BEFORE THE

FEDERAL COMMUNICATIONS COMMISSION

WASHINGTON, D. C.

In the Matter of)

AM STEREOPHONIC BROADCASTING) F.C.C. Docket No. 21313

TEST RESULTS OF
THE HARRIS CORPORATION
V-CPM AM STEREO SYSTEM

Conducted by

C K L W R A D I O

On Behalf of the Canadian Department of Communications
Technical Advisory Sub-Committee on AM Stereo

E. R. Buterbaugh
Vice President/Director of Engineering
CKLW Radio Broadcasting Ltd.

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INTRODUCTION

The following test program was developed by members of the Canadian Department of Communication Technical Advisory Sub-Committee on AM Stereo, and has been designed to answer specific questions concerning the transmission of AM Stereo signals.

The tests were conducted on the Harris Corporation V-CPM AM Stereo System, utilizing the transmitting and studio facilities of CKLW Radio, Windsor, Ontario, Canada. All tests were conducted by CKLW technical personnel or their representatives. The information contained in this report has been written and compiled by CKLW Radio, and is believed to be a true representation of the test results obtained.

E. R. Buterbaugh

The following people participated in, or acted as witnesses in all or portions of this test program.

Ronald D. Taggart	Canadian Department of Communications
Peter Cahn	Broadcast Engineering Consultant and Chairman of the Canadian Department of Communications Technical Advisory Sub-Committee on AM Stereo.
Herman E. Hurst	Broadcast Engineering Consultant, Carl T. Jones & Associates
Edwin R. Buterbaugh	V.P. and Director of Engineering, CKLW Radio Member of the Canadian Department of Communications Technical Advisory Sub-Committee on AM Stereo
Kenneth Stewart	CKLW Engineering Department
William Tofflemire	CKLW Engineering Department
Mark Lantz	CKLW Engineering Department
Peter Burk	Chief Engineer, WKBW Radio
Benjamin J. Friedland	Lightning Electric Company
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M. L. Koch	Harris Corporation
Clint Nichol	Director of Engineering, Moffat Communications Ltd.
Rodney Clark	Chief Engineer, CBC Radio, Windsor

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TEST #1

DIRECTIONAL ANTENNA NULL PROTECTION

OBJECTIVE

To determine the effect of stereo transmission on the protection afforded by directional antenna nulls.

PROCEDURES

This test was conducted at three specific points in the major null of the CKLW nighttime radiation pattern. Point number one represents the deepest portion of the null on a radial 58° from true north (see attached polargraph). The point of measurement was located at a distance from the antenna system of 18.2 kilometers. At this location, the measured carrier field intensity was 89.3 dbu. Point number two was located on the 54° radial representing the northern edge of the null. Measurements on this radial were taken at a distance of 19 kilometers from the antenna system, where the carrier field intensity measured 95.7 dbu. Point number three was located on the 66° radial from true north and represents the southern edge of the null. Measurements on this radial were taken at a point 17 kilometers from the antenna system, where the carrier field intensity measured 102.6 dbu.

The tests were conducted in the following manner: With the CKLW transmitter operating in the monaural mode and modulated at a level of 80% with separate sine waves of 4 kHz. and 8 kHz. the received carrier level and then the upper and lower sideband were measured at the points described on a Stoddard MN-25 Field Intensity Meter and simultaneously at the transmitter output on a Techtronics 7L5 Spectrum Analyzer. The transmitter was then switched to the stereo mode and the same measurements were made, first with an L + R and then with an L - R modulating sine wave equal to 80% total modulation at the same frequencies transmitted in the monaural tests. In addition, tests of left channel only and right channel only were conducted in exactly the same manner.

Tests were also conducted utilizing a composite tone consisting of the following frequencies:

400 Hz @ 35% Modulation

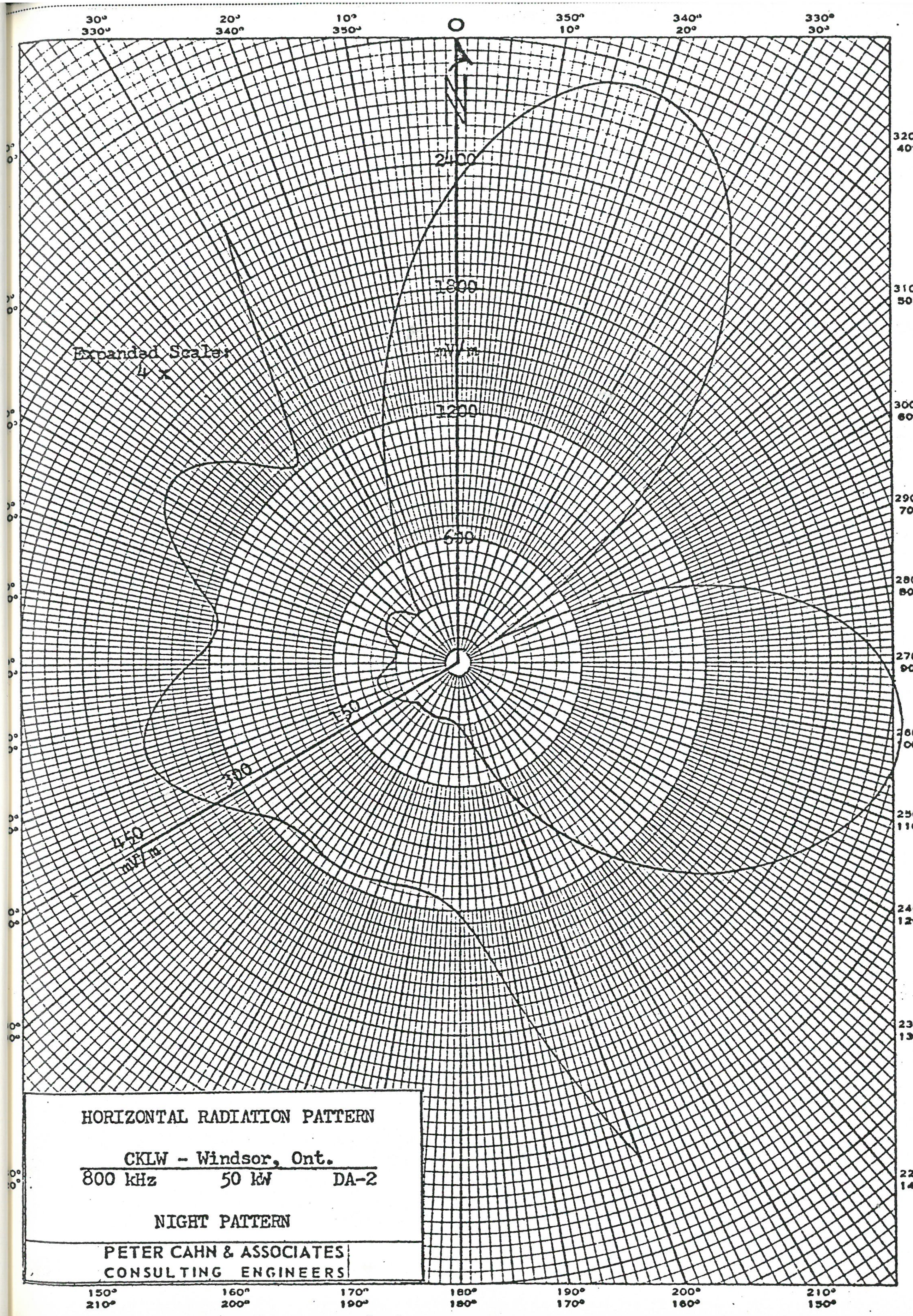
2700 Hz @ 25% Modulation

5500 Hz @ 15% Modulation

8500 Hz @ 10% Modulation

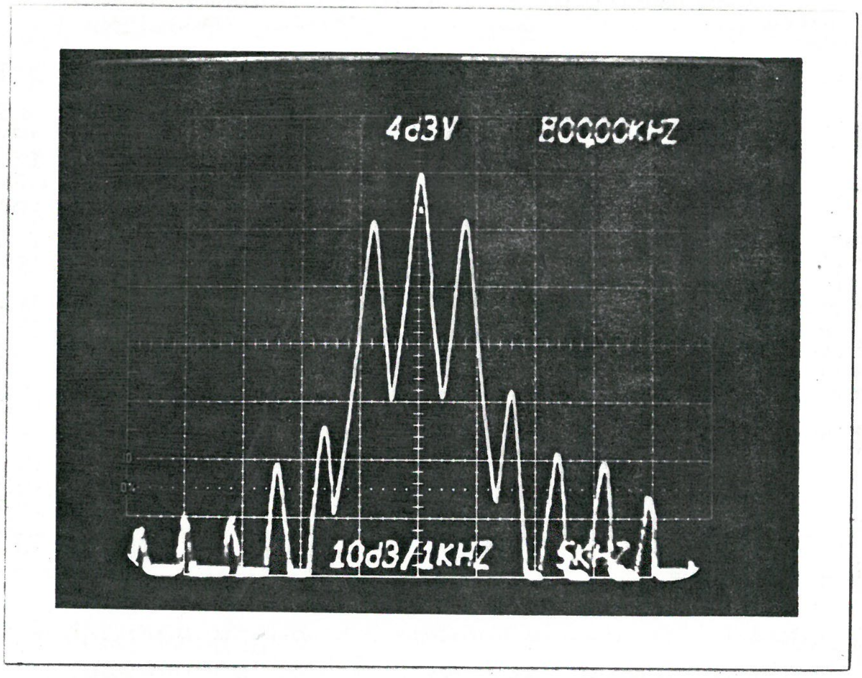
These tones were first transmitted in the monaural mode and then in the stereo mode; further spectrum analyzer observations and field measurements were made with these tones modulating the carrier in the L + R configuration then L - R, and finally the right channel audio was phase shifted 90° with the left channel to produce a quadrature audio signal. The results of this test as observed on the spectrum analyzer are shown in figures 6 and 7. Due to the fact that the Stoddard Field Intensity Meter is not sufficiently selective at the lower modulating frequencies, accurate field measurements utilizing the composite tone could not be made, except at 8.5 kHz in the monaural and L + R modes. However, it is apparent from the measurements obtained that no increased interference resulted.

Spectral photographs of the entire test taken from the transmitter output are shown in figures 1 through 7, and the simultaneous field measurements recorded at the measurement points appear on the subsequent three pages.



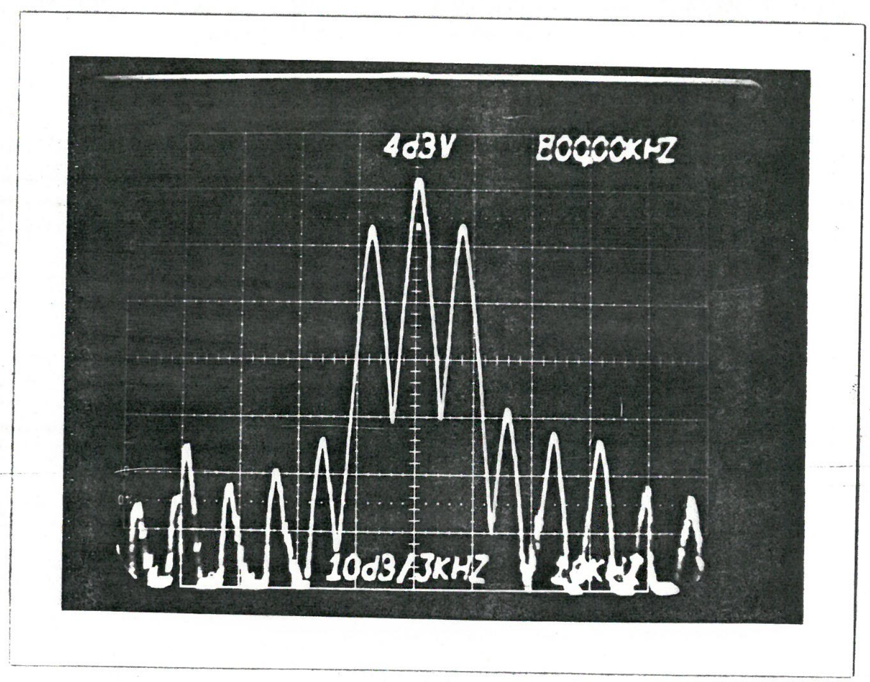
0
30° 330°
20° 340°
10° 350°
350° 10°
340° 20°
330° 30°
320° 40°
310° 50°
300° 60°
290° 70°
280° 80°
270° 90°
260° 100°
250° 110°
240° 120°
230° 130°
220° 140°
150° 210°
160° 200°
170° 190°
180° 180°
190° 170°
200° 160°
210° 150°
2400
1800
mV/m
1200
600
150
300
450 mV/m
Expanded Scale: 4 x
HORIZONTAL RADIATION PATTERN
CKLW - Windsor, Ont.
800 kHz 50 kW DA-2
NIGHT PATTERN
PETER CAHN & ASSOCIATES
CONSULTING ENGINEERS

TEST #1



4 kHz. @ 80% Modulation

Monaural

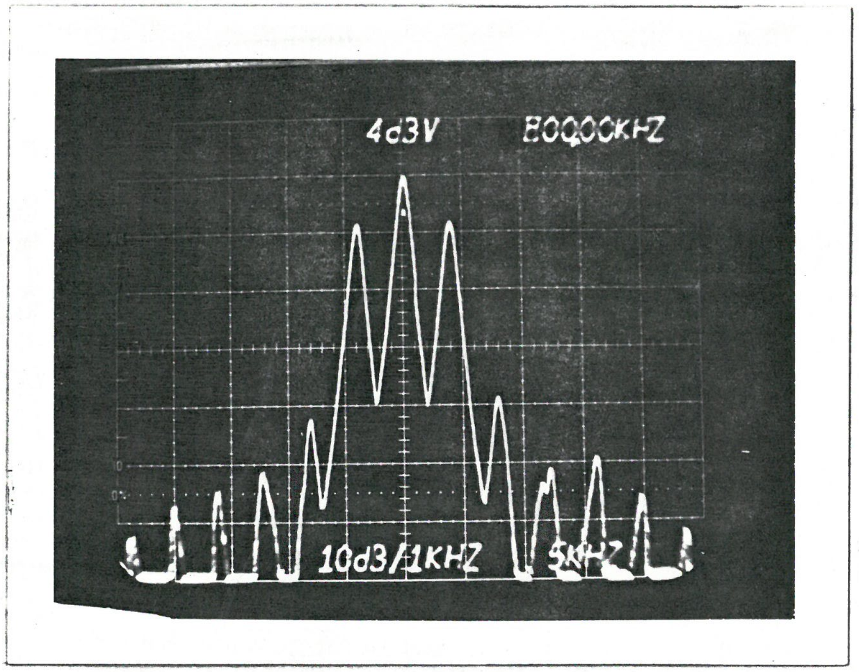


8 kHz. @ 80% Modulation

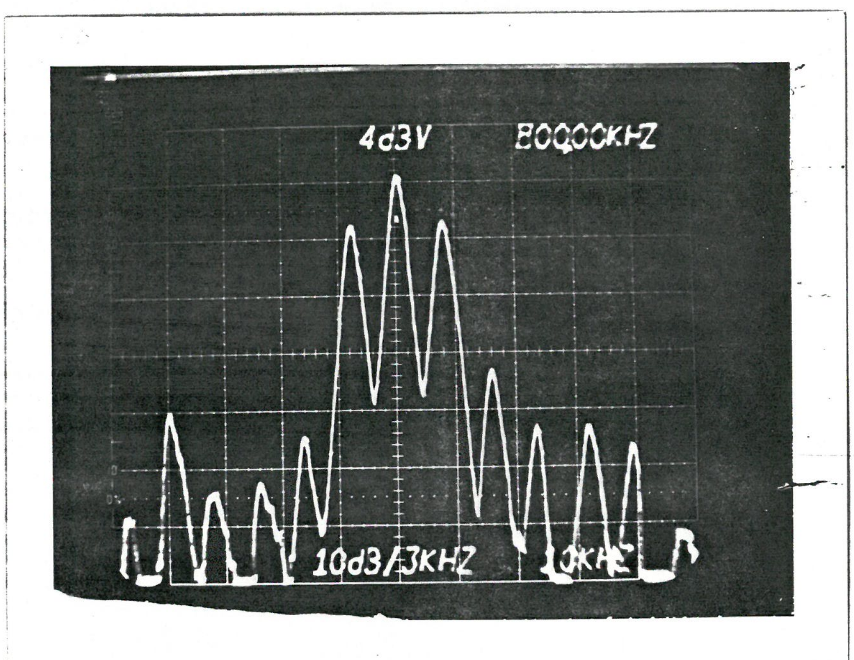
Monaural

Fig. 1

TEST #1



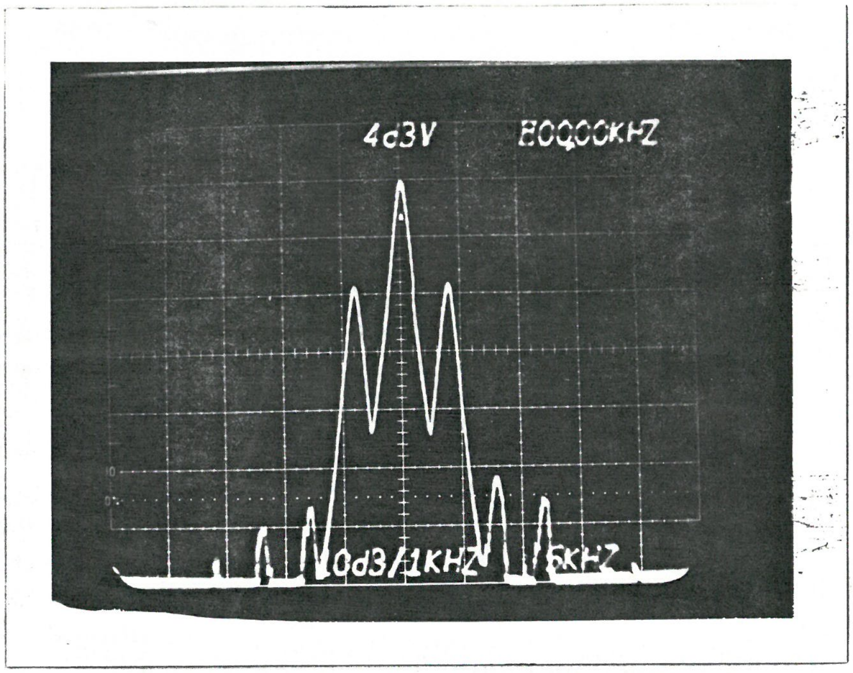
4 kHz. @ 80% Modulation
Stereo (L + R)



8 kHz. @ 80% Modulation
Stereo (L + R)

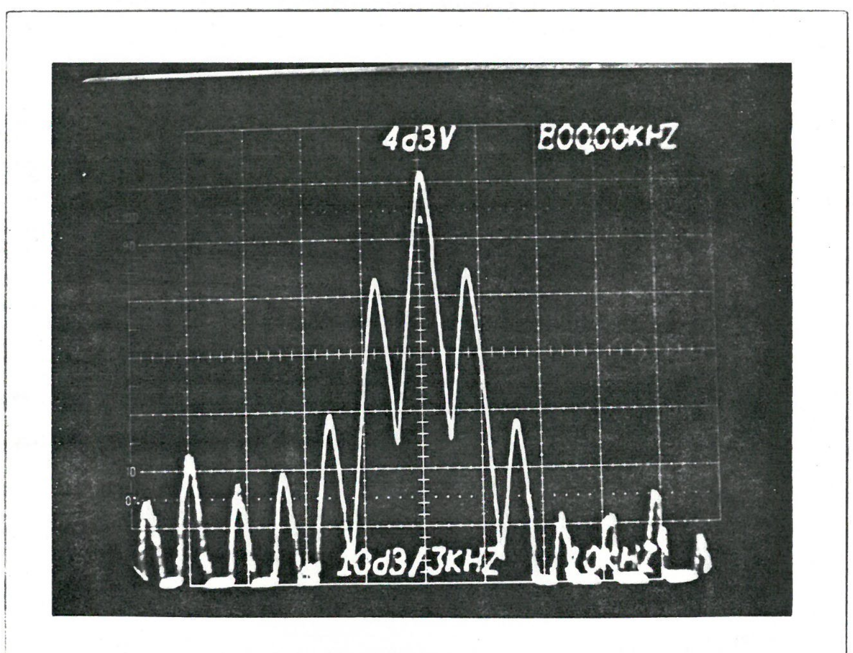
Fig. 2

TEST #1



4 kHz. @ 80% Modulation

Stereo (L - R)

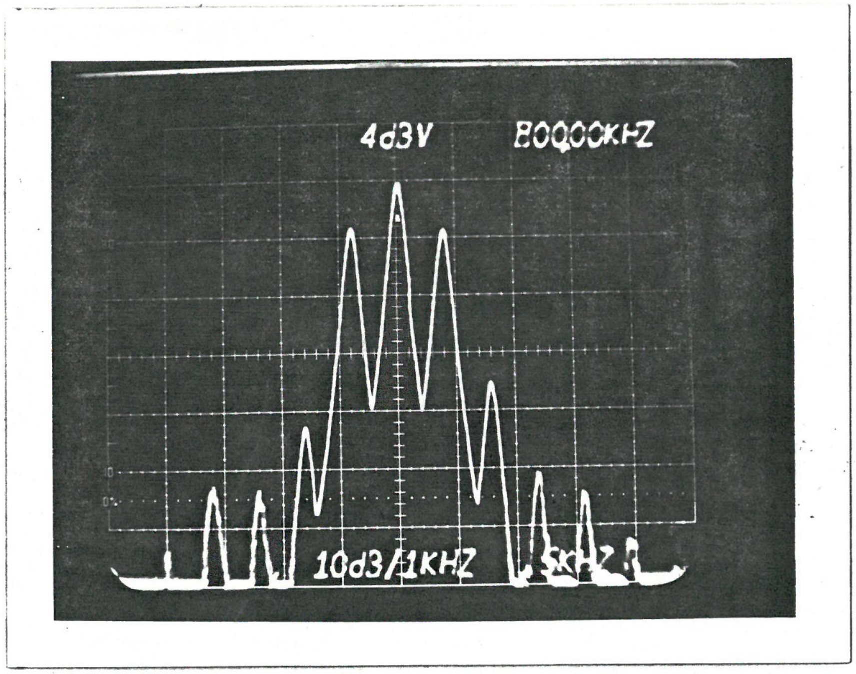


8 kHz. @ 80% Modulation

Stereo (L - R)

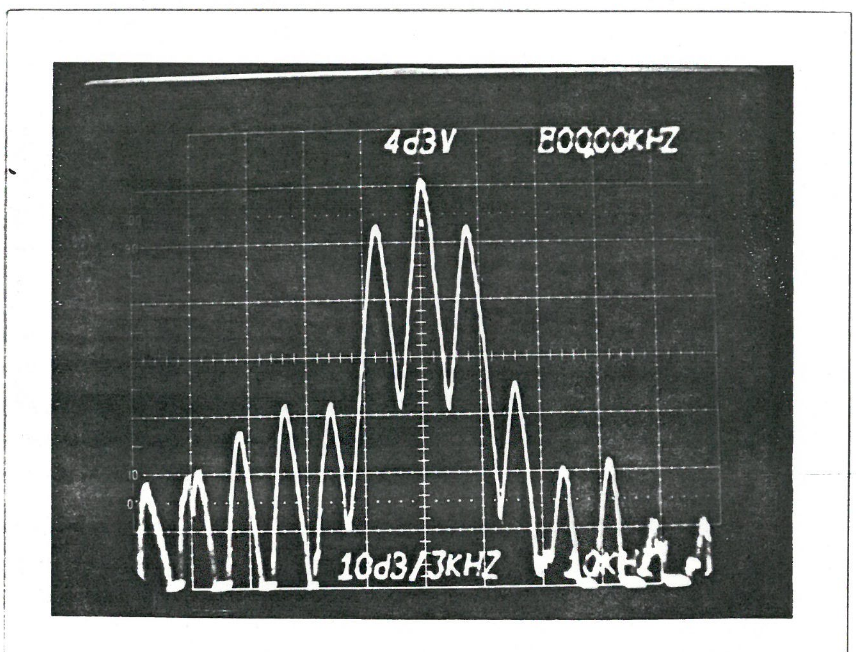
Fig. 3

TEST #1



4 kHz. @ 80% Modulation

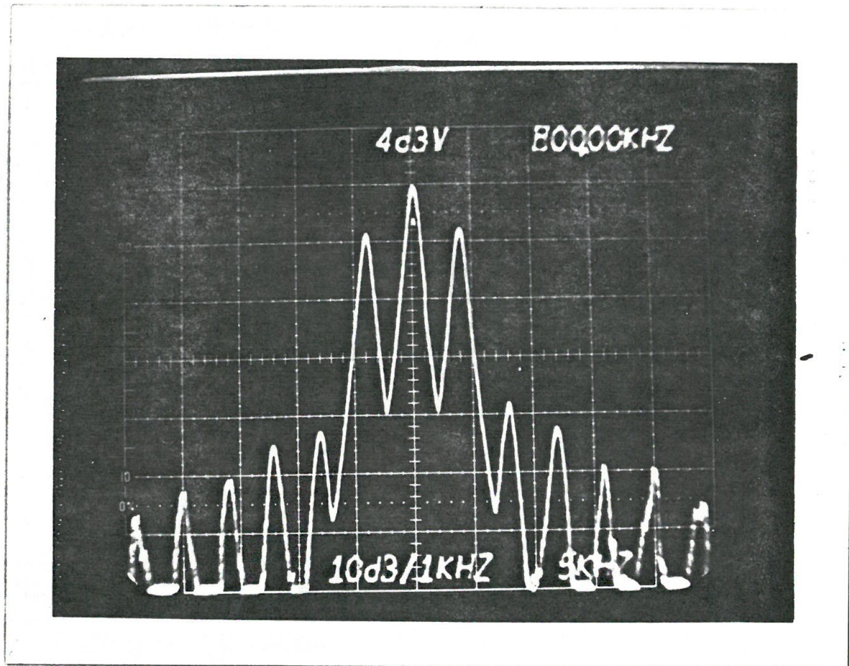
Stereo (Left Channel Only)



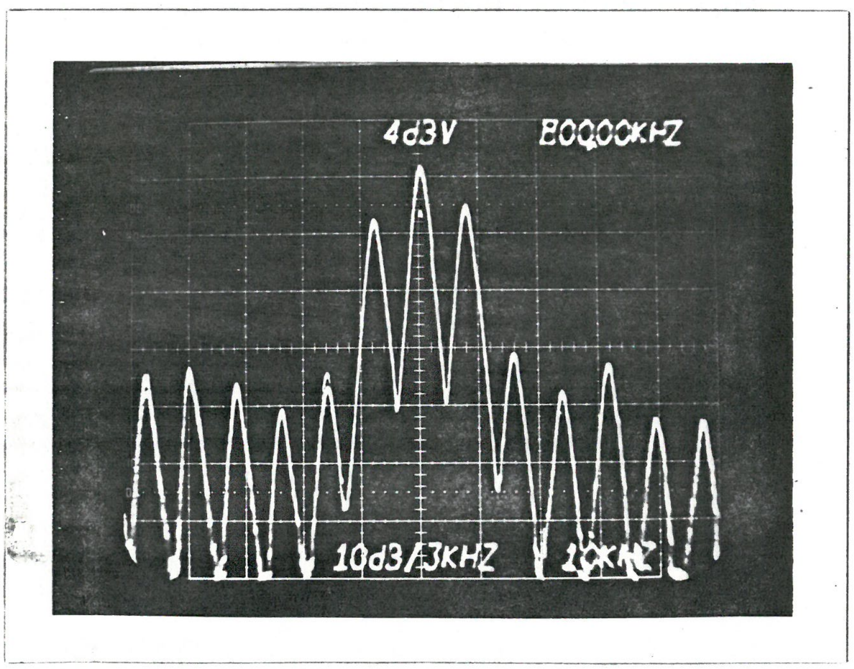
8 kHz. @ 80% Modulation

Stereo (Left Channel Only)

Fig. 4



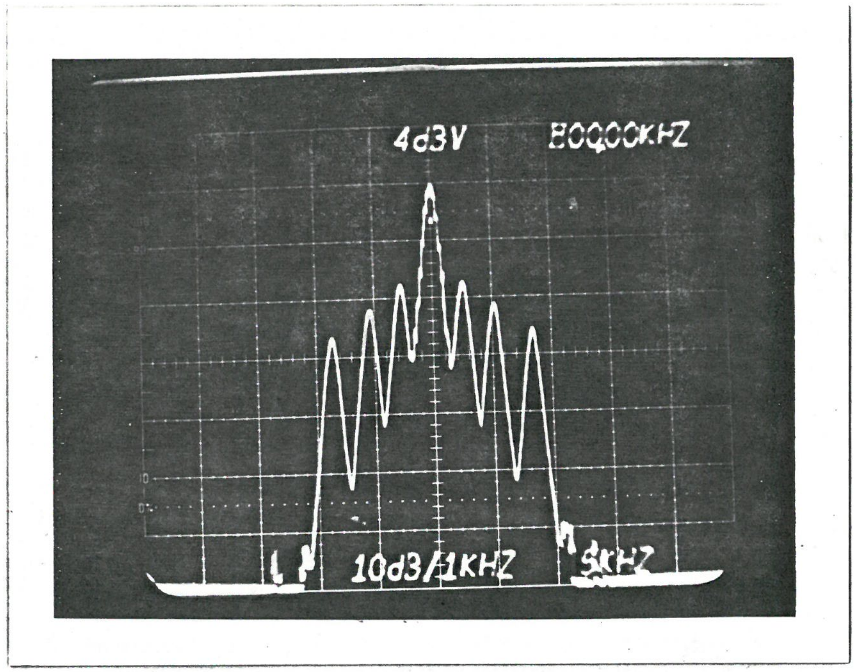
4 kHz. @ 80% Modulation
Stereo (Right Channel Only)



8 kHz. @ 80% Modulation
Stereo (Right Channel Only)

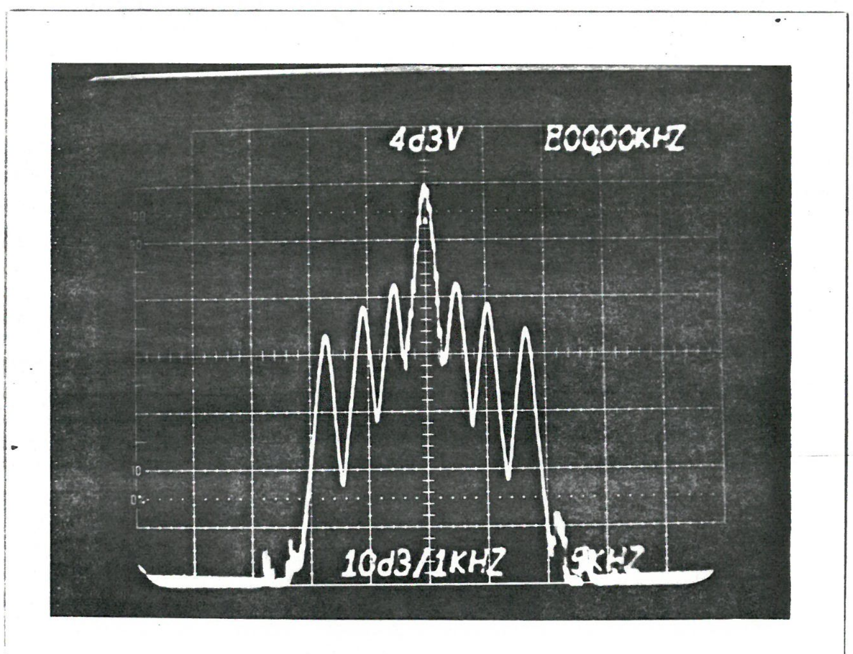
Fig. 5

TEST #1



Composite Tones @ 85% Modulation

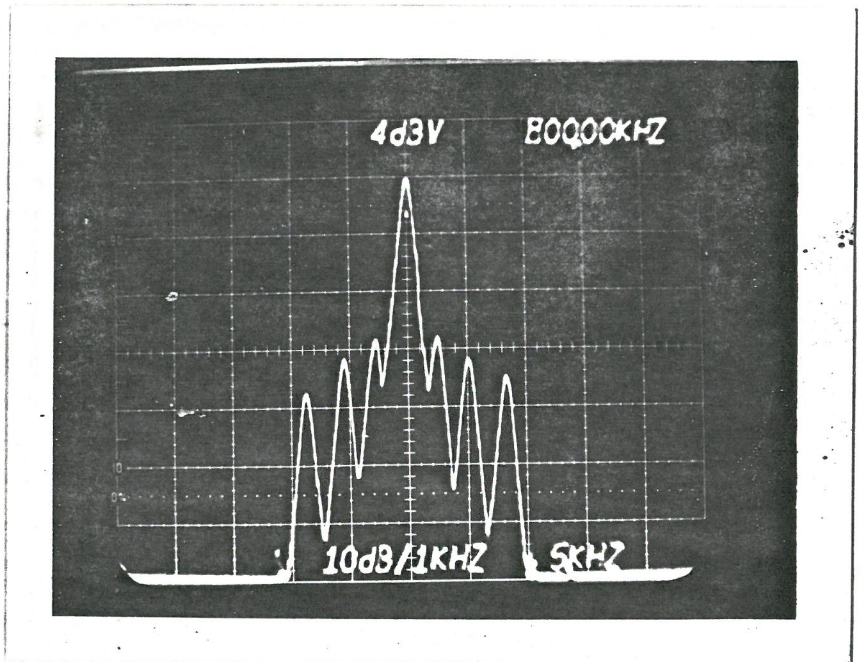
Monaural



Composite Tones @ 85% Modulation

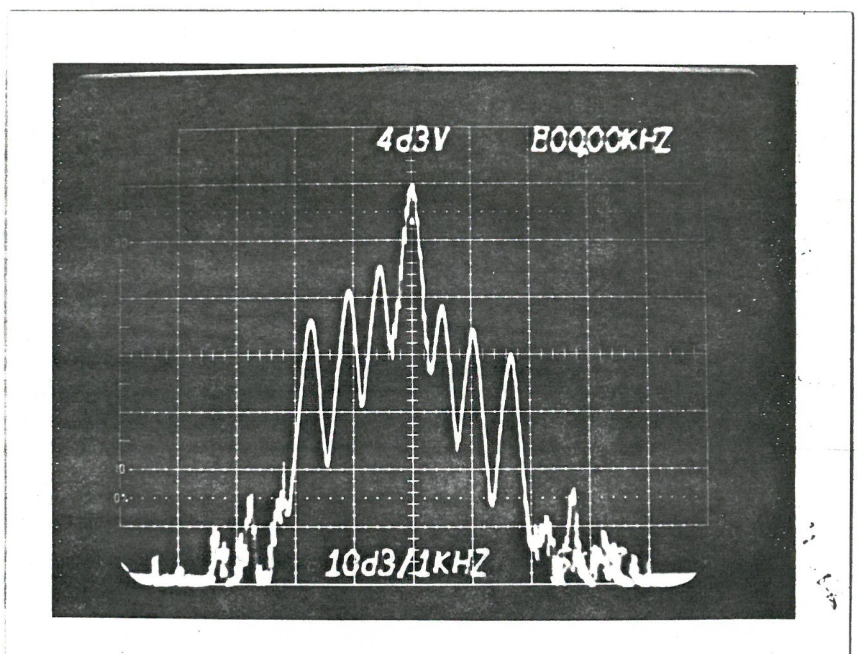
Stereo (L + R)

Fig. 6



Composite Tones @ 85% Modulation

Stereo (L - R)



Composite Tones @ 85% Modulation

Stereo (Quadrature)

Fig. 7

TEST #1

DIRECTIONAL ANTENNA NULL PROTECTION

PROPONENT: Harris Corporation DATE: July 3, 1979

Azimuth: 58° Distance from Transmitter: 18.2 km Carrier Field Intensity: 89.3 dbu

MONAURAL TEST

Modulation: 80% neg. 80% pos.

	Carrier Level	Upper Sideband	Lower Sideband
4 kHz.	32.8	24.1	24.0
8 kHz.	32.0	24.0	21.8
400 Hz. @ 35%, 2700 Hz. @ 25%			
5500 Hz. @ 15%, 8500 Hz. @ 10%	31.5	11.0	7.5

STEREO TESTS

Total Modulation: 80% neg. 80% pos.

4 kHz. (L+R)	32.0	25.1	24.5
8 kHz. (L+R)	32.0	23.0	21.6
4 kHz. (L-R)	31.5	24.8	22.7
8 kHz. (L-R)	31.4	14.0	11.2

LEFT CHANNEL ONLY

Modulation: 80% neg. 80% pos.

4 kHz. (L)	31.8	25.5	24.2
8 kHz. (L)	31.8	23.2	22.0

RIGHT CHANNEL ONLY

4 kHz. (R)	31.4	24.2	23.5
8 kHz. (R)	31.5	23.0	21.2

COMPOSITE TONES (L + R)

Total Modulation: 80% neg. 80% pos.

400 Hz. @ 35%, 2700 Hz. @ 25%			
5500 Hz. @ 15%, 8500 Hz. @ 10%	32.0	8.0	6.0

NOTE: Measurements are indicated in relative db.

TEST #1

DIRECTIONAL ANTENNA NULL PROTECTION

PROPONENT: Harris Corporation DATE: July 3, 1979

Azimuth: 54° Distance from Transmitter: 19 km. Carrier Field Intensity: 95.7 dbu

MONAURAL TEST

Modulation: 80% neg. 80% pos.

	Carrier Level	Upper Sideband	Lower Sideband
4 kHz.	18.0	10.6	10.8
8 kHz.	18.0	10.8	12.0
400 Hz. @ 35%, 2700 Hz. @ 25% 5500 Hz. @ 15%, 8500 Hz. @ 10%	37.9*	16.2*	16.5*

STEREO TESTS

Total Modulation: 80% neg. 80% pos.

	Carrier Level	Upper Sideband	Lower Sideband
4 kHz. (L+R)	17.9	10.6	10.6
8 kHz. (L+R)	18.0	11.0	12.4
4 kHz. (L-R)	17.9	5.8	5.0
8 kHz. (L-R)	17.9	1.8	1.9

LEFT CHANNEL ONLY

	Carrier Level	Upper Sideband	Lower Sideband
4 kHz. (L)	17.8	10.6	11.2
8 kHz. (L)	17.8	10.0	13.0

RIGHT CHANNEL ONLY

Modulation: 80% neg. 80% pos.

	Carrier Level	Upper Sideband	Lower Sideband
4 kHz. (R)	17.8	11.2	11.0
8 kHz.	17.8	11.8	11.2

COMPOSITE TONES (L + R)

Total Modulation: 80% neg. 80% pos.

	Carrier Level	Upper Sideband	Lower Sideband
400 Hz. @ 35%, 2700 Hz. @ 25% 5500 Hz. @ 15%, 8500 Hz. @ 10%	37.9*	16.8*	16.6*

*NOTE: 20 db pad removed from field intensity meter.
Measurements are indicated in relative db.

TEST #1

DIRECTIONAL ANTENNA NULL PROTECTION

PROPONENT: Harris Corporation DATE: July 3, 1979

Azimuth: 66° Distance from Transmitter: 17 km. Carrier Field Intensity: 102.6 dbu

MONAURAL TEST

Modulation: 80% neg. 80% pos.

	Carrier Level	Upper Sideband	Lower Sideband
4 kHz.	24.9	17.8	17.4
8 kHz.	24.9	17.0	15.2
400 Hz. @ 35%, 2700 Hz. @ 25% 5500 Hz. @ 15%, 8500 Hz. @ 10%	24.8	8.5	8.0

STEREO TESTS

Total Modulation: 80% neg. 80% pos.

	Carrier Level	Upper Sideband	Lower Sideband
4 kHz. (L+R)	24.9	17.8	17.1
8 kHz. (L+R)	24.9	17.3	15.2
4 kHz. (L-R)	24.8	15.8	17.1
8 kHz. (L-R)	24.8	7.2	4.8

LEFT CHANNEL ONLY

Modulation: 80% neg. 80% pos.

	Carrier Level	Upper Sideband	Lower Sideband
4 kHz. (L)	24.8	17.4	17.0
8 kHz. (L)	24.8	17.1	16.2

RIGHT CHANNEL ONLY

	Carrier Level	Upper Sideband	Lower Sideband
4 kHz. (R)	24.8	17.6	16.1
8 kHz. (R)	24.8	18.1	14.9

COMPOSITE TONES (L + R)

	Carrier Level	Upper Sideband	Lower Sideband
400 Hz. @ 35%, 2700 Hz. @ 25% 5500 Hz. @ 15%, 8500 Hz. @ 10%	24.8	8.0	7.8

NOTE: Measurements are indicated in relative db.

TEST #1

CONCLUSION

It is apparent from the test data collected that the Harris AM Stereo System does not alter or distort the protection afforded by directional antenna systems. Assuming measurements observed on the Stoddard Field Intensity Meter to be accurate within 1 db, there is no indication that the received carrier and sideband characteristics in the directional antenna null points differ from the characteristics of the transmitted signal.

The distortion components in the 8 kHz single channel only tests are due to imperfect stereo signal generation in the transmitter, and could have been substantially reduced had the transmitter modulator equalizer been used. The transmitter modulator equalizer is part of the transmitter interface, supplied by Harris, and is used to correct amplifier phase deficiencies in the transmitter's modulator. The circuit was not used in the CKLW tests because the initial tune up of the system, conducted by representatives of the Harris Corporation, included test frequencies up to a maximum of 5 kHz. The results of this tune up procedure deemed the use of this built in correction circuitry unnecessary for this application. In addition, it is extremely unlikely that any program material would exhibit the high frequency single channel information demonstrated in this test. It should also be noted that the signal appearing at 760 kHz on the 8 kHz spectrum photographs is that of WJR Radio, Detroit.

There were no indications of any significant increases in the stereo mode of the received carrier or fundamental sideband levels as referenced to the monaural transmissions.

TEST #2

CHANNEL SEPARATION AS AFFECTED BY DIRECTIONAL ANTENNA SYSTEMS

OBJECTIVE

To determine the effects on transmitted stereo channel separation as it is affected by different directional antenna systems.

PROCEDURES

CKLW has just recently completed the installation of a new 50 ohm directional antenna feeder system, designed specifically for AM Stereo in terms of maximum bandwidth and minimum sideband phase shift. The old system, an open wire, high "Q" 230 ohm system has been maintained specifically for purposes of conducting these comparative tests. Separation tests were conducted comparing the new antenna feeder system to the old feeder system. The tests were conducted in the following manner: Sine wave tones were introduced into the stereo generator audio input terminals at a level sufficient to cause 45% modulation of the carrier, first left channel, then right channel. Additional tests were conducted at 80% single channel modulation into the 50 ohm antenna system, to determine if separation was effected at different modulation levels.

Audio levels were measured on the unmodulated channel at the CKLW studios, utilizing a Sansui Model TUX1 receiver, converted for AM Stereo by the proponent. Additional receiving tests were conducted at the same location on a Harris TRF receiver modified to provide decoding of the stereo signal. Measurements were also made at the transmitter site utilizing the proponents stereo modulation monitor fed from the output sample of the transmitter. Identical tests were conducted at the 45% modulation levels on both directional antenna systems and additionally with the antenna system operating in the non-directional mode at reduced power. The results of these tests are shown on the following pages of this section.

TEST #2

CHANNEL SEPARATION AS AFFECTED BY DIRECTIONAL ANTENNA SYSTEMS

PROPONENT: Harris Corporation DATE: July 2, 1979

MEASUREMENTS MADE FROM PROPONENTS MODULATION MONITOR AT TRANSMITTER SITE

Modulation: 45% neg. 45% pos. (Single Channel)

SEPARATION

WIDEBAND 50 ohm ANTENNA SYSTEM

	Left Modulated Right Measured		Right Modulated Left Measured	
FREQUENCY	LEFT (Ref)	RIGHT	RIGHT (Ref)	LEFT
50 Hz.	0	0	0	0
100 Hz.	+.3	+.3	+.5	+.5
400 Hz.	+6.6	-23.4	+6	-19.6
1,000 Hz.	+6.5	-24	+6.3	-23
2,500 Hz.	+6.5	-21.4	+6	-20
5,000 Hz.	+6.4	-24.6	+5.5	-15.4
7,500 Hz.	+6.4	-24.6	+5.4	-10.3
10,000 Hz.	+6.4	-15	+6	-5

NARROW BAND 230 ohm ANTENNA SYSTEM

FREQUENCY	LEFT (Ref)	RIGHT	RIGHT (Ref)	LEFT
50 Hz.	0	0	0	0
100 Hz.	+.4	+.4	+.6	+.6
400 Hz.	+7	-27	+6.5	-22.8
1,000 Hz.	+7	-28.5	+6.7	-22.6
2,500 Hz.	+7	-22.8	+6.8	-17
5,000 Hz.	+6.2	-18.5	+5.2	-11.8
7,500 Hz.	+6	-15.4	+6	-6
10,000 Hz.	+4.5	-12.6	+7	-2

Measurements are indicated in relative db.

TEST #2

CHANNEL SEPARATION AS AFFECTED BY DIRECTIONAL ANTENNA SYSTEMS

PROPONENT: Harris Corporation DATE: July 2, 1979

MEASUREMENTS MADE FROM PROPONENTS MODULATION MONITOR AT TRANSMITTER SITE

Modulation: 45% neg. 45% pos. (Single Channel)

SEPARATION

NON-DIRECTIONAL

	Left Modulated Right Measured		Right Modulated Left Measured	
FREQUENCY	LEFT (Ref)	RIGHT	RIGHT (Ref)	LEFT
50 Hz.	0	0	0	0
100 Hz.	+.2	+.2	+.5	+.5
400 Hz.	+6.8	-18.5	+7.2	-21.5
1,000 Hz.	+6.8	-18.5	+7.2	-23.8
2,500 Hz.	+6.8	-19	+7.2	-21.2
5,000 Hz.	+6.5	-21.6	+5.5	-16.8
7,500 Hz.	+6.5	-18.4	+5.5	-10.5
10,000 Hz.	+6.4	-16.2	+6	-5.2

Measurements are indicated in relative db.

TEST #2

CHANNEL SEPARATION AS AFFECTED BY DIRECTIONAL ANTENNA SYSTEMS

PROPONENT: Harris Corporation DATE: July 2, 1979

MEASUREMENTS MADE FROM PROPONENTS MODULATION MONITOR AT TRANSMITTER SITE

Modulation: 80% neg. 80% pos. (Single Channel)

SEPARATION

WIDEBAND 50 ohm ANTENNA SYSTEM

	Left Modulated Right Measured		Right Modulated Left Measured	
FREQUENCY	LEFT (Ref)	RIGHT	RIGHT (Ref)	LEFT
400 Hz.	+13	-17.4	+11	-10.7
1,000 Hz.	+12.5	-19.5	+11.6	-10
2,500 Hz.	+13.5	-18	+11.6	-8.5
5,000 Hz.	+13.7	-15.5	+10.8	-5.6
7,500 Hz.	+12.5	-10.4	+10.8	-1.8

Measurements are indicated in relative db.

TEST #2

CHANNEL SEPARATION AS AFFECTED BY DIRECTIONAL ANTENNA SYSTEMS

PROPONENT: Harris Corporation DATE: July 1, 1979

Azimuth: 358°

Distance from Transmitter: 32 Km. Carrier Field Intensity: 165 mv/m

Receiver Type: Sansui Model TUX1 Modulation: 45% neg. 45% pos. Single Channel)

SEPARATION

WIDE BAND 50 ohm ANTENNA SYSTEM

	Left Modulated Right Measured		Right Modulated Left Measured	
FREQUENCY	LEFT (Ref)	RIGHT	RIGHT (Ref)	LEFT
50 Hz.	0	0	0	0
100 Hz.	0	0	0	-.5
400 Hz.	0	-20	0	-21
1,000 Hz.	0	-21	0	-26
2,500 Hz.	0	-24	0	-20
5,000 Hz.	0	-21	0	-12
7,500 Hz.	0	-10	0	-6
10,000 Hz.	*	*	*	*

NARROW BAND 230 ohm ANTENNA SYSTEM

FREQUENCY	LEFT (Ref)	RIGHT	RIGHT (Ref)	LEFT
50 Hz.	0	0	0	0
100 Hz.	0	0	0	0
400 Hz.	0	-21	0	-23
1,000 Hz.	0	-25	0	-27
2,500 Hz.	0	-26	0	-19
5,000 Hz.	0	-16	0	-11
7,500 Hz.	0	-8	0	-6
10,000 Hz.	*	*	*	*

* 10 kHz notch filter built into receiver circuitry.

Measurements are indicated in relative db.

TEST #2

CHANNEL SEPARATION AS AFFECTED BY DIRECTIONAL ANTENNA SYSTEMS

PROPONENT: Harris Corporation DATE: July 1, 1979

Azimuth: 358° Distance from Transmitter: 32 km.

Receiver Type: Sansui Model TUX1 Modulation: 45% neg. 45% pos. (Single Channel)

SEPARATION

NON-DIRECTIONAL

	Left Modulated Right Measured		Right Modulated Left Measured	
FREQUENCY	LEFT (Ref)	RIGHT	RIGHT (Ref)	LEFT
50 Hz.	0	0	0	0
100 Hz.	0	0	0	0
400 Hz.	0	-22	0	-21
1,000 Hz.	0	-25	0	-23
2,500 Hz.	0	-24	0	-27
5,000 Hz.	0	-14	0	-16
7,500 Hz.	0	-8	0	-7
10,000 Hz.	*	*	*	*

* 10 kHz notch filter built into receiver circuitry.

Measurements are indicated in relative db.

TEST #2

CHANNEL SEPARATION AS AFFECTED BY DIRECTIONAL ANTENNA SYSTEMS

PROPONENT: Harris Corporation　　　　DATE: July 1, 1979

Azimuth: 358°

Distance from Transmitter: 32 km.　　　　Carrier Field Intensity: 165 mv/m

Receiver Type: Sansui Model TUX1　Modulation: 80% neg. 80% pos. (Single Channel)

SEPARATION

WIDEBAND 50 ohm ANTENNA SYSTEM

	Left Modulated Right Measured		Right Modulated Left Measured	
FREQUENCY	LEFT (Ref)	RIGHT	RIGHT (Ref)	LEFT
50 Hz.	0	0	0	0
100 Hz.	0	0	0	0
400 Hz.	0	-15	0	-15
1,000 Hz.	0	-23	0	-18
2,500 Hz.	0	-22	0	-22
5,000 Hz.	0	-14	0	-10
7,500 Hz.	0	-10	0	-1
10,000 Hz.	*	*	*	*

* 10 kHz. notch filter built into receiver circuitry.

Measurements are indicated in relative db.

TEST #2

CHANNEL SEPARATION AS AFFECTED BY DIRECTIONAL ANTENNA SYSTEMS

PROPONENT: Harris Corporation DATE: July 1, 1979

Azimuth: 358°

Distance from Transmitter: 32 km. Carrier Field Intensity: 165 mv/m

Receiver Type: Harris TRF Modulation: 45% neg. 45% pos. (Single Channel)

SEPARATION

WIDEBAND 50 ohm ANTENNA SYSTEM

	Left Modulated Right Measured		Right Modulated Left Measured	
FREQUENCY	LEFT (ref)	RIGHT	RIGHT (Ref)	LEFT
50 Hz.	0	0	0	0
100 Hz.	0	-1.5	0	0
400 Hz.	0	-25	0	-16
1,000 Hz.	0	-18	0	-17
2,500 Hz.	0	-24	0	-22
5,000 Hz.	0	-25	0	-22
7,500 Hz.	0	-24	0	-18
10,000 Hz.	*	0	0	-2

NARROW BAND 230 ohm ANTENNA SYSTEM

FREQUENCY	LEFT (ref)	RIGHT	RIGHT (Ref)	LEFT
50 Hz.	0	0	0	0
100 Hz.	0	-1.5	0	0
400 Hz.	0	-21	0	-15
1,000 Hz.	0	-20	0	-19
2,500 Hz.	0	-21	0	-19
5,000 Hz.	0	-20	0	-18
7,500 Hz.	0	-21	0	-14
10,000 Hz.	*	*	*	*

* 10 kHz. notch filter built into receiver circuitry.

Measurements are indicated in relative db.

TEST #2

CHANNEL SEPARATION AS AFFECTED BY DIRECTIONAL ANTENNA SYSTEMS

PROPONENT: Harris Corporation DATE: July 1, 1979

Azimuth: 358°

Distance from Transmitter: 32 km. Carrier Field Intensity: 165 mv/m

Receiver Type: Harris TRF Modulation: 80% neg. 80% pos. (Single Channel)

SEPARATION

WIDEBAND 50 ohm ANTENNA SYSTEM

	Left Modulated Right Measured		Right Modulated Left Measured	
FREQUENCY	LEFT (Ref)	RIGHT	RIGHT (Ref)	LEFT
50 Hz.	0	0	0	0
100 Hz.	0	0	0	0
400 Hz.	0	-22	0	-12
1,000 Hz.	0	-21	0	-14
2,500 Hz.	0	-23	0	-15
5,000 Hz.	0	-26	0	-17
7,500 Hz.	0	-22	0	-16
10,000 Hz.	*	*	*	*

* 10 kHz. notch filter built into receiver circuitry.

Measurements are indicated in relative db.

TEST #2

CONCLUSION

The test results indicate that separation resulting from the Harris AM Stereo System does not seem to be critically affected by directional antenna characteristics. Although some slight variations are evident between antenna systems, it is doubtful that the stereo signal generated by the Harris system would be degraded substantially beyond the resultant high frequency attenuation and distortion characteristics experienced in monaural transmissions where a sharply band limited antenna system is used.

It should be noted that channel separation below 200 Hz. is minimal. This phenomena exists due to the 200 Hz. fourth order double Butterworth high-pass filters used to remove the L - R signal components below 200 Hz. This is required to isolate the stereo pilot signal from interference from stereophonic audio signals. Tests, however, indicate that frequencies below 200 Hz. cannot be easily perceived in terms of directionality and most record companies mix little or no separation into their product at these lower audio frequencies.

TEST #3

ADJACENT CHANNEL INTERFERENCE

OBJECTIVE

To determine the effect of interference to first adjacent channel stations, stereo vs. monaural.

PROCEDURE

This test was conducted utilizing the monaural transmissions of WPIC, 790 kHz, Sharron, Pennsylvania, in conjunction with CKLW, 800 kHz, transmitting in both the monaural and stereo modes.

A point was located near Cleveland, Ohio, where the CKLW ground wave signal interferes significantly with the WPIC ground wave signal. At this point, the measured field intensity of CKLW was 2.2 mv/m and the WPIC measured field strength was 300 uv/m. Subjective listening tests were made at this location on a standard AM automobile radio and additionally on a RCA Model WX-2D Field Intensity Meter. Both receivers were tuned to 790 kHz. and the CKLW transmitter, modulated with normal stereo and monaural programming material was alternately switched between the monaural mode and the stereo mode every thirty seconds, for a period of one-half hour.

Tape recordings of the WPIC signal were made during this half hour test period and have been submitted to the Canadian Department of Communications, and the Federal Communications Commission.

CONCLUSION

The subjective listening tests substantiated with tape recordings, indicate that the Harris AM Stereo System does not create any audible increased interference to first adjacent channel stations.

TEST #4

DISTORTION IN MONOPHONIC RECEIVERS

OBJECTIVE

To determine the effect of AM Stereo transmissions on harmonic distortion characteristics of band limited monophonic receivers.

PROCEDURES

These tests were conducted utilizing three standard middle grade AM receivers. The CKLW transmitter was modulated to a level of 80% in the monaural mode with a 3 kHz sine wave. Each of the three receivers located at the CKLW studios were then carefully tuned for minimum harmonic distortion at the 3 kHz audio signal by adjusting the receivers front panel tuning controls. No further adjustments were made to the receivers during these tests. The transmitter was then modulated to a level of 80% in the monaural mode, with a series of sine wave tones between 50 Hz. and 7.5 kHz. Reference levels, noise levels and harmonic distortion measurements were then recorded from the audio output terminals of each receiver using the transmitted tones as an audio signal.

The transmitter was then switched to the stereo mode and modulated to 80% with the same series of sine wave tones used in the monaural test. The left channel audio was phase shifted 90^{o} with reference to the right channel, in order to provide a phase modulated signal at the detector of the standard AM receivers. Measurements were then taken in the same manner as in the monaural mode. All received measurements were read from a Hewlett Packard Model 334 Distortion Analyzer, and appear in the following pages of this section.

TEST #4

DISTORTION IN MONOPHONIC RECEIVERS

PROPONENT: Harris Corporation DATE: July 1, 1979

Azimuth: 358°

Distance from Transmitter: 32 km. Carrier Field Intensity: 165 mv/m

Receiver Type: #1 Audiovox Series #AX

MONOPHONIC

Modulation: 80% neg. 80% pos.

FREQUENCY	REFERENCE LEVEL	RESIDUAL NOISE	HARMONIC DISTORTION
50 Hz.	+1.0	-35	17%
100 Hz.	+9.0	-35	7.2%
400 Hz.	+3.0	-35	5.3%
1,000 Hz.	0	-35	4%
2,500 Hz.	-5.0	-35	2.7%
5,000 Hz.	-19.0	-35	15%

STEREO

(Left Channel Audio Phase Shifted 90° with Ref. to Right)

Total Modulation: 80% neg. 80% pos.

50 Hz.	+1.0	-35	17%
100 Hz.	+8.5	-35	7.4%
400 Hz.	+2.5	-35	3.4%
1,000 Hz.	0	-35	3.0%
2,500 Hz.	-4.0	-35	4.4%
5,000 Hz.	-17	-35	14%

TEST #4

DISTORTION IN MONOPHONIC RECEIVERS

PROPONENT: Harris Corporation DATE: July 1, 1979

Azimuth: 358°

Distance from Transmitter: 32 km. Carrier Field Intensity: 165 mv/m

Receiver Type: #2 Wintronics Model OEM-30

MONOPHONIC

Modulation: 80% neg. 80% pos.

FREQUENCY	REFERENCE LEVEL	RESIDUAL NOISE	HARMONIC DISTORTION
50 Hz.	+10	-36	16%
100 Hz.	+11	-36	4.6%
400 Hz.	+5	-36	2%
1,000 Hz.	0	-36	5%
2,500 Hz.	-4	-36	10%
5,000 Hz.	-11	-36	9%

STEREO

(Left Channel Audio Phase Shifted 90° with Ref. to Right)

Total Modulation: 80% neg. 80% pos.

50 Hz.	+11	-32	17%
100 Hz.	+12	-32	4.5%
400 Hz.	+5	-33	2.6%
1,000 Hz.	0	-33	4.4%
2,500 Hz.	-5	-34	9%
5,000 Hz.	-13	-34	12%

TEST #4

DISTORTION IN MONOPHONIC RECEIVERS

PROPONENT: Harris Corporation   DATE: July 1, 1979

Azimuth: 358°

Distance from Transmitter: 32 km.   Carrier Field Intensity: 165 mv/m

Receiver Type: #3 Bogen RP 150 BM

MONOPHONIC

Modulation: 80% neg. 80% pos.

FREQUENCY	REFERENCE LEVEL	RESIDUAL NOISE	HARMONIC DISTORTION
50 Hz	+2	-30	6.6%
100 Hz	+2	-30	4.2%
400 Hz	+1	-30	3.4%
1,000 Hz	0	-29	4%
2,500 Hz	-4	-29	6.2%
5,000 Hz	-11	-30	12.5%
7,500 Hz	-19	-29	10%

STEREO

(Left Channel Audio Phase Shifted 90° with Ref. to Right)

Total Modulation: 80% neg. 80% pos.

50 Hz	+2	-30	7.3%
100 Hz	+2	-30	4.4%
400 Hz	+1	-30	5.7%
1,000 Hz	0	-29	6.6%
2,500 Hz	-3	-29	9%
5,000 Hz	-9	-29	11.5%
7,500 Hz	-17	-30	8%

TEST #4

CONCLUSION

The test data collected indicates that the Harris AM Stereo System does not generate a substantial increase in harmonic distortion when detected by a conventional monaural band limited AM receiver. It should be noted that in some cases, the harmonic distortion is actually lower when receiving stereo transmissions as compared to the monaural signals. It is believed that this phenomena occurs due to partial phase cancellation of certain distortion components created by non-linearities in the receiver's envelope detector. It should also be noted that the received signal to noise ratio, stereo to mono, is not substantially affected on a conventional monaural receiver employing envelope detection.

TEST #5

SKYWAVE EFFECTS

OBJECTIVE

To determine the effects of skywave propagation on the received stereo signal as it pertains to separation characteristics.

PROCEDURES

These tests were conducted in the same manner as those outlined in test number two, using a Delco AM/FM automotive receiver, converted by the proponent to decode AM Stereo transmissions. It should be noted that because of the sharp cutoff ceramic filters employed in the manufacturer's original design of this receiver, measurements of audio frequencies above 3 kHz. could not be obtained.

Tests were conducted by technical personnel in Buffalo, New York, where a combination of ground wave and skywave signals were detected. The RF signal as read on a standard RF field intensity meter showed fluctuations between 150 uv/m and 1 mv/m. Sine wave tones were introduced into the stereo generator audio input terminals at a level sufficient to cause 45% modulation of the carrier, first left channel, then right channel. Audio levels were then measured, at the receiver location, first on the modulated channel and then on the unmodulated channel. Additional tests were conducted at 80% single channel modulation into the 50 ohm antenna system, and again at 45% single channel modulation into the 230 ohm antenna system. The receiver used to conduct these tests was then shipped to Maplewood, New Jersey, where further tests were conducted by technical personnel under conditions of absolute skywave signal. The RF signal level as read during the tests on a FIM-41 field intensity meter showed fluctuations between .45 mv/m and .50 mv/m. These tests were conducted in the same manner as those outlined above, except that only one series of tones was transmitted. These consisted of sine wave tones transmitted

TEST #5 (Cont'd)

at 45% modulation from the 50 ohm antenna system. The above tests were conducted between the hours of 12:01 AM and 2:00 AM local time, and the results are shown on the following pages of this section.

TEST #5

SKYWAVE EFFECTS ON SEPARATION

PROPONENT: Harris Corporation DATE: July 2, 1979

Location: Buffalo, New York Carrier Field Intensity: 150 uv/m - 1 mv/m

Receiver Type: Modified Delco Automotive Radio

SEPARATION

WIDEBAND 50 ohm ANTENNA SYSTEM

Modulation: 45% neg. 45% pos. (Single Channel)

	Left Modulated Right Measured		Right Modulated Left Measured	
FREQUENCY	LEFT (Ref)	RIGHT	RIGHT (Ref)	LEFT
100 Hz.	0	0	0	0
400 Hz.	0	-14	0	-19
1,000 Hz.	0	-17	0	-17
2,500 Hz.	0	-9	0	-8

Modulation: 80% neg. 80% pos. (Single Channel)

100 Hz.	0	0	0	0
400 Hz.	0	-16	0	-11
1,000 Hz.	0	-10	0	-16
2,500 Hz.	0	-5	0	-4

NARROW BAND 230 ohm ANTENNA SYSTEM

Modulation: 45% neg. 45% pos. (Single Channel)

100 Hz.	0	-1	0	0
400 Hz.	0	-11	0	-7
1,000 Hz.	0	-16	0	-13
2,500 Hz.	0	-11	0	-15

TEST #5

SKYWAVE EFFECTS ON SEPARATION

PROPONENT: Harris Corporation DATE: July 3, 1979

Location: Maplewood, New Jersey Carrier Field Intensity: .45 - .50 mv/m

Receiver Type: Modified Delco Automotive Radio

SEPARATION

WIDEBAND 50 ohm ANTENNA SYSTEM

Modulation: 45% neg. 45% pos. (Single Channel)

	Left Modulated Right Measured		Right Modulated Left Measured	
FREQUENCY	LEFT (Ref)	RIGHT	RIGHT (Ref)	LEFT
100 Hz.	0	0	0	0
400 Hz.	0	-11	0	-14
1,000 Hz.	0	-9	0	-12
2,500 Hz.	0	-7	0	-7

TEST #5

CONCLUSION

It is obvious from the test data obtained, that the Harris AM Stereo System does provide a reasonable stereo signal in areas where skywave and ground wave are evident, as well as areas served by skywave alone. It should be pointed out that accurate separation measurements were difficult to achieve in both test locations, due to signal fading and noise conditions. However, during normal programming in stereo, both locations reported an excellent stereo signal during those periods when the signal strength was sufficient to override the interference levels.

TEST #6

COMPATIBILITY

OBJECTIVE

To determine the compatibility of normal AM Stereo program transmissions to standard monaural receivers, and to determine the occupied bandwidth of the stereo transmissions under conditions of normal programming, without the implementation of band-limiting audio filters.

PROCEDURES AND COMMENTS

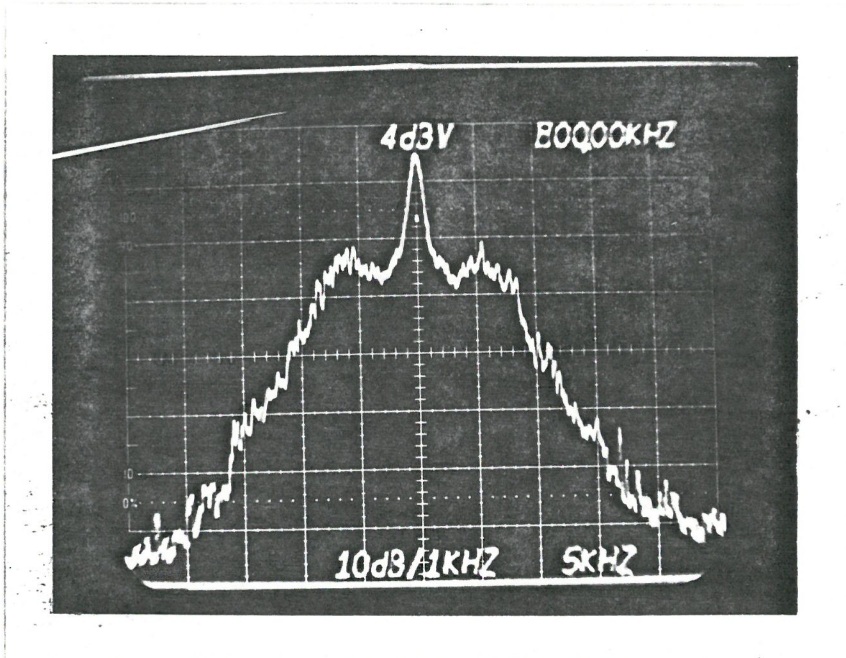
CKLW transmitted normal programming in the stereo mode for a period of seven days, using all stereo music sources, while the remainder of the transmitted audio sources originated in monaural. Listeners and employees of CKLW were asked to submit their comments regarding the quality of reception on their standard monaural receivers. All of the legitimate comments received indicated that the CKLW stereo transmissions sounded as good if not better than normal monaural transmissions. As mentioned in test number four, there is some indication that partial phase cancellation by the stereo signal of certain distortion components, generated in the envelope detector of some mono radios, can actually be reduced by this type of stereo generation. The audio processing equipment used during these programming tests was identical to that used by CKLW under normal monaural programming, but was duplicated for left and right audio channels and interconnected for stereo operation where applicable. The only exception being that the Harris Peak Limiter normally used in monaural operation was replaced with a Harris prototype MSP90 AM Stereo Peak Limiter and Standard MSP90 Stereo AGC. The MSP90 AGC amplifiers were disabled because the CKLW audio processing equipment made them unnecessary.

During normal stereo programming, spectral photographs of several musical selections were taken from the transmitter output sample on a Techtronics

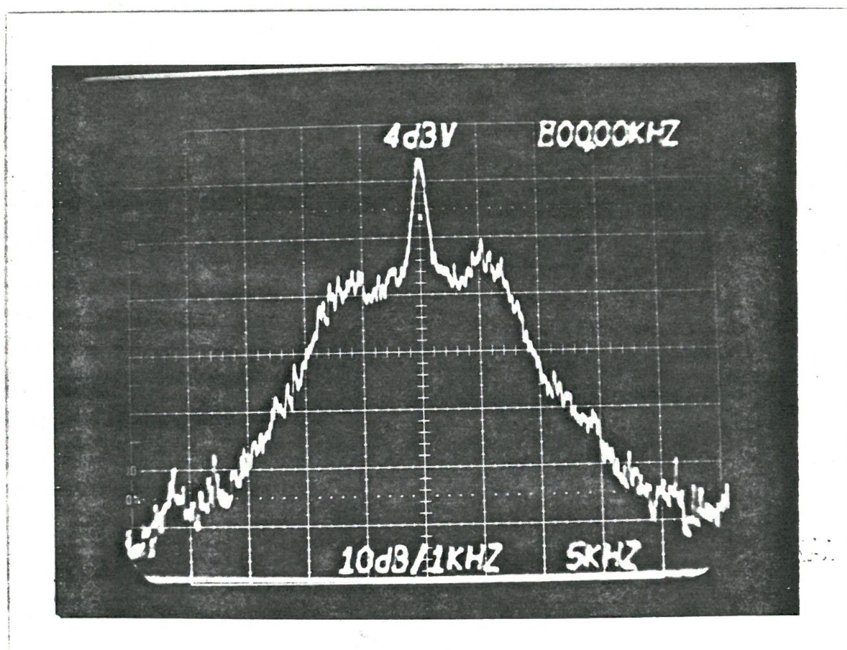
TEST #6 (Cont'd)

7L5 Spectrum Analyzer. For comparative purposes, these same musical selections were then photographed under identical conditions, except that the transmitter was switched to the monaural mode. The spectrum analyzer was adjusted to record and store peak information of the transmitted audio in the maximum hold mode. The photographs appearing on the following three pages are of the entire musical selection, first in the monaural mode, and then in the stereo mode. These photographs indicate that there is no substantial increase in the occupied bandwidth of the signal under normal programming in the stereo mode. In addition, it should be emphasized that no high frequency audio filtering was used or required in either mode of operation. In fact, CKLW normally employes a slight amount of high frequency pre-emphasis during normal programming. This pre-emphasis was not disabled or altered for any portion of the programming tests.

TEST #6

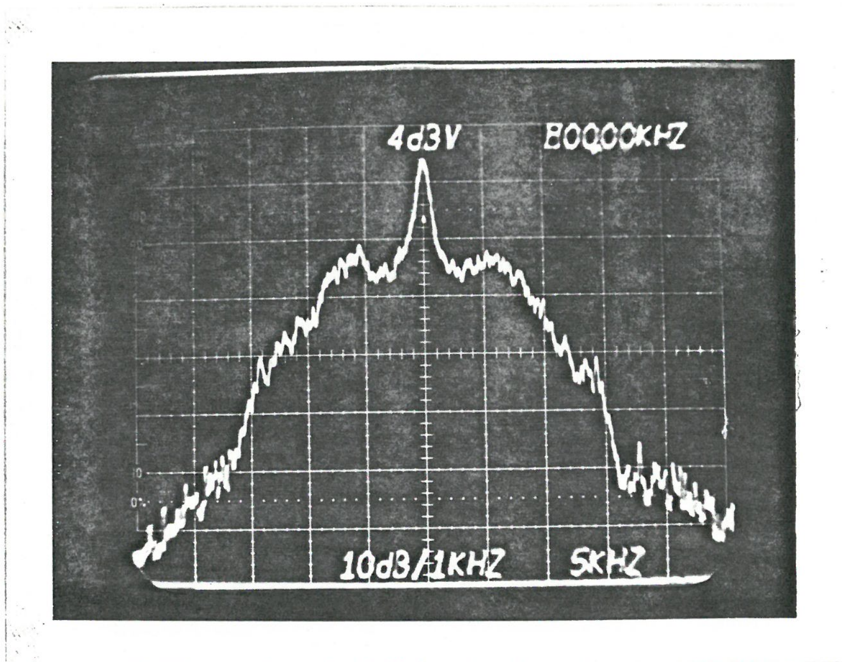


Musical Selection #1 - Mono

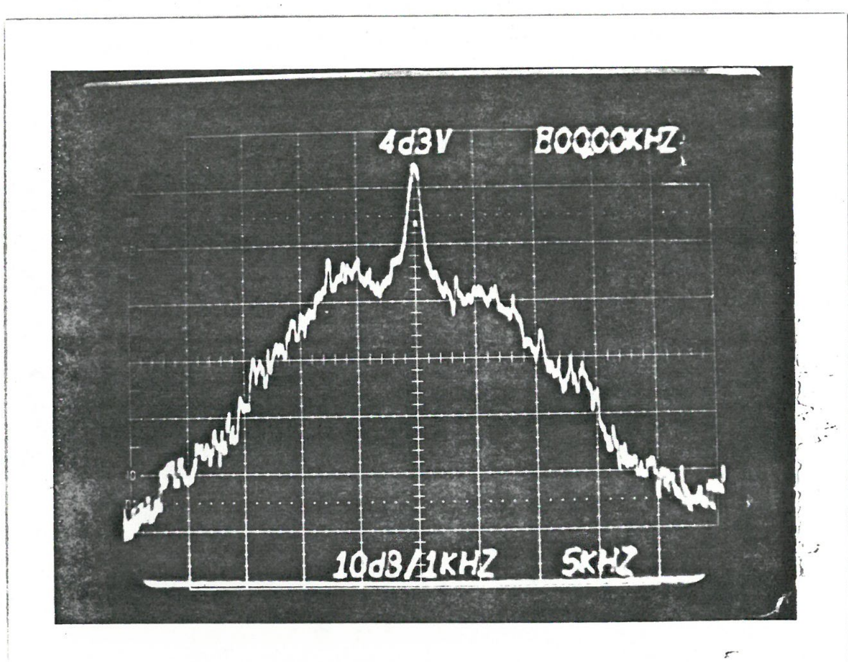


Musical Selection #1 - Stereo

Fig. 8

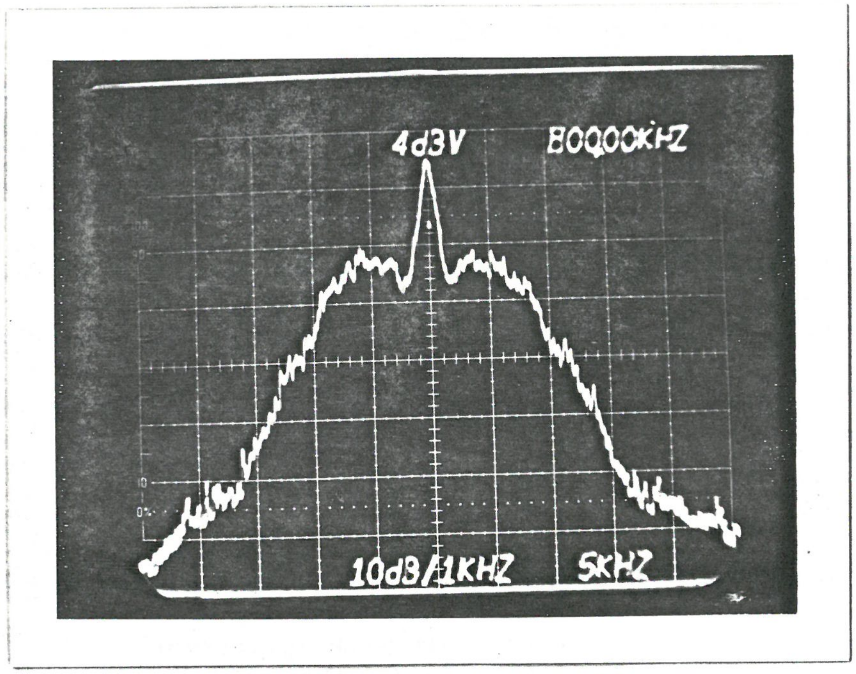


Musical Selection #2 - Mono

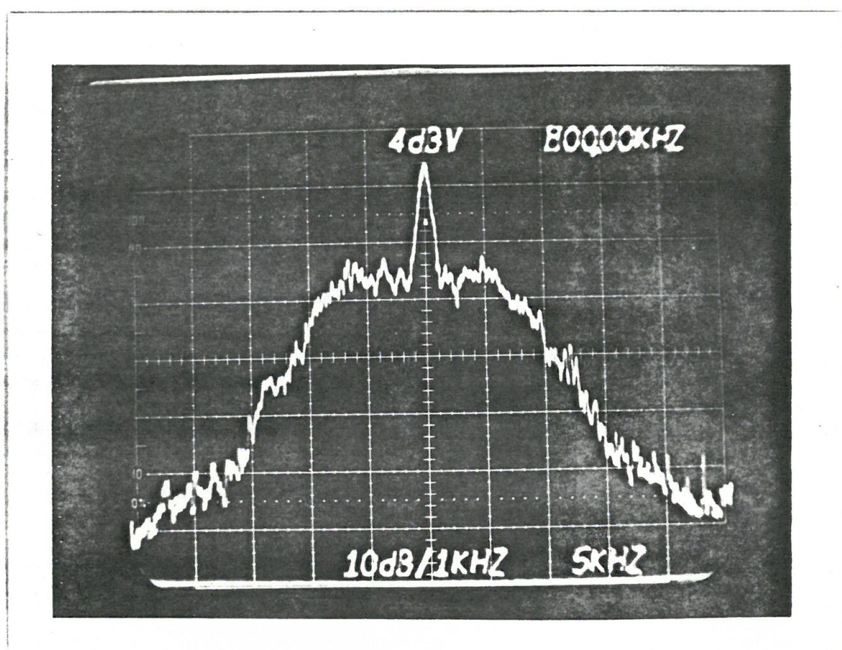


Musical Selection #2 - Stereo

Fig. 9



Musical Selection #3 - Mono



Musical Selection #3 - Stereo

Fig. 10

TEST #7

FREQUENCY RESPONSE AND DISTORTION

OBJECTIVE

To determine the frequency response departure from 1,000 Hz reference, in a band of frequencies from 50 Hz to 10 kHz and to determine the total harmonic and intermodulation distortion of the transmitted signal.

PROCEDURES

Sine wave audio was introduced into the left channel of the stereo generator at the appropriate levels required to produce 25%, 50% and 80% modulation, as indicated on the proponents stereo modulation monitor. The output level of the audio generator was held constant at each level of modulation, and the variances in amplitude were recorded from the proponents stereo modulation monitor. The modulation monitor was directly fed from the transmitter output sample. Harmonic and intermodulation distortion measurements were observed on a Potomac Instruments Model AA-51 Distortion Analyzer, connected to the audio output terminals of the modulation monitor. In addition, frequency response and harmonic distortion measurements were also observed at the CKLW studios from a Sansui Model TUX1 receiver, modified for AM Stereo by the proponent. Measurements were made in the same manner as previously described and were recorded from a Hewlett Packard Model 334 Distortion Analyzer. The results of these tests appear on the following pages of this section.

TEST #7

AUDIO FREQUENCY RESPONSE AND DISTORTION

PROPONENT: Harris Corporation DATE: July 3, 1979

MEASUREMENTS MADE FROM PROPONENTS MODULATION MONITOR AT TRANSMITTER SITE

25% MODULATION - LEFT CHANNEL ONLY

FREQUENCY	LEVEL (Modulated Channel)	HARMONIC DISTORTION
50 Hz.	+6.5	2.15%
100 Hz.	+6.2	2.1%
400 Hz.	+10	1.4%
1,000 Hz. (Ref)	+10	1.5%
2,500 Hz.	+10	1.6%
5,000 Hz.	+10	1.8%
7,500 Hz.	+9.2	1.75%
10,000 Hz.	+8	2.2%

50% MODULATION - LEFT CHANNEL ONLY

50 Hz.	+12	1.1%
100 Hz.	+12	1.2%
400 Hz.	+16	1.35%
1,000 Hz. (Ref)	+16	1.25%
2,500 Hz.	+16	1.55%
5,000 Hz.	+15.8	1.58%
7,500 Hz.	+15.5	1.6%
10,000 Hz.	+14.4	2.4%

TEST #7

AUDIO FREQUENCY RESPONSE AND DISTORTION

PROPONENT: Harris Corporation DATE: July 3, 1979

MEASUREMENTS MADE FROM PROPONENTS MODULATION MONITOR AT TRANSMITTER SITE

80% MODULATION - LEFT CHANNEL ONLY*

FREQUENCY	LEVEL (Modulated Channel)	HARMONIC DISTORTION
50 Hz.	+14	1.35%
100 Hz.	+14	1.2%
400 Hz.	+20	1.95%
1,000 Hz. (Ref)	+20	1.8%
2,500 Hz.	+20	2.05%
5,000 Hz.	+20	2.35%
7,500 Hz.	+19.5	3.4%
10,000 Hz.	+18.6	4.15%

INTERMODULATION DISTORTION

80% MODULATION - LEFT CHANNEL ONLY

25% Modulation (Left Only)	3%
50% Modulation (Left Only)	5.6%
80% Modulation (Left Only)	8.2%
25% Modulation (L + R)	1.9%
50% Modulation (L + R)	2.6%
80% Modulation (L + R)	5.2%

* Low frequency correction circuit disabled to prevent overmodulation.

TEST #7

AUDIO FREQUENCY RESPONSE AND DISTORTION

PROPONENT: Harris Corporation DATE: July 2, 1979

Azimuth: 358°

Distance from Transmitter: 32 km. Carrier Field Intensity: 165 mv/m

Receiver Type: Sansui Model TUX1

25% MODULATION - LEFT CHANNEL ONLY

FREQUENCY	LEVEL (Modulated Channel)	HARMONIC DISTORTION
50 Hz.	+8.0	2.5%
100 Hz.	+8.0	2.5%
400 Hz.	+11.5	1.8%
1,000 Hz. (Ref)	+11.5	1.9%
2,500 Hz.	+11.2	1.9%
5,000 Hz.	+9	2.4%
7,500 Hz.	+5	4%
10,000 Hz.	*	*

50% MODULATION - LEFT CHANNEL ONLY

FREQUENCY	LEVEL (Modulated Channel)	HARMONIC DISTORTION
50 Hz.	+14	2%
100 Hz.	+14	1.6%
400 Hz.	+17	2.2%
1,000 Hz. (Ref)	+17	1.5%
2,500 Hz.	+16.2	1.4%
5,000 Hz.	+14.6	1.5%
7,500 Hz.	+11.3	2.3%
10,000 Hz.	*	*

* 10 kHz notch filter built into receiver circuitry.

TEST #7

AUDIO FREQUENCY RESPONSE AND DISTORTION

PROPONENT: Harris Corporation DATE: July 2, 1979

Azimuth: 358°

Distance from Transmitter: 32 km. Carrier Field Intensity: 165 mv/m

Receiver Type: Sansui Model TUX1

80% MODULATION - LEFT CHANNEL ONLY**

FREQUENCY	LEVEL (Modulated Channel)	HARMONIC DISTORTION
50 Hz.	+15.4	1.7%
100 Hz.	+15.4	3.8%
400 Hz.	+20	2.4%
1,000 Hz. (Ref)	+20.5	2.3%
2,500 Hz.	+20.2	1.8%
5,000 Hz.	+18.8	1.6%
7,500 Hz.	+15	2.3%
10,000 Hz.	*	*

* 10 kHz. notch filter built into receiver circuitry.

** Low frequency correction circuit disabled to prevent overmodulation.

TEST #7

CONCLUSION

It is noted that there is approximately a 3 to 4 db attenuation at the lower single channel modulating frequencies. As indicated in the conclusion of test number two, high pass filters are used to remove the L - R signal components below 200 Hz. This is required to protect the stereo pilot from interference from low frequency audio information. For this reason, a low frequency correction circuit has been included in the Harris AM Stereo System. This circuit permits the L - R audio information below the filter cutoff point to be rotated by 90° and added to the L + R signal. The relative amplitude of the low frequency components is therefore essentially flat with respect to the remaining band of audio frequencies and is simply divided between the left and right audio channels. The low frequency correction circuit was disabled during the tests at 80% modulation, in order to prevent overmodulation of the L + R signal. In general, the overall frequency response and distortion characteristics of the Harris AM Stereo System are well within the technical standards regarded as acceptable for good quality AM broadcasting.

TEST #8

SIGNAL TO NOISE RATIO

OBJECTIVE

To determine the effective stereo vs. monaural coverage as a function of the signal to noise ratio.

PROCEDURES

The receiving tests were conducted at the CKLW studios on a Sansui Model TUX1 receiver, modified for AM Stereo by the proponent, and employing an envelope detector and a synchronous detector switchable on the rear panel of the receiver. A General Radio Guassian Noise Generator, a W-J M1A Balanced Mixer, and a Potomac Instruments Synthesized RF Generator were used to generate a radio frequency signal consisting of white Gaussian noise. The output of the noise generating system was connected in parallel with the receiver's external antenna at the RF input of the receiver. A Ward Beck Extended Range VU Meter was then connected to the receiver output and all measurements were observed and recorded directly from the meter scale. The envelope detector was selected on the receiver panel, and both the receiver and transmitter were placed in the monaural mode. A 400 Hz tone was transmitted at 50% modulation from the CKLW transmitter, and a received reference level was obtained on the extended VU meter. The output level of the Gaussian noise generator was then increased until a signal to noise ratio of 20 db was obtained by alternately removing the modulation source from the transmitter and adjusting the output of the noise generator. Once the 20 db signal to noise ratio was achieved at the receiver output, no further adjustments were made to the transmitted modulation levels or noise levels.

TEST #8 (Cont'd)

The receiver was then switched to synchronous detection and the signal to noise ratio was measured in the monaural mode. Both transmitter and receiver were then switched to the stereo mode and additional signal to noise measurements were made on the left and right channels of the receiver output with an L + R modulating tone, and subsequently with left channel only and right channel only modulation. The results of this test appear on the following page.

TEST #8

SIGNAL TO NOISE RATIO

PROPONENT: Harris Corporation DATE: July 2, 1979

Azimuth: 358°

Carrier Field Intensity: 165 mv/m Modulating Frequency: 400 Hz.

MONAURAL TEST

Modulation: 50% neg. 50% pos.

Envelope Detector - Signal to noise ratio	20 db
Synchronous Detector - Signal to noise ratio	20 db

STEREO TEST

L + R Modulating signal - Left channel signal to noise ratio	18.5 db
L + R Modulating signal - Right channel signal to noise ratio	18.5 db
50% Modulation left channel only - Signal to noise ratio	21 db
50% Modulation right channel only - Signal to noise ratio	24 db

TEST #8

CONCLUSION

The test data indicates a 1.5 db change in the received stereo signal to noise ratio, as compared to monaural transmissions and reception. Mono and stereo coverage areas are defined as the regions where demodulated signal to noise ratios are above some acceptable limit. The Harris AM Stereo system does not diminish the coverage area or signal to noise ratio on existing monophonic receivers. Because the stereophonic signal to noise ratio was measured to be 1.5 db worse than mono, the stereo coverage area is determined to be almost as great as the mono coverage area. Stereo receivers can, or course, receive the stereo signal anywhere within this stereo coverage area. Outside of the defined stereo coverage area, stereo receivers have the option of either (a) continuing to operate in the stereo mode, with a signal to noise ratio 1 - 3 db below the acceptable limit, or, (b) switching manually or automatically to the mono mode to keep the signal to noise ratio above the acceptable limit. In summary, adding stereo to AM does not in any way reduce the mono coverage area; it simply adds a new stereo coverage area over most of the existing mono coverage area.

During the course of these tests, it was noted that synchronous detection of an AM signal provides several advantages not apparent in conventional envelope detectors. Substantial reduction of impulse noise is an important function of synchronous detection, as is the reduction of non-linear distortion components created by selective fading, where only the sidebands may be available for detection without the carrier, or in the case of combined sky wave/ground wave detection where envelope detectors tend to create an unlistenable signal. Further tests of synchronous detectors were conducted at CKLW and this data will be furnished to the Technical Advisory Committee in the near future. However, it is important that the authorities consider the advantages of synchronous detection and refrain from making any decisions which would restrict future implementation of this vastly improved method of AM signal detection.

SUMMARY

All of the tests conducted in the preceding test program have indicated that the Harris V-CPM AM stereo system is capable of producing high fidelity AM stereo without producing objectionable interference or exceeding the authorized occupied band width. It is the opinion of CKLW Radio that if future regulations were to restrict the spacing of AM allocations to 9 kHz the Harris V-CPM AM stereo system could conform appropriately to these regulations.

This company wishes to urge the authorities to strongly consider the fidelity capabilities of AM radio in their final decison regarding the matter of AM stereo. New receiver and transmission techniques have made high fidelity AM radio possible and the recent growth of FM radio has caused a substantial increase in the demands of the listening public. It is our opinion that if the authorities approve an AM stereo system requiring audio band pass limiting (filtering) to reduce objectionable interference it would certainly preclude the further growth of AM radio and would definitely not be in the public interest.