5	35	0.985	1.077

1174 kHz	Field Ratio	Phase
Tower No. 1	0.522	-109.9^{o}
Tower No. 2	0.89	-151.9^{o}
Tower No. 3	1.00	0
Tower No. 4	0.633	147.9^{o}

1166 kHz	Field Ratio	Phase
Tower No. 1	0.538	-110^{o}
Tower No. 2	0.90	-152^{o}
Tower No. 3	1.00	0
Tower No. 4	0.64	148.5^{o}

Due to limitations on time and resources, it was decided that we should limit our measurement program to two additional stations, one close to either end of the broadcast band. It also seemed advisable to choose arrays with a wide spacing between elements since the change in electrical spacing would be greater with changes in frequency. Radio Station KLAK at 1600 kHz and Radio Station WELO at 580 kHz were selected. Both stations had fairly wide-spaced, parallelogram, antenna arrays.

The tests at KLAK, in Denver, Colorado, were conducted on September 12 and 13. Tests were authorized during daytime hours by the FCC, who also provided three engineers and field strength meters to assist with the measurements. Field strength measurements were made at three points on each of the 12 radials used in the original proof of performance. Since six engineers and field intensity meters were available, each engineer was assigned two radials, and all measurements on each of the radials were made by the same engineer and with the same equipment. A commercial in-line bridge was connected at the common point, and the same input power to the phasor was maintained for all measurements.

The field strength at each of the selected measurement points was measured with the transmitter on 1600 kHz and the directional antenna adjusted to the licensed parameters. The frequency was then changed to 1596 kHz, and the field strength at the measurement points was measured with no adjustment of the directional antenna. The antenna was then adjusted to the licensed parameters with the frequency at 1596 kHz, and another set of measurements was made. The frequency was then returned to 1600 kHz, and the antenna adjusted to licensed parameters. The measurement sequence was repeated with the transmitter frequency at 1604 kHz. The points were first measured with no adjustment of the directional antenna, and then measured with the antenna adjusted to licensed parameters.

The measurements at KLAK are shown in Table 7 with the ratios between the field intensities at the offset frequencies and the 1600 kHz values in the right hand columns. Again, the measured field strengths deviate from the predicted values by a larger amount than had been expected.

Adjustment of the phasing equipment to restore the licensed parameters at the offset frequencies was achieved with the front panel controls of the phasor by the station engineering personnel. No more than one-half hour was required for each adjustment.

The indicated field ratios and phases for the three frequencies and modes of operation at KLAK are given below.

<u>1600 kHz</u> - Night Pattern - aligned

	Field Ratio	Phase
Tower No. 1	1.00	0
Tower No. 2	1.253	116°
Tower No. 3	1.164	106°
Tower No. 4	1.698	7.5°

<u>1596 kHz</u> - Night Pattern - not adjusted

	Field Ratio	Phase
Tower No. 1	1.00	0
Tower No. 2	1.203	119.3°
Tower No. 3	1.141	109.5°
Tower No. 4	1.715	7.4°

<u>1596 kHz</u> - Night Pattern - adjusted

	Field Ratio	Phase
Tower No. 1	1.00	0
Tower No. 2	1.265	116.4°
Tower No. 3	1.157	106.8°
Tower No. 4	1.715	7.4°

<u>1604 kHz</u> - Night Pattern - not adjusted

	Field Ratio	Phase
Tower No. 1	1.00	0
Tower No. 2	1.272	112°
Tower No. 3	1.158	102.5°
Tower No. 4	1.645	7.8°

Table 7. Measurements on Radio Station KLAK - 09/12 & 13/79

Points	Field Strength mV/m A	B	C	D	E	Ratios B/A	C/A	D/A	E/A
				Radial B - 25°					
B 1.7	400	410	417	415	408	1.025	1.042	1.037	1.020
B 2.6	268	270	275	272	275	1.007	1.026	1.015	1.026
B 3.0	225	238	237	232	232	1.058	1.053	1.053	1.031
				Radial C - 45°					
C 1.5	288	285	288	287	284	0.990	1.000	0.996	0.986
C 2.0	207	212	213	212	208	1.024	1.029	1.024	1.005
C 2.5	139	144	143	138	142	1.036	1.029	0.993	1.022
				Radial D - 71°					
D 1.7	34	27	32.5	45	35.1	0.794	0.956	1.323	1.032
D 2.4	13.5	13.7	16.5	19.5	16	1.015	1.222	1.444	1.185
D 2.85	13	10.8	13.5	18.2	15.2	0.831	1.038	1.400	1.169
				Radial E - 91°					
E 1.6	49	49	53	51	45	1.000	1.082	1.041	0.918
E 2.3	32	30.9	31.3	35	33	0.966	0.978	1.094	1.031
E 2.9	30.8	28.8	29.8	32.7	30.6	0.935	0.967	1.062	0.993
				Radial F - 121°					
F 1.62	13	13.5	13	11	15	1.038	1.000	0.846	1.154
F 2.5	14	16	19	14	14	1.143	1.357	1.000	1.000
F 3.2	7.9	10	10.5	6.4	5.8	1.266	1.329	0.81	0.734
				Radial G - 155°					
G 1	87	120	110	64	75	1.379	1.264	0.736	0.862
G 1.5	54	70	60	40	45	1.296	1.111	0.741	0.833
G 2.4	27	39	32	22	23	1.444	1.185	0.815	0.852
				Radial H - 190°					
H 1	93	120	105	46	98	1.290	1.129	0.495	1.054
H 2	71	90	81	37	70	1.268	1.141	0.521	0.986
H 3	51	63	54	37	50	1.235	1.059	0.725	0.980
				Radial I - 220°					
I 1	46	43	46.5	50	46	0.935	1.011	1.087	1.000
I 2	34	31	31.5	26	28	0.912	0.926	0.765	0.823
I 3	24	22	21	22	25	0.917	0.875	0.917	1.042
				Radial J - 249°					
J 0.9	60	59	62	62	60	0.983	1.033	1.033	1.000
J 2.8	29	32.5	31.5	29	26	1.121	1.086	1.000	0.897
J 3.3	22.5	20.5	22	20	19.5	0.911	0.978	0.889	0.867
				Radial K - 275°					
K 1.55	14	10	11	16.5	16	0.714	0.786	1.179	1.143
K 2.37	16	12.2	14.5	17.5	16	0.762	0.906	1.094	1.000
K 5.85	2.3	1.52	1.95	3.8	3.2	0.661	0.848	1.652	1.391
				Radial L - 301°					
L 1	70	68	69	54	54	0.971	0.986	0.771	0.771
L 2	78	71	71	61	60	0.910	0.910	0.782	0.769
L 3	62	52	52	43	46	0.839	0.839	0.693	0.742
				Radial M - 330°					
M 3.3	155	125	128	100	105	0.806	0.826	0.645	0.677
M 4	92	85	85	68	69	0.924	0.924	0.739	0.750
M 4.5	90	88	85	66	65	0.978	0.944	0.733	0.722

A - 1600 kHz - aligned
B - 1596 kHz - not aligned
C - 1596 kHz - licensed parameters
D - 1604 kHz - not aligned
E - 1604 kHz - licensed parameters

1604 kHz - Night Pattern - adjusted

	Field Ratio	Phase
Tower No. 1	1.00	0
Tower No. 2	1.251	115.9°
Tower No. 3	1.177	106.4°
Tower No. 4	1.67	7.7°

Measurements were made at Radio Station WELO in Tupelo, Mississippi, on September 25 and 26. WELO operates on 580 kHz using a two-tower directional array for its daytime operation and a four-element parallelogram array at night. Authorization to make the measurements during the daytime was granted by the FCC, who also assigned three of their engineers equipped with field strength meters to assist with the measurements. The nighttime four-element array was measured following the same procedure used at KLAK. Three points were measured on each of the 12 radials used for the original proof of performance. Measurements were first made on 580 kHz, the frequency was then changed to 584 kHz, and measurements made without realigning the array to licensed parameters. Licensed parameters were then restored, and measurements made at 584 kHz. This operation was repeated at 576 kHz. The results are shown in Table 8. Parameters of the array are given in Section 2.

It was not possible to obtain the licensed parameters with the front panel controls at the 584 kHz frequency. Taps were changed in the phasor during the test period on September 27. About two hours were required to establish the licensed parameters at this frequency. About one-half hour was required to obtain the licensed parameters at 576 kHz using front panel controls.

The indicated field ratios and phases at WELO for the different frequencies and modes of operation are given below.

580 kHz - Night Pattern - aligned

	Field Ratio	Phase
Tower No. 1	0.595	-150.4°
Tower No. 2	1.00	0
Tower No. 3	0.393	-149.4°
Tower No. 4	0.65	+ 0.3°

Table 8. Measurements on Radio Station WELO - 09/25 & 26/79
Nighttime Pattern

Points	Distance Miles	Field Strength mV/m A	B	C	D	E	Ratios B/A	C/A	D/A	E/A
				25° Radial						
Pt. 20	2.23	50.1	56.4	51.6	66	57.6	1.126	1.030	1.317	1.150
Pt. 21	2.68	43.2	44	36	50.2	45.5	1.019	0.833	1.162	1.053
Pt. 22	3.35	27	29.1	22	28.1	32.4	1.078	0.815	1.041	1.200
				52° Radial						
Pt. 21	3.0	14	19.8	11.2	10.9	15.0	1.414	0.800	0.779	1.071
Pt. 22	3.4	15.2	20.4	12.6	11.2	15.4	1.342	0.829	0.737	1.013
Pt. 23	3.65	10.8	14.5	8.1	7.6	10.8	1.343	0.750	0.704	1.000
				75° Radial						
Pt. 22	3.38	28.5	30.2	39.0	27.2	28.6	1.060	1.368	0.954	1.004
Pt. 23	3.62	27.2	29.0	37.8	26.0	27.2	1.066	1.390	0.956	1.000
Pt. 24	3.95	22.5	23.5	31.4	21.8	22.6	1.044	1.396	0.969	1.004
				96° Radial						
Pt. 20	2.60	15.5	11.5	26.2	26.5	19.5	0.742	1.690	1.710	1.258
Pt. 22	3.85	12.3	10.5	19.5	15.5	15.5	0.854	1.585	1.260	1.260
Pt. 23	4.2	10.7	6.3	15.5	19.5	13.0	0.589	1.449	1.822	1.215
				130° Radial						
Pt. 21	2.13	13.5	8.6	29	21	14	0.637	2.148	1.556	1.037
Pt. 23A	3.0	9.6	5.1	19	15.8	10.5	0.531	1.979	1.646	1.094
Pt. 26	3.51	9.2	5.2	19.1	14.5	10	0.565	2.076	1.576	1.087
				155° Radial						
Pt. 23	3.15	52	50	53	55	52	0.962	1.019	1.056	1.000
Pt. 24	3.40	41.5	40	41	44	41.5	0.964	0.988	1.060	1.000
Pt. 25	4.05	28.5	27	30	29.5	28	0.947	1.053	1.035	0.983
				200° Radial						
Pt. 20	2.09	84	80	83	80	78	0.952	0.988	0.952	0.929
Pt. 21	2.20	66	65	70	68	67	0.985	1.061	1.030	1.015
Pt. 23	2.61	64	60	64	64	63	0.938	1.000	1.000	0.984
				228° Radial						
Pt. 20	2.03	32.8	26	46.8	34.8	32.1	0.793	1.427	1.061	0.979
Pt. 21	2.15	25.1	19.8	37.5	28.1	25.2	0.789	1.494	1.120	1.004
Pt. 22	2.30	24.4	19.6	39.2	27.2	24.2	0.803	1.607	1.115	0.992
Pt. 24	3.7	14.5	11.1	24.0	16.2	14.5	0.766	1.655	1.117	1.000
				245° Radial						
Pt. 21	2.39	46.5	44.7	36.5	48	47	0.961	0.785	1.032	1.011
Pt. 22	3.65	33.8	32.9	27.8	33.2	34.5	0.973	0.823	0.982	1.021
Pt. 23	4.4	30.8	29.7	24.8	30.3	31.4	0.964	0.805	0.984	1.020
				278° Radial						
Pt. 18	2.03	63	61	42	63	64	0.968	0.667	1.000	1.016
Pt. 25	4.75	24.2	24	16	25.8	25.9	0.992	0.661	1.066	1.070
Pt. 26	4.95	24.0	23.2	15	25.2	25.3	0.967	0.625	1.050	1.054
				310° Radial						
Pt. 23	3.0	7.3	11.8	9	9.8	8.1	1.616	1.233	1.343	1.110
Pt. 24	3.20	8.4	12.5	6.5	9.0	8.5	1.438	0.774	1.071	1.012
Pt. 30	6.65	2.5	5.2	2.95	2.7	2.62	2.080	1.18	1.08	1.048
				358° Radial						
Pt. 19	2.13	72	71	76	79	77.5	0.986	1.056	1.097	1.076
Pt. 21	2.51	63.2	63.1	66.2	71.2	68.1	0.998	1.048	1.127	1.078
Pt. 22	2.64	55	53.2	55.1	61.3	57.2	0.967	1.002	1.115	1.040

A - 580 kHz, aligned, 535 watts
B - 584 kHz, not aligned, 535 watts
C - 584 kHz, licensed parameters, 535 watts
D - 576 kHz, not aligned, 535 watts
E - 576 kHz, licensed parameters, 535 watts

584 kHz - Night Pattern - not adjusted

	Field Ratio	Phase
Tower No. 1	0.662	-160.3^{o}
Tower No. 2	1.00	0
Tower No. 3	0.455	-143.1^{o}
Tower No. 4	0.671	$- 5.1^{o}$

584 kHz - Night Pattern - adjusted

	Field Ratio	Phase
Tower No. 1	0.594	-150.2^{o}
Tower No. 2	1.00	0
Tower No. 3	0.406	-149.8^{o}
Tower No. 4	0.655	$+ 0.4^{o}$

576 kHz - Night Pattern - not adjusted

	Field Ratio	Phase
Tower No. 1	0.502	-143.4^{o}
Tower No. 2	1.00	0
Tower No. 3	0.371	-156.0^{o}
Tower No. 4	0.637	$+ 5.3^{o}$

576 kHz - Night Pattern - adjusted

	Field Ratio	Phase
Tower No. 1	0.60	-150.4^{o}
Tower No. 2	1.00	0
Tower No. 3	0.40	-149.2^{o}
Tower No. 4	0.657	$+ 0.6^{o}$

580 kHz - Day Pattern - aligned

	Field Ratio	Phase
Tower No. 1	0.48	83.8^{o}
Tower No. 2	1.00	0

584 kHz - Day Pattern - not adjusted

	Field Ratio	Phase
Tower No. 1	0.387	69.3^{o}
Tower No. 2	1.00	0

576 kHz - Day Pattern - not adjusted

	Field Ratio	Phase
Tower No. 1	0.55	104.9^{o}
Tower No. 2	1.00	0

The daytime array for WELO was also measured at the licensed frequency and at 584 kHz and at 576 kHz without adjusting the array. Since monitoring equipment was located in the transmitting building and phasing equipment was located at the tower bases, it was decided not to attempt to adjust the two-tower array to licensed parameters at the offset frequencies. The measurements are shown in Table 9.

The measurements made at Radio Station KLAK and at Radio Station WELO without any adjustments to the array demonstrate that frequency changes of ±4 kHz do not cause serious changes in radiation patterns. The changes were greater at WELO than at KLAK. Field ratio changes and phase changes were greater at WELO. These changes are due to changes in the electrical lengths of transmission lines and phase shifts in phasing and matching networks. The changes are proportional to the percentage change in frequency and are greater at the lower end of the band.

The measured field intensities of the directional antennas when the frequency was changed ±4 kHz and the antenna aligned showed markedly greater changes than were predicted by the theoretical calculations. The explanation of the larger deviations may lie in the fact that the assumption that the array was aligned to the design parameters when it was in compliance with the construction permit is not true. No attempt was made to bring the stations monitor points to the permitted values, but it is believed that this could have been done with minor changes in the field ratios and phases.

Table 10 is a list of the engineers who made the field strength measurements on the radio stations and the radials for which they were responsible.

4. 1430 kHz CALCULATIONS

To evaluate the impact of changing frequencies as much as ±4 kHz on the nighttime interference level, a model system at 1430 kHz was set up on a computer. Existing licensees or permittees* in the continental U.S. were assigned a standard pattern utilizing the presently licensed antenna system parameters at the presently licensed sites. The standard pattern was computed using Sec. 73.150 of the FCC Rules and Regulations (1976). A loss resistance of one ohm at the current loop was assumed for each element of the array. The

*Radio Station WBRB, Mt. Clemens, Michigan, was not included in the study.

Table 9. Measurements on Radio Station WELO - 09/26/79
Daytime Pattern

Points	Distance Mile	Field Strength mV/m A	B	C	Ratios B/A	C/A
		25° Radial				
Pt. 20	2.23	93.1	100.8	109.2	1.083	1.173
Pt. 21	2.68	82.8	78.1	95	0.943	1.147
Pt. 22	3.35	55.2	51.2	59.2	0.928	1.073
		52° Radial				
Pt. 21	3.0	72	66	82	0.917	1.139
Pt. 22	3.4	70	64.5	86	0.921	1.143
Pt. 23	3.65	60.5	56	67.5	0.926	1.116
		75° Radial				
Pt. 22	3.38	66.5	64.5	72	0.970	1.083
Pt. 23	3.62	66.5	64	70	0.962	1.053
Pt. 24	3.95	55.5	54.5	58.5	0.982	1.054
		96° Radial				
Pt. 20	2.60	76	72	70	0.947	0.921
Pt. 22	3.85	47	47	46	1.000	0.979
Pt. 23	4.2	39.5	40	36	1.013	0.911
		130° Radial				
Pt. 21	2.13	56	64	55	1.143	0.982
Pt. 23A	3.0	41	49	34	1.195	0.829
Pt. 26	3.51	38	44	31	1.158	0.816
		155° Radial				
Pt. 23	3.15	30.5	38.5	26	1.262	0.853
Pt. 24	3.40	23	33	21	1.435	0.913
Pt. 25	4.05	17	23	14.5	1.353	0.853
		200° Radial				
Pt. 20	2.09	41	39	50.5	0.951	1.232
Pt. 21	2.20	32.5	32	41	0.985	1.262
Pt. 23	2.61	30	30.5	37	1.017	1.233
		228° Radial				
Pt. 20	2.03	34.2	39.2	36.1	1.146	1.056
Pt. 21	2.15	27.6	31.8	30.8	1.152	1.116
Pt. 22	2.30	28.9	35.0	31.8	1.211	1.100
Pt. 24	3.7	17.2	20.2	20.3	1.174	1.180
		245° Radial				
Pt. 21	2.39	27.2	38.0	20.1	1.397	0.739
Pt. 22	3.65	18.2	24.8	15.6	1.363	0.857
Pt. 23	4.4	18.7	23.5	16.2	1.257	0.866
		278° Radial				
Pt. 18	2.03	62	71	50.5	1.145	0.815
Pt. 25	4.75	26.6	29.9	21.4	1.124	0.805
Pt. 26	4.95	24.8	28.0	20.3	1.129	0.819
		310° Radial				
Pt. 23	3.0	69	71	67	1.029	0.971
Pt. 24	3.20	63	65	60	1.032	0.952
Pt. 30	6.65	27.6	30	27.2	1.087	0.986
		358° Radial				
Pt. 19	2.13	106.8	108	111	1.011	1.039
Pt. 21	2.51	93.1	90.1	101	0.968	1.192
Pt. 22	2.64	73.2	77.4	98	1.057	1.339

A - 580 kHz, aligned, 1080 watts
B - 584 kHz, not adjusted, 1080 watts
C - 576 kHz, not adjusted, 1080 watts

The daytime patterns were not adjusted to the licensed parameters on 576 and 584 kHz since the monitoring equipment was located in the transmitter building and the phasing networks were at the antenna bases.

Table 10. Measurement Assignments

Assignment	Engineer	Affiliation
Radio Station WLBH Measurements		
233^{o}, 250^{o}, 270^{o}, 293^{o} Radials	John B. Heffelfinger	Consultant/NTIA
50^{o}, 70^{o}, 87^{o}, 125^{o} Radials	Ray Livesay	WLBH
314^{o}, 340^{o}, 6^{o}, 27^{o} Radials	Arthur C. Stewart	NTIA/ITS
Radio Station KLAK Measurements		
35^{o} (B), 45^{o}(C) Radials	John B. Heffelfinger	Consultant/NTIA
71^{o} (D), 91^{o}(E) Radials	Larry Brock	FCC
121^{o} (F), 155^{o}(G) Radials	Don Wyatt	FCC
190^{o} (H), 220^{o}(I) Radials	Brion C. Gilbert	FCC
249.3^{o}(J), 275^{o}(K) Radials	Girard M. Westerberg	KLAK
301^{o} (L), 330^{o}(M) Radials	Arthur C. Stewart	NTIA/ITS
Radio Station WELO Measurements		
25^{o}, 358^{o} Radials	Bill Simpson	FCC
52^{o}, 75^{o} Radials	Bob Bradley	FCC
96^{o}, 130^{o} Radials	George J. Bourda, Jr.	FCC
155^{o}, 200^{o} Radials	Arthur C. Stewart	NTIA/ITS
228^{o}, 245^{o} Radials	John B. Heffelfinger	Consultant/NTIA
310^{o}, 278^{o} Radials	Billy Joe Crabb	WELO

site-to-site 50% RSS interference free signal level for each station was calculated using Figures 2 and 6a of the FCC Rules and Regulations.

Using the FCC soil conducivity map, Figure M3, and Graph 18 of the FCC Rules and Regulations, the standard horizontal plane pattern for each station was computed and used to obtain the location of the 1430 kHz, 50% RSS (site-to-site), interference-free, signal contour at points along 36 radials spaced 10^{o} apart at each station. The geographical coordinates for each of these points were calculated using formulas contained in Special Publication #8 (U.S. Coast and Geodetic Survey, 1933). For frequencies of 1426 and 1434 kHz, the 50% RSS interference-free signal value was recomputed at each of the 36 points for each licensee.

Appendix A tabulates the results of the above described computations. An examination of the data in the appendix shows that variations in the fields at the interference-free contours at the offset frequencies are minimal.

5. SUMMARY AND CONCLUSIONS

Theoretical calculations of radiation patterns for directional antenna arrays indicate that frequency changes of up to 4 kHz have only minor effects on radiated fields. The fact that measured fields on radio station antennas showed greater changes with frequency than the computed values may be due to initial misalignment of the array. It should be possible to bring the fields at monitor points within limits with minor adjustments of the phasing equipment.

The study comparing the interference levels at 1426 kHz and 1434 kHz with the interference which exists at 1430 kHz when all nighttime occupants of the band are considered shows only minimal changes in the levels of interference at any station. This may not be true for all channels; however this was a randomly chosen, heavily populated, regional channel.

If some regulations were relaxed for the transition period, it should be possible to make the change to a 9 kHz allocation bandwidth overnight without a disruption of present service and without undue overload to the consulting engineering community. The proposed frequency changes are small, and station engineering personnel could, in most cases, restore the licensed parameters for the antenna without trouble. Power could be determined by the indirect method until input impedances could be measured and approved. Some adjustment period could be established to allow time to bring the monitor point fields to authorized limits. This work could be performed by engineering personnel at the stations in the majority of cases. There would undoubtedly be some problem cases, and the consulting engineers could concentrate on these, resolving less critical cases later and measuring input impedances as time permitted. Most stations would be able to make partial proofs of performance using station personnel.

The cost to broadcasters of making the change to a 9 kHz allocation bandwidth is dependent on the requirements of the FCC. The cost of making input impedance measurements is about $500 to $750 plus expenses. The time required for making a partial proof of performance on the average directional array would be about six man-days. This assumes no problems with alignment to reestablish the approved fields in the protection directions and should be true for the majority of stations. A full proof of performance would require a maximum of 21 man-days for the average station with a single DA pattern. Many stations would be able to perform part of the requirements using their own personnel. No redesign of directional antennas should be required except in the case of a very few critical arrays.

6. ACKNOWLEDGMENTS

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The work of Christopher Brooks from the University of Colorado, Stephen Stewart from the Mine Safety and Health Administration, and Nancy Madonna and Duane Hyovalti from NTIA/ITS in adapting computer programs developed by one of the authors (John B. Heffelfinger) for the CDC 6600 computer and processing the large amount of data required for the interference analysis on 1430 kHz is also gratefully acknowledged.

7. REFERENCES

Federal Communication Commission (1976), Rules and Regulations, Volume III, Part 73, August.

U.S. Coast and Geodetic Survey (1933), Formulas and tables for the computation of geodetic positions, Special Publication #8, 7th Edition, (Superintendent of Documents, U.S. Government Printing Office).

APPENDIX. COMPUTATIONS OF INTERFERENCE FREE SIGNAL CONTOURS FOR RADIO STATIONS OPERATING ON 1430 KHZ

The attached computations were made for night operation on 1430 kHz and 1430 kHz ±4 kHz. All computations were made using standard patterns with a loss resistance of one ohm per element at the current loop. Site-to-site interference levels (50% RSS) were used to determine the interference-free signal contour of each station. The FCC soil conductivity map and the computed standard horizontal plane pattern were used to determine the location of the interference-free contour at 1430 kHz. Points on the interference-free signal contour were computed using azimuthal increments of 10^{o} beginning at N 0^{o} E. For the differential frequencies (±4 kHz), the standard patterns were recomputed using the present operating parameters except for antenna heights and spacings, and the interference to each of the previously located points on the interference free signal contour (50% RSS value on 1430 kHz) were recalculated and the comparisons made. Figure 2 and 6a of the FCC Rules and Regulations (1976) were used to compute the interference signals, and Graph 18 of Section 73.184 of the FCC Rules and Regulations (1976) was used to compute the location of the interference-free signal contours. The Andoyer-Lambert formula (Clarke Spheriod 1866) was used to determine the bearing and distance between stations and between stations and points on the interference-free signal contour. Formulas contained in special publication #8 (U.S. Coast and Geodetic Survey, 1933) were used to determine the geographic coordinates of points on the interference-free signal contour.

1. REFERENCES

Federal Communications Commission (1976), Rules and Regulations, Volume III, Part 73, August.

U.S. Coast and Geodetic Survey (1933), Formulas and tables for the computation of geodetic positions, Special Publication #8, 7th Edition, (Superintendent of Documents, U.S. Government Printing Office).

Table A-1

(Site-to-Site)
Interference Limit 50% RSS Values

Station	1434 kHz	50% RSS Values 1430 kHz	1426 kHz
KELI	2.574486	2.572259	2.572837
KALV	9.068736	9.084286	9.118945
WVAM	4.649008	4.793371	4.775929
KLO	2.708158	2.699287	2.692089
WEIR	4.537801	4.544997	4.552867
WJRB	22.29698	22.28698	22.27692
KRGI	16.76261	16.75473	16.67028
KEES	27.41962	27.47289	27.41640
KBRC	3.929017	3.933098	3.956561
WBEV	32.81107	32.82299	32.77794
KARM	2.230129	2.2266001	2.315314
KALI	25.02177	25.03202	25.04111
KNTA	22.98419	23.09384	23.20038
WQDI	8.600525	8.599298	8.598017
WQPD	8.737696	8.760033	8.713349
WWGS	22.21879	22.27990	22.34040
WWWQ	15.44082	15.40918	15.37186
WIRE	3.744660	3.740293	3.755180
WYMC	20.75804	20.65408	20.61676
WIL	5.215959	5.232283	5.225892
WNJR	2.428348	2.709657	2.433308
KKAT	15.32290	15.34355	15.32989
WENE	8.387507	8.396380	8.405075
WMNC	22.74791	22.41471	22.71842
WFOB	13.95319	13.95677	13.96034
WNAV	15.75850	15.87456	15.98863
KOSI	6.334624	6.330468	6.332558

Table A-2

Station Call: KELI

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	35.34	2.85	2.84	2.84
10	32.27	2.76	2.75	2.75
20	27.92	2.66	2.65	2.66
30	26.44	2.62	2.61	2.61
40	24.08	2.59	2.58	2.58
50	20.63	2.57	2.57	2.57
60	18.70	2.59	2.59	2.59
70	19.57	2.62	2.62	2.61
80	23.93	2.68	2.69	2.68
90	27.81	2.77	2.78	2.77
100	31.14	2.60	2.62	2.60
110	33.76	2.73	2.75	2.74
120	35.50	2.84	2.86	2.84
130	37.24	2.93	2.95	2.93
140	38.37	2.96	2.99	2.97
150	39.08	2.95	2.97	2.95
160	39.52	2.89	2.92	2.90
170	39.75	2.82	2.84	2.83
180	39.83	2.73	2.76	2.74
190	39.75	2.63	2.65	2.64
200	34.74	2.78	2.79	2.78
210	31.91	2.71	2.71	2.71
220	30.54	2.66	2.66	2.66
230	28.30	2.63	2.62	2.63
240	26.72	2.60	2.60	2.60
250	25.36	2.58	2.58	2.58
260	23.21	2.57	2.57	2.57
270	20.97	2.56	2.56	2.56
280	18.39	2.56	2.56	2.56
290	15.83	2.56	2.56	2.56
300	15.02	2.56	2.56	2.56
310	16.89	2.56	2.56	2.56
320	19.14	2.58	2.58	2.58
330	37.91	2.87	2.86	2.86
340	36.24	2.87	2.86	2.86
350	36.81	2.89	2.88	2.88

*1430 kHz 50% RSS site-to-site value.

Table A-3

Station Call: KALV

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	1.38	8.95	8.91	8.90
10	0.87	8.99	8.96	8.94
20	0.73	9.04	9.01	8.99
30	1.21	9.00	8.96	8.95
40	1.56	8.97	8.94	8.92
50	1.56	8.98	8.95	8.93
60	1.21	9.03	8.99	8.98
70	0.73	9.08	9.04	9.02
80	0.87	9.08	9.05	9.03
90	1.38	9.12	9.08	9.07
100	1.56	9.14	9.10	9.09
110	1.09	9.16	9.13	9.11
120	0.98	9.15	9.11	9.10
130	3.14	9.34	9.30	9.29
140	5.82	9.64	9.60	9.59
150	8.56	9.80	9.76	9.75
160	11.13	10.20	10.16	10.15
170	13.25	10.50	10.46	10.45
180	15.05	10.95	10.92	10.91
190	16.30	11.01	10.98	10.96
200	17.08	10.94	10.91	10.90
210	17.53	10.95	10.92	10.91
220	17.73	10.72	10.69	10.67
230	17.73	10.45	10.42	10.41
240	17.53	10.14	10.11	10.09
250	17.08	9.79	9.76	9.74
260	16.30	9.48	9.45	9.43
270	15.05	9.18	9.15	9.13
280	13.25	8.94	8.91	8.89
290	11.13	8.79	8.76	8.74
300	8.56	8.74	8.71	8.69
310	5.82	8.79	8.76	8.74
320	3.14	8.83	8.80	8.78
330	0.98	9.01	8.98	8.96
340	1.09	8.99	8.96	8.94
350	1.56	8.94	8.90	8.89

*1430 kHz 50% RSS site-to-site value.

Table A-4

Station Call: WVAM

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	4.66	4.70	4.72	4.58
10	4.77	4.71	4.73	4.59
20	4.92	4.74	4.75	4.61
30	7.23	4.78	4.79	4.65
40	7.38	4.81	4.83	4.69
50	7.27	4.84	4.86	4.72
60	6.78	4.86	4.89	4.74
70	5.69	4.88	4.90	4.75
80	3.80	4.85	4.87	4.72
90	3.91	4.86	4.88	4.73
100	6.34	4.21	4.26	4.10
110	8.07	4.28	4.32	4.16
120	9.28	4.34	4.39	4.22
130	10.12	4.39	4.44	4.27
140	10.75	4.43	4.48	4.31
150	11.10	4.45	4.49	4.33
160	11.30	4.46	4.50	4.34
170	11.40	4.41	4.45	4.28
180	11.40	4.38	4.42	4.26
190	11.30	4.40	4.44	4.28
200	11.10	4.91	4.93	4.78
210	10.75	4.85	4.87	4.72
220	7.20	4.79	4.81	4.66
230	6.57	4.76	4.78	4.63
240	5.69	4.73	4.75	4.61
250	4.52	4.76	4.78	4.64
260	2.79	4.77	4.79	4.65
270	2.71	4.77	4.78	4.64
280	4.03	4.73	4.74	4.61
290	4.80	4.71	4.72	4.59
300	5.11	4.69	4.71	4.57
310	5.19	4.69	4.70	4.57
320	5.08	4.70	4.71	4.58
330	4.92	4.71	4.72	4.59
340	4.77	4.67	4.69	4.55
350	4.66	4.69	4.70	4.57

*1430 kHz 50% RSS site-to-site value.

Table A-5

Station Call: KLO

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	30.66	2.68	2.70	2.72
10	31.42	2.66	2.68	2.70
20	32.83	2.64	2.66	2.68
30	30.67	2.63	2.64	2.66
40	28.52	2.62	2.63	2.65
50	25.60	2.62	2.63	2.64
60	21.59	2.63	2.64	2.65
70	21.16	2.95	2.96	2.65
80	18.07	2.97	2.97	2.98
90	15.21	2.98	2.98	2.99
100	11.72	2.67	2.99	3.00
110	10.98	2.68	2.69	2.69
120	14.47	2.71	2.71	2.71
130	17.55	2.74	2.73	2.73
140	19.02	2.77	2.77	2.76
150	20.75	2.81	2.80	2.80
160	25.31	2.87	2.86	2.86
170	28.95	2.93	2.92	2.91
180	24.05	2.88	2.87	2.87
190	17.70	2.83	2.82	2.82
200	12.55	2.78	2.78	3.79
210	13.58	2.79	2.79	2.79
220	14.91	2.79	2.79	2.79
230	14.48	2.78	2.78	2.79
240	15.55	2.77	2.78	2.79
250	19.74	2.78	2.79	2.80
260	25.78	2.79	2.80	2.81
270	30.08	2.50	2.52	2.54
280	32.86	2.52	2.54	2.57
290	34.04	2.53	2.55	2.58
300	33.49	2.52	2.55	2.58
310	30.72	2.78	2.81	2.54
320	24.70	2.74	2.76	2.79
330	13.99	2.69	2.71	2.73
340	22.14	2.69	2.71	2.73
350	28.50	2.69	2.71	2.74

*1430 kHz 50% RSS site-to-site value.

Table A-6

Station Call: WEIR

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	8.22	4.84	4.84	4.83
10	8.00	4.85	4.84	4.84
20	7.55	4.82	4.82	4.81
30	6.77	4.78	4.77	4.77
40	5.65	4.64	4.63	4.62
50	4.43	4.59	4.58	4.57
60	3.50	4.55	4.54	4.54
70	3.43	4.54	4.53	4.52
80	3.29	4.52	4.51	4.51
90	3.60	4.51	4.51	4.50
100	5.23	4.52	4.51	4.50
110	6.95	4.49	4.48	4.47
120	8.35	4.49	4.47	4.46
130	9.42	4.47	4.46	4.45
140	10.18	4.47	4.46	4.45
150	10.75	4.47	4.46	4.45
160	11.06	4.47	4.45	4.44
170	11.20	4.44	4.43	4.41
180	11.22	4.42	4.40	4.39
190	11.13	4.39	4.38	4.36
200	10.90	4.44	4.43	4.42
210	10.45	4.42	4.41	4.40
220	9.75	4.40	4.39	4.39
230	8.79	4.41	4.40	4.39
240	7.56	4.43	4.42	4.41
250	5.94	4.47	4.46	4.45
260	4.19	4.50	4.49	4.48
270	3.24	4.53	4.52	4.51
280	3.41	4.54	4.53	4.52
290	3.41	4.56	4.55	4.54
300	3.94	4.58	4.57	4.57
310	5.18	4.62	4.61	4.61
320	6.34	4.67	4.67	4.66
330	7.27	4.74	4.73	4.73
340	7.85	4.79	4.78	4.78
350	8.17	4.83	4.82	4.82

*1430 kHz 50% RSS site-to-site value.

Table A-7

Station Call: WJRB

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	0.95	22.33	22.34	22.35
10	0.86	22.33	22.34	22.35
20	1.24	22.34	22.35	22.36
30	1.46	22.34	22.35	22.36
40	1.24	22.34	22.35	22.36
50	0.92	22.34	22.35	22.36
60	1.81	22.36	22.36	22.37
70	2.78	22.37	22.38	22.39
80	3.46	22.39	22.40	22.41
90	3.84	22.34	22.35	22.36
100	3.96	22.34	22.35	22.36
110	3.93	22.29	22.30	22.31
120	3.81	22.23	22.24	22.25
130	3.68	22.22	22.23	22.24
140	3.61	22.45	22.46	22.47
150	3.65	22.44	22.45	22.46
160	3.79	22.43	22.45	22.46
170	3.98	22.37	22.38	22.39
180	4.27	22.36	22.37	22.38
190	4.52	22.29	22.31	22.32
200	4.73	22.28	22.29	22.30
210	4.83	22.32	22.33	22.34
220	4.77	22.31	22.32	22.33
230	4.47	22.35	22.37	22.38
240	3.90	22.12	22.13	22.14
250	3.07	22.18	22.19	22.20
260	2.01	22.19	22.20	22.21
270	1.19	22.26	22.27	22.28
280	1.30	22.25	22.26	22.27
290	1.34	22.25	22.26	22.27
300	1.00	22.26	22.27	22.28
310	0.52	22.27	22.28	22.29
320	0.90	22.32	22.33	22.34
330	1.29	22.32	22.33	22.34
340	1.43	22.32	22.33	22.34
350	1.27	22.32	22.33	22.34

*1430 kHz 50% RSS site-to-site value.

Table A-8

Station Call: KRGI

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	12.48	17.12	17.20	17.21
10	12.39	17.23	17.31	17.32
20	12.10	17.30	17.39	17.39
30	11.53	17.35	17.44	17.44
40	10.72	17.33	17.41	17.42
50	9.60	17.28	17.37	17.38
60	8.06	17.19	17.28	17.29
70	6.18	17.05	17.14	17.14
80	3.99	16.92	17.00	17.01
90	1.75	16.75	16.83	16.84
100	1.61	16.75	16.83	16.84
110	2.56	16.76	16.85	16.85
120	2.80	16.75	16.83	16.84
130	2.44	16.71	16.80	16.80
140	1.72	16.68	16.76	16.77
150	1.21	16.66	16.74	16.75
160	1.58	16.63	16.72	16.73
170	2.09	16.62	16.70	16.71
180	2.26	16.60	16.68	16.69
190	2.09	16.56	16.64	16.65
200	1.58	16.58	16.67	16.68
210	1.21	16.59	16.68	16.68
220	1.72	16.58	16.66	16.67
230	2.44	16.53	16.61	16.62
240	2.80	16.49	16.58	16.59
250	2.56	16.52	16.61	16.61
260	1.61	16.59	16.67	16.68
270	1.75	16.60	16.68	16.69
280	3.99	16.49	16.58	16.58
290	6.18	16.44	16.52	16.53
300	8.06	16.44	16.52	16.53
310	9.60	16.49	16.58	16.58
320	10.72	16.59	16.68	16.68
330	11.53	16.71	16.79	16.80
340	12.10	16.86	16.94	16.95
350	12.39	16.99	17.07	17.08

*1430 kHz 50% RSS site-to-site value.

Table A-9

Station Call: KEES

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	1.11	27.48	27.54	27.49
10	0.98	27.48	27.54	27.48
20	0.62	27.41	27.47	27.42
30	0.48	27.41	27.47	27.42
40	1.26	27.47	27.53	27.48
50	2.13	27.47	27.52	27.47
60	2.93	27.46	27.51	27.46
70	3.66	27.38	27.44	27.39
80	4.28	27.38	27.43	27.38
90	4.72	27.30	27.36	27.31.
100	4.99	27.24	27.29	27.24
110	5.13	27.17	27.23	27.18
120	5.15	27.11	27.17	27.11
130	5.06	27.12	27.17	27.12
140	4.92	27.06	27.11	27.06
150	4.75	27.06	27.12	27.07
160	4.59	27.07	27.13	27.08
170	4.47	27.08	27.14	27.08
180	4.43	27.15	27.21	27.16
190	4.47	27.16	27.22	27.16
200	4.59	27.17	27.22	27.17
210	4.75	27.17	27.23	27.18
220	4.92	27.25	27.30	27.25
230	5.06	27.32	27.38	27.32
240	5.15	27.32	27.38	27.33
250	5.13	27.39	27.45	27.40
260	4.99	27.46	27.52	27.46
270	4.72	27.53	27.58	27.53
280	4.28	27.52	27.58	27.52
290	3.66	27.58	27.64	27.58
300	2.93	27.57	27.63	27.57
310	2.13	27.56	27.62	27.57
320	1.26	27.49	27.55	27.49
330	0.48	27.42	27.47	27.42
340	0.62	27.42	27.47	27.42
350	0.98	27.48	27.54	27.49

*1430 kHz 50% RSS site-to-site value.

Table A-10

Station Call: KBRC

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	9.55	3.76	3.74	3.73
10	9.74	3.75	3.72	3.72
20	9.85	3.75	3.72	3.72
30	9.87	3.75	3.73	3.73
40	9.75	3.76	3.74	3.73
50	9.45	3.79	3.76	3.76
60	8.92	3.82	3.79	3.79
70	8.34	3.85	3.82	3.82
80	7.60	3.89	3.86	3.86
90	6.79	3.92	3.90	3.90
100	6.06	3.95	3.93	3.92
110	5.57	3.97	3.95	3.95
120	5.42	3.99	3.97	3.97
130	5.43	4.01	3.99	3.98
140	5.45	4.03	4.01	4.00
150	5.43	4.05	4.03	4.02
160	5.41	4.06	4.03	4.03
170	5.52	4.07	4.05	4.05
180	5.94	4.08	4.06	4.06
190	6.63	4.11	4.08	4.08
200	7.44	4.12	4.10	4.09
210	8.19	4.13	4.11	4.11
220	8.82	4.14	4.11	4.11
230	9.37	4.13	4.10	4.10
240	9.70	4.10	4.08	4.08
250	9.85	4.08	4.06	4.06
260	9.87	4.04	4.02	4.02
270	9.77	4.01	3.99	3.98
280	9.59	3.97	3.95	3.95
290	9.37	3.94	3.92	3.91
300	9.14	3.90	3.88	3.87
310	8.98	3.87	3.85	3.84
320	8.91	3.85	3.83	3.82
330	8.95	3.82	3.80	3.79
340	9.11	3.79	3.77	3.77
350	9.32	3.74	3.75	3.75

*1430 kHz 50% RSS site-to-site value.

Table A-11

Station Call: WBEV

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	4.99	32.48	32.53	32.52
10	5.05	32.42	32.46	32.45
20	5.12	32.39	32.43	32.42
30	5.15	32.36	32.40	32.39
40	5.07	32.30	32.34	32.33
50	4.46	32.35	32.40	32.38
60	4.43	32.39	32.44	32.42
70	3.75	32.48	32.52	32.51
80	2.88	32.56	32.61	32.60
90	1.90	32.63	32.67	32.66
100	0.87	32.75	32.79	32.78
110	0.18	32.76	32.81	32.80
120	0.47	32.78	32.83	32.81
130	0.49	32.78	32.83	32.81
140	0.32	32.76	32.80	32.79
150	0.19	32.77	32.81	32.80
160	0.31	32.77	32.81	32.80
170	0.38	32.80	32.85	32.84
180	0.31	32.77	32.82	32.81
190	0.19	32.78	32.82	32.81
200	0.32	32.78	32.83	32.81
210	0.49	32.79	32.84	32.82
220	0.47	32.80	32.84	32.83
230	0.18	32.79	32.83	32.82
240	0.87	32.83	32.87	32.86
250	1.90	32.95	32.99	32.98
260	2.88	32.99	33.04	33.03
270	3.75	33.04	33.08	33.07
280	4.43	33.01	33.06	33.05
290	4.86	32.96	33.00	33.99
300	5.07	32.91	32.96	32.95
310	5.15	32.81	32.85	32.84
320	5.12	32.77	32.81	32.80
330	5.05	32.67	32.71	32.70
340	4.99	32.61	32.66	32.65
350	4.97	32.55	32.59	32.58

*1430 kHz 50% RSS site-to-site value.

Table A-12

Station Call: KARM

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	14.97	2.53	2.47	2.43
10	17.23	2.55	2.49	2.45
20	22.69	2.61	2.55	2.51
30	15.98	2.51	2.46	2.42
40	14.76	2.47	2.42	2.38
50	12.63	2.42	2.36	2.33
60	13.90	2.40	2.35	2.31
70	18.30	2.67	2.63	2.60
80	22.47	2.65	2.61	2.58
90	26.13	2.64	2.60	2.57
100	27.64	2.58	2.54	2.52
110	33.34	2.53	2.50	2.48
120	34.68	2.46	2.43	2.43
130	34.42	2.37	2.35	2.35
140	30.74	2.05	2.02	2.25
150	29.34	2.03	2.00	1.99
160	27.40	2.03	1.99	1.98
170	25.09	2.04	2.00	1.98
180	23.09	2.07	2.03	2.00
190	21.48	2.09	2.05	2.02
200	20.55	2.11	2.06	2.03
210	20.55	2.13	2.09	2.06
220	21.48	2.15	2.10	2.07
230	23.09	2.17	2.13	2.10
240	25.09	2.21	2.16	2.13
250	27.40	2.25	2.20	2.17
260	29.34	2.31	2.26	2.22
270	30.74	2.37	2.32	2.28
280	31.41	2.43	2.38	2.34
290	31.40	2.50	2.44	2.40
300	30.62	2.56	2.50	2.46
310	32.45	2.63	2.57	2.53
320	31.92	2.69	2.63	2.59
330	28.21	2.68	2.62	2.58
340	22.79	2.63	2.58	2.53
350	13.90	2.51	2.46	2.42

*1430 kHz 50% RSS site-to-site value.

Table A-13

Station Call: KALI

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	0.58	25.06	25.05	25.04
10	1.00	25.09	25.08	25.07
20	1.58	25.21	25.20	25.19
30	1.91	25.25	25.24	25.23
40	1.91	25.18	25.17	25.16
50	1.58	25.16	25.16	25.15
60	1.00	25.12	25.11	25.10
70	0.58	25.01	25.00	24.99
90	0.96	25.04	25.03	25.02
90	1.12	25.05	25.04	25.03
100	0.69	25.01	25.00	24.99
110	1.36	25.04	25.03	25.03
120	3.13	24.95	24.94	24.93
130	4.92	24.81	24.80	24.79
140	6.50	24.62	24.61	24.60
150	7.78	24.47	24.46	24.45
160	8.79	24.86	24.86	24.85
170	9.58	24.65	24.65	24.64
180	11.17	24.48	24.47	24.46
190	11.65	24.32	24.31	24.30
200	12.46	24.22	24.21	24.20
210	13.17	23.58	23.56	23.55
220	12.63	23.67	23.65	23.64
230	12.46	23.76	23.75	23.73
240	11.65	24.01	24.00	23.98
250	10.12	24.29	24.27	24.25
260	9.58	23.84	23.82	23.80
270	8.79	24.02	24.00	23.98
280	7.78	24.22	24.20	24.18
290	6.50	24.36	24.35	24.33
300	4.92	24.51	24.49	24.47
310	3.13	24.48	24.46	24.44
320	1.36	25.09	25.08	25.07
330	0.69	25.04	25.03	25.02
340	1.12	25.13	25.12	25.11
350	0.96	25.06	25.06	25.05

*1430 kHz 50% RSS site-to-site value.

Table A-14

Station Call: KNTA

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	0.55	23.18	23.08	22.97
10	0.47	23.18	23.08	22.97
20	0.47	17.02	16.87	16.71
30	0.54	17.02	16.87	16.71
40	0.56	17.02	16.87	16.71
50	0.50	17.03	16.87	16.71
60	0.45	17.03	16.87	16.71
70	0.51	17.03	16.87	16.72
80	0.57	17.03	16.87	16.72
90	0.54	17.03	16.88	16.72
100	0.46	17.03	16.88	16.72
110	0.46	17.04	16.88	16.72
120	0.46	17.04	16.88	16.72
130	0.82	17.04	16.89	16.73
140	1.87	17.13	16.97	16.81
150	3.11	17.22	17.06	16.90
160	4.41	17.25	17.09	16.93
170	5.48	17.27	17.12	16.95
180	6.40	17.22	17.07	16.91
190	7.02	17.16	17.01	16.85
200	7.49	23.38	23.27	23.16
210	7.73	23.30	23.20	23.09
220	7.77	23.15	23.04	22.93
230	7.61	23.06	22.95	22.84
240	7.23	23.04	22.93	22.82
250	6.69	22.94	22.83	22.72
260	5.88	22.90	22.80	22.69
270	4.86	22.95	22.84	22.73
280	3.63	22.99	22.89	22.78
290	2.35	23.05	22.94	22.83
300	1.19	23.12	23.01	22.90
310	0.50	23.19	23.09	22.98
320	0.46	23.19	23.09	23.98
330	0.45	23.19	23.08	22.97
340	0.50	23.19	23.08	22.97
350	0.57	23.18	23.08	22.97

*1430 kHz 50% RSS site-to-site value.

Table A-15

Station Call: WQDI

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	6.98	8.76	8.76	8.76
10	7.55	8.76	8.76	8.76
20	7.89	8.76	8.76	8.76
30	8.10	8.73	8.73	8.73
40	8.21	8.68	8.68	8.68
50	8.25	8.65	8.65	8.65
60	8.27	8.63	8.63	8.63
70	8.25	8.67	8.67	8.67
80	8.21	8.64	8.64	8.65
90	8.10	8.62	8.62	8.62
100	7.89	8.57	8.57	8.57
110	7.55	8.57	8.57	8.57
120	6.98	8.54	8.54	8.55
130	6.29	8.54	8.54	8.55
140	5.46	8.57	8.57	8.57
150	4.97	8.57	8.57	8.57
160	5.22	8.57	8.57	8.57
170	5.98	8.54	8.54	8.55
180	6.74	8.54	8.54	8.55
190	7.31	8.54	8.54	8.55
200	7.73	8.57	8.57	8.57
210	7.97	8.59	8.59	8.60
220	8.12	8.62	8.62	8.62
230	8.19	8.64	8.64	8.65
240	8.21	8.67	8.67	8.67
250	8.19	8.63	8.63	8.63
260	8.12	8.65	8.65	8.65
270	7.97	8.71	8.71	8.71
280	7.73	8.73	8.73	8.73
290	7.31	8.73	8.73	8.73
300	6.74	8.76	8.76	8.76
310	5.98	8.76	8.76	8.76
320	5.22	8.73	8.73	8.73
330	4.97	8.73	8.73	8.73
340	5.46	8.76	8.76	8.76
350	6.29	8.76	8.76	8.76

*1430 kHz 50% RSS site-to-site value.

Table A-16

Station Call: WQPD

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	4.14	8.81	8.82	8.84
10	4.14	8.81	8.83	8.84
20	4.14	8.82	8.83	8.84
30	4.14	8.80	8.82	8.83
40	4.14	8.81	8.82	8.83
50	4.14	8.80	8.81	8.82
60	4.14	8.78	8.79	8.80
70	4.14	8.77	8.78	8.80
80	4.14	8.75	8.77	8.78
90	4.14	8.74	8.75	8.76
100	4.14	8.72	8.74	8.75
110	4.14	8.71	8.72	8.73
120	4.14	8.68	8.69	8.71
130	4.14	8.67	8.69	8.70
140	4.14	8.66	8.67	8.68
150	4.14	8.65	8.66	8.67
160	4.14	8.63	8.64	8.66
170	4.14	8.63	8.64	8.65
180	4.14	8.62	8.63	8.64
190	4.14	8.63	8.64	8.65
200	4.14	8.63	8.64	8.65
210	4.61	8.62	8.64	8.65
220	4.61	8.63	8.65	8.66
230	4.61	8.63	8.64	8.66
240	4.61	8.65	8.66	8.67
250	4.61	8.67	8.68	8.69
260	4.14	8.69	8.70	8.72
270	4.61	8.70	8.72	8.73
280	4.14	8.72	8.73	8.74
290	4.14	8.74	8.75	8.77
300	4.14	8.75	8.77	8.78
310	4.14	8.77	8.78	8.79
320	4.14	8.78	8.79	8.81
330	4.14	8.79	8.81	8.82
340	4.14	8.80	8.81	8.82
350	4.14	8.81	8.82	8.83

*1430 kHz 50% RSS site-to-site value.

Table A-17

Station Call: WWGS

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	0.88	22.12	22.06	22.00
10	0.95	22.13	22.07	22.00
20	0.41	22.22	22.16	22.10
30	1.15	22.18	22.12	22.05
40	2.42	22.04	21.98	21.92
50	3.51	21.84	21.78	21.71
60	4.39	21.96	21.89	21.83
70	5.00	22.19	22.13	22.07
80	5.43	22.43	22.37	22.31
90	5.59	22.66	22.60	22.53
100	5.55	22.88	22.82	22.76
110	4.54	23.05	22.99	22.93
120	4.19	23.12	23.06	23.00
130	3.66	23.12	23.06	23.01
140	3.06	23.00	22.94	22.88
150	1.93	22.80	22.74	22.68
160	0.69	22.49	22.43	22.37
170	0.57	22.47	22.41	22.35
180	0.88	22.51	22.45	22.39
190	0.77	22.46	22.40	22.34
200	0.47	22.41	22.35	22.29
210	0.27	22.37	22.31	22.25
220	0.30	22.36	22.30	22.24
230	0.68	22.36	22.30	22.24
240	1.24	22.38	22.31	22.25
250	1.74	22.29	22.23	22.16
260	2.02	22.24	22.18	22.12
270	2.00	22.13	22.07	22.00
280	1.67	22.12	22.06	22.00
290	0.97	22.16	22.10	22.04
300	0.32	22.27	22.21	22.15
310	1.03	22.11	22.05	21.98
320	1.25	22.04	21.98	21.92
330	1.12	22.08	22.01	21.95
340	0.61	22.21	22.15	22.09
350	0.38	22.27	22.21	22.15

*1430 kHz 50% RSS site-to-site value.

Table A-18

Station Call: WWWQ

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	1.40	15.40	15.44	15.47
10	1.08	15.41	15.44	15.47
20	1.16	15.39	15.43	15.46
30	1.75	15.39	15.43	15.46
40	1.69	15.39	15.43	15.46
50	1.00	15.37	15.40	15.44
60	3.17	15.36	15.40	15.43
70	4.57	15.34	15.38	15.41
80	5.29	15.32	15.36	15.39
90	5.21	15.28	15.32	15.35
100	4.32	15.28	15.31	15.34
110	2.68	15.30	15.34	15.37
120	1.09	15.33	15.37	15.40
130	1.83	15.31	15.35	15.38
140	1.04	15.33	15.37	15.40
150	1.69	15.30	15.33	15.37
160	2.66	15.28	15.31	15.35
170	3.13	15.28	15.32	15.35
180	3.24	15.28	15.32	15.35
190	3.01	15.30	15.33	15.36
200	2.36	15.32	15.35	15.39
210	1.00	15.35	15.39	15.42
220	1.54	15.35	15.39	15.42
230	1.75	15.35	15.39	15.42
240	1.31	15.37	15.41	15.44
250	3.43	15.39	15.43	15.46
260	4.77	15.42	15.46	15.49
270	5.34	15.45	15.49	15.52
280	5.08	15.48	15.52	15.55
290	4.09	15.47	15.51	15.54
300	2.43	15.43	15.47	15.50
310	0.93	15.40	15.43	15.46
320	1.83	15.42	15.46	15.49
330	1.57	15.42	15.46	15.49
340	0.94	15.41	15.45	15.48
350	1.25	15.41	15.44	15.48

*1430 kHz 50% RSS site-to-site value.

Table A-19

Station Call: WIRE

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	26.72	3.67	3.65	3.66
10	26.86	3.64	3.63	3.63
20	26.19	3.64	3.62	3.63
30	25.71	3.63	3.61	3.62
40	21.63	3.64	3.62	3.63
50	20.10	3.64	3.62	3.63
60	17.57	3.64	3.62	3.63
70	13.62	3.65	3.64	3.64
80	7.90	3.69	3.67	3.68
90	12.37	3.66	3.26	3.65
100	16.75	3.65	3.67	3.65
110	19.33	3.67	3.72	3.67
120	20.97	3.70	3.79	3.69
130	21.85	3.73	3.85	3.33
140	22.27	3.37	3.91	3.36
150	22.48	3.40	3.95	3.39
160	22.57	3.43	3.98	3.42
170	22.57	3.45	3.99	3.44
180	22.48	3.47	3.99	3.46
190	22.27	3.47	3.97	3.46
200	21.85	3.47	3.94	3.46
210	20.97	3.46	3.90	3.46
220	19.33	3.45	3.45	3.44
230	16.75	3.84	3.43	3.83
240	12.37	3.83	3.82	3.82
250	7.90	3.81	3.80	3.80
260	13.62	3.85	3.83	3.84
270	17.57	3.88	3.86	3.87
280	20.09	3.89	3.87	3.88
290	21.63	3.88	3.86	3.87
300	22.31	3.86	3.84	3.85
310	23.29	3.84	3.83	3.83
320	22.67	3.81	3.80	3.80
330	24.90	3.77	3.76	3.76
340	25.95	3.73	3.72	3.72
350	26.60	3.70	3.68	3.69

*1430 kHz 50% RSS site-to-site value.

Table A-20

Station Call: WYMC

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	1.06	20.61	20.65	20.75
10	1.08	20.59	20.63	20.73
20	1.08	20.59	20.63	20.73
30	1.06	20.60	20.64	20.74
40	1.12	20.61	20.64	20.75
50	1.21	20.61	20.65	20.75
60	1.20	20.62	20.66	20.76
70	1.04	20.62	20.66	20.76
80	1.13	20.63	20.67	20.77
90	1.67	20.65	20.68	20.79
100	2.04	20.65	20.69	20.79
110	1.98	20.67	20.71	20.81
120	1.33	20.65	20.68	20.79
130	1.52	20.65	20.68	20.78
140	2.95	21.57	21.61	21.72
150	4.04	21.59	21.63	21.74
160	4.83	21.59	21.63	21.74
170	5.35	21.59	21.63	21.75
180	5.65	21.58	21.62	21.73
190	5.83	21.58	21.62	21.74
200	5.83	21.59	21.63	21.75
210	5.65	21.58	21.62	21.74
220	5.35	20.82	20.86	20.96
230	4.83	20.82	20.86	20.96
240	4.04	20.81	20.85	20.96
250	2.95	20.80	20.84	20.94
260	1.52	20.80	20.84	20.95
270	1.33	20.61	20.64	20.75
280	1.97	20.60	20.64	20.75
290	2.04	20.58	20.62	20.72
300	1.67	20.58	20.61	20.72
310	1.13	20.59	20.62	20.73
320	1.04	20.62	20.66	20.76
330	1.20	20.60	20.64	20.75
340	1.21	20.60	20.64	20.74
350	1.12	20.60	20.64	20.75

*1430 kHz 50% RSS site-to-site value.

Table A-21

Station Call: WIL

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	33.21	7.36	7.37	7.36
10	30.54	6.78	6.79	6.78
20	26.53	6.16	6.16	6.15
30	20.33	5.56	5.56	5.54
40	13.96	5.25	5.25	5.24
50	5.97	5.19	5.19	5.18
60	5.86	5.18	5.19	5.17
70	5.26	5.18	5.18	5.17
80	6.06	5.18	5.18	5.17
90	8.20	5.19	5.20	5.18
100	7.04	5.20	5.21	5.19
110	5.99	5.22	5.22	5.21
120	13.42	5.44	5.45	5.43
130	18.49	5.81	5.82	5.81
140	22.11	6.17	6.18	6.17
150	24.42	6.47	6.48	6.48
160	25.07	6.49	6.51	6.50
170	24.42	6.35	6.36	6.35
180	22.11	6.14	6.15	6.13
190	18.49	5.80	5.80	5.79
200	13.42	5.50	5.50	5.49
210	5.99	5.27	5.28	5.26
220	7.04	5.27	5.28	5.26
230	8.20	5.30	5.31	5.29
240	6.06	5.25	5.26	5.24
250	5.26	5.25	5.26	5.24
260	5.86	5.27	5.27	5.26
270	5.96	5.28	5.28	5.27
280	13.96	5.46	5.47	5.45
290	20.33	5.77	5.77	5.76
300	26.53	6.25	6.26	6.25
310	30.54	6.77	6.78	6.77
320	33.21	7.24	7.26	7.25
330	34.63	7.52	7.53	7.52
340	35.05	7.69	7.70	7.70
350	34.63	7.61	7.62	7.62

*1430 kHz 50% RSS site-to-site value.

Table A-22

Station Call: WNJR

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	14.50	2.61	2.65	2.60
10	16.25	2.69	2.90	2.68
20	17.61	2.66	2.80	2.65
30	18.75	2.61	2.69	2.60
40	19.42	2.56	2.66	2.55
50	19.71	2.50	2.59	2.49
60	19.73	2.45	2.58	2.43
70	19.54	2.42	2.71	2.40
80	19.21	2.44	2.80	2.42
90	18.83	2.48	2.61	2.46
100	16.66	2.49	2.68	2.47
110	15.37	2.53	2.74	2.50
120	15.36	2.58	2.77	2.56
130	15.47	2.64	2.77	2.62
140	14.83	2.60	2.73	2.58
150	14.63	2.63	2.73	2.61
160	14.36	2.65	2.72	2.63
170	19.71	2.54	2.73	2.53
180	19.74	2.54	2.98	2.55
190	19.51	2.55	2.92	2.55
200	18.92	2.51	2.85	2.51
210	17.82	2.40	2.69	2.41
220	16.58	2.60	2.64	2.59
230	14.91	2.53	2.63	2.52
240	12.82	2.47	2.69	2.46
250	10.61	2.42	2.70	2.41
260	8.27	2.42	2.49	2.42
270	7.30	2.43	2.54	2.42
280	7.98	2.44	2.56	2.43
290	8.63	2.45	2.58	2.45
300	8.69	2.47	2.61	2.46
310	8.16	2.48	2.64	2.47
320	7.37	2.48	2.64	2.47
330	7.88	2.50	2.65	2.49
340	10.06	2.53	2.66	2.53
350	12.40	2.58	2.68	2.57

*1430 kHz 50% RSS site-to-site value.

Table A-23

Station Call: KKAT

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	3.06	15.34	15.35	15.33
10	2.79	15.35	15.36	15.34
20	0.98	15.34	15.36	15.34
30	3.05	15.37	15.38	15.36
40	4.61	15.38	15.40	15.38
50	4.58	15.42	15.43	15.41
60	2.51	15.37	15.39	15.36
70	2.92	15.38	15.39	15.37
80	7.10	15.45	15.47	15.45
90	10.31	15.53	15.54	15.52
100	12.63	15.58	15.59	15.57
110	13.78	15.55	15.57	15.55
120	14.32	15.51	15.53	15.51
130	14.32	15.47	15.49	15.47
140	13.78	15.43	15.45	15.43
150	12.63	15.39	15.40	15.38
160	10.31	15.34	15.36	15.34
170	7.10	15.33	15.34	15.32
180	2.92	15.32	15.33	15.31
190	2.51	15.31	15.33	15.30
200	4.58	15.29	15.31	15.29
210	4.61	15.27	15.29	15.27
220	2.60	15.30	15.32	15.30
230	0.90	15.31	15.33	15.31
240	2.40	15.30	15.31	15.29
250	3.06	15.28	15.30	15.27
260	2.71	15.30	15.31	15.29
270	1.48	15.31	15.32	15.30
280	1.42	15.31	15.32	15.30
290	2.80	15.30	15.31	15.30
300	3.49	15.29	15.31	15.29
310	3.49	15.30	15.32	15.29
320	2.80	15.31	15.32	15.30
330	1.42	15.33	15.34	15.32
340	1.48	15.33	15.34	15.32
350	2.71	15.33	15.35	15.33

*1430 kHz 50% RSS site-to-site value.

Table A-24

Station Call: WENE

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	8.91	8.83	8.83	8.82
10	10.80	8.78	8.77	8.77
20	12.15	8.71	8.70	8.70
30	13.08	8.63	8.63	8.62
40	13.66	8.55	8.55	8.54
50	13.85	8.48	8.48	8.47
60	13.73	8.41	8.41	8.40
70	13.23	8.36	8.36	8.35
80	12.32	8.21	8.21	8.20
90	11.01	8.22	8.21	8.21
100	9.03	8.28	8.28	8.27
110	6.61	8.15	8.15	8.14
120	3.61	8.27	8.26	8.25
130	1.86	8.34	8.33	8.32
140	2.02	8.34	8.33	8.32
150	2.62	8.33	8.32	8.31
160	3.68	8.32	8.31	8.30
170	4.35	8.33	8.32	8.31
180	4.17	8.35	8.34	8.33
190	3.61	8.38	8.37	8.36
200	2.97	8.41	8.40	8.39
210	2.48	8.42	8.41	8.40
220	2.24	8.44	8.43	8.42
230	2.21	8.45	8.44	8.43
240	2.37	8.46	8.45	8.45
250	2.68	8.48	8.47	8.46
260	3.05	8.50	8.49	8.48
270	3.51	8.52	8.51	8.50
280	4.12	8.54	8.54	8.53
290	4.69	8.57	8.56	8.55
300	4.94	8.57	8.56	8.55
310	4.88	8.55	8.54	8.53
320	4.71	8.54	8.53	8.52
330	4.75	8.52	8.51	8.50
340	5.34	8.66	8.65	8.64
350	6.97	8.65	8.64	8.63

*1430 kHz 50% RSS site-to-site value.

Table A-25

Station Call: WMNC

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	1.25	22.76	22.46	22.79
10	1.15	22.76	22.46	22.79
20	1.17	22.76	22.46	22.79
30	1.25	22.76	22.46	22.79
40	1.06	22.73	22.42	22.76
50	0.65	22.73	22.43	22.76
60	1.69	22.73	22.42	22.76
70	2.55	22.71	22.40	22.74
80	3.18	22.69	22.38	22.72
90	3.55	22.66	22.35	22.69
100	3.82	22.61	22.31	22.64
110	3.95	22.62	22.31	22.65
120	4.02	22.60	22.29	22.63
130	4.01	22.59	22.28	22.62
140	3.94	22.59	22.29	22.62
150	3.78	22.61	22.30	22.64
160	3.49	22.61	22.31	22.64
170	3.07	22.65	22.34	22.68
180	2.40	22.66	22.36	22.69
190	1.48	22.71	22.40	22.74
200	0.61	22.72	22.42	22.75
210	1.14	22.74	22.43	22.77
220	1.25	22.74	22.43	22.77
230	1.15	22.74	22.43	22.77
240	1.17	22.73	22.42	22.75
250	1.26	22.76	22.46	22.79
260	1.24	22.76	22.45	22.79
270	1.06	22.75	22.45	22.78
280	0.88	22.75	22.45	22.78
290	0.92	22.75	22.45	22.78
300	1.02	22.77	22.47	22.80
310	1.01	22.77	22.46	22.80
320	0.90	22.77	22.46	22.80
330	0.90	22.77	22.46	22.80
340	1.10	22.76	22.46	22.79
350	1.25	22.76	22.46	22.79

*1430 kHz 50% RSS site-to-site value.

Table A-26

Station Call: WFOB

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	13.38	15.43	15.42	15.42
10	12.85	15.12	15.11	15.11
20	11.89	15.26	15.26	15.26
30	10.45	14.89	14.89	14.89
40	8.65	14.10	14.10	14.09
50	6.35	13.90	13.89	13.89
60	3.90	13.80	13.80	13.80
70	1.72	13.83	13.83	13.83
80	1.50	13.84	13.83	13.83
90	1.56	13.79	13.79	13.79
100	1.44	13.77	13.76	13.76
110	2.88	13.52	13.52	13.51
120	4.74	13.21	13.20	13.20
130	6.26	12.91	12.90	12.90
140	7.44	12.69	12.69	12.69
150	8.18	12.57	12.57	12.56
160	8.50	12.56	12.56	12.55
170	8.37	12.11	12.11	12.10
180	7.78	12.33	12.32	12.31
190	6.79	12.59	12.58	12.57
200	5.42	12.87	12.87	12.86
210	3.64	13.12	13.11	13.10
220	1.87	13.27	13.27	13.26
230	1.42	13.34	13.33	13.32
240	1.61	13.38	13.37	13.36
250	1.37	13.41	13.41	13.40
260	2.93	13.57	13.57	13.56
270	5.44	13.93	13.92	13.92
280	7.76	14.34	14.33	14.32
290	9.77	14.74	14.73	14.72
300	11.33	15.10	15.09	15.08
310	12.54	15.30	15.29	15.28
320	13.21	15.37	15.36	15.35
330	13.56	16.10	16.09	16.09
340	13.69	15.92	15.92	15.92
350	13.63	15.71	15.71	15.70

*1430 kHz 50% RSS site-to-site value.

Table A-27

Station Call: WNAV

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	4.30	15.84	15.72	15.61
10	4.01	15.88	15.76	15.64
20	3.59	15.93	15.81	15.69
30	2.98	15.94	15.82	15.70
40	2.17	15.98	15.86	15.74
50	1.80	15.98	15.87	15.75
60	2.69	15.99	15.87	15.76
70	3.65	16.02	15.90	15.79
80	4.42	16.05	15.93	15.81
90	4.99	16.09	15.98	15.85
100	5.46	16.14	16.02	15.90
110	5.81	16.19	16.07	15.95
120	6.08	16.78	16.66	16.55
130	6.26	16.81	16.70	16.58
140	6.38	16.83	16.71	16.60
150	6.47	17.83	17.72	17.62
160	6.51	17.81	17.70	17.60
170	6.50	17.77	17.67	17.56
180	6.46	17.17	17.06	16.95
190	6.36	17.12	17.01	16.90
200	6.23	17.09	16.98	16.87
210	6.04	17.05	16.94	17.83
220	5.74	17.00	16.89	16.79
230	5.38	16.95	16.85	16.74
240	4.90	16.93	16.83	16.72
250	4.29	16.92	16.81	16.71
260	3.47	16.90	16.79	16.69
270	2.48	16.91	16.80	16.69
280	1.75	16.88	16.77	16.66
290	2.34	16.86	16.75	16.64
300	3.12	15.92	15.80	15.69
310	3.70	15.88	15.77	15.66
320	4.08	15.86	15.75	15.63
330	4.33	15.84	15.73	15.62
340	4.44	15.82	15.71	15.60
350	4.43	15.85	15.73	15.62

*1430 kHz 50% RSS site-to-site value.

Table A-28

Station Call: KOSI

Azimuth (N degrees E)	Distance to Interference Free Contour* (miles)	Interference Limit 50% RSS Value (mV/m) 1426 kHz	1430 kHz	1434 kHz
0	33.91	6.24	6.25	6.30
10	34.31	6.26	6.27	6.32
20	33.91	6.19	6.20	6.25
30	32.57	6.76	6.78	6.81
40	30.12	6.50	6.52	6.55
50	26.23	6.22	6.23	6.26
60	19.96	5.94	5.94	5.96
70	13.80	5.77	5.78	5.79
80	6.09	5.66	5.66	5.67
90	4.51	6.32	6.32	6.32
100	4.40	6.31	6.31	6.32
110	4.69	6.32	6.31	6.32
120	4.54	6.31	6.31	6.31
130	8.31	6.31	6.31	6.31
140	12.66	6.31	6.31	6.31
150	14.81	6.34	6.33	6.33
160	15.60	6.38	6.37	6.36
170	15.39	6.40	6.39	6.39
180	14.82	6.41	6.40	6.39
190	14.52	6.42	6.41	6.40
200	14.82	6.44	6.42	6.42
210	15.39	6.45	6.43	6.43
220	15.60	6.43	6.42	6.41
230	14.81	6.40	6.39	6.38
240	12.66	6.36	6.35	6.35
250	8.31	6.33	6.32	6.32
260	4.54	6.32	6.32	6.32
270	4.69	6.32	6.32	6.32
280	4.40	6.32	6.32	6.32
290	4.51	6.32	6.32	6.33
300	6.09	6.68	5.67	5.68
310	13.80	5.76	5.76	5.77
320	19.96	5.93	5.93	5.95
330	26.23	6.21	6.22	6.24
340	30.12	5.81	6.51	5.86
350	32.57	6.05	6.06	6.11

*1430 kHz 50% RSS site-to-site value.

FORM OT-29
(3-73)

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15. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

The pressure to provide additional full time facilities in the AM (standard broadcasting) band in the United States resulted in a rulemaking petition filed with the Federal Communications Commission (FCC). The petition proposed the reduction of the AM channel spacing from 10 to 9 kHz. According to the suggested frequency allocation plan, the maximum frequency change required for any standard AM broadcast station would be ±4 kHz. A study was conducted both theoretically and experimentally to determine the magnitude of the radiation pattern changes that would be caused by a ±4 kHz frequency change for stations using directional antenna arrays. Additionally, a computer study of the 1430 kHz regional channel was conducted to determine the effects of a ±4 kHz frequency change on the interference levels suffered by co-channel stations. The results of the study demonstrate that the effects of small frequency changes on the radiation patterns of directional antenna arrays are greater in practice than theoretical predictions would indicate, but that the required pattern corrections could probably be quickly and easily effected.

16. Key Words *(Alphabetical order, separated by semicolons)*

AM broadcast band; allocation bandwidth; directional antennas; frequency allocations

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