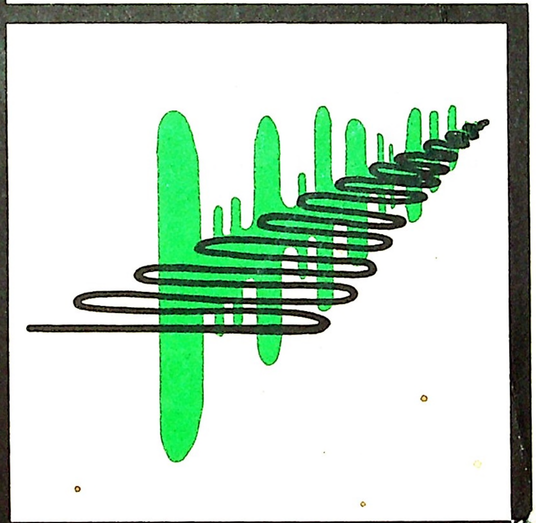
AM STEREO



The National AM Stereophonic Radio Committee

December 1977

AM Stereo

The National AM Stereophonic Radio Committee

December 19, 1977

Copies of this report, while available, may be obtained by writing:

AM Stereo Report
Electronic Industries Association
2001 Eye Street, N.W.
Washington, D.C. 20006

Payment of $20.00 must accompany the order. Checks are to be made payable to "EIA".

Summary and Conclusion

The National AM Stereophonic Radio Committee (NAMSRC) conducted tests and performed analyses of the Magnavox, Motorola and Belar systems of transmitting stereophonic sound over standard broadcast (AM) radio.

All three systems are capable of transmitting and receiving stereophonic sound with fidelity nearly comparable to FM stereo, are basically compatible with existing radio receivers and radio stations, are generally practical and economically feasible to implement for both transmitting and receiving, and do not occupy substantially more spectrum space than standard AM.

The principle differences in observed test results are a consequence of the proponent's system design philosophy.

Organization of this Report

This report is divided into two basic parts. The first section is a general discussion of AM stereo and an abbreviated description of the field tests performed by NAMSRC. There are samples included of some data from the tests.

The second section contains the appendices and includes detailed discussions of the theory and measurements in the many special areas such as audio processing and stereo receivers. The complete results of the field tests are included in the second section.

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INTRODUCTION

The National AM Stereophonic Radio Committee, (NAMSRC) was formed September 24, 1975 for the purpose of studying AM stereophonic broadcast systems in response to a growing interest by industry, broadcasters, and the Federal Communications Commission. The NAMSRC was jointly sponsored by:

The Electronic Industries Association (EIA)
The National Association of Broadcasters (NAB)
The National Radio Broadcasters Association (NRBA)
The Broadcasting, Cable and Consumer Electronies Society
  of the Institute of Electrical and Electronics
  Engineers (BCCE)

The Committee was divided into areas of special interest as follows: Panel I - System Specifications, Panel II - Transmission Systems, Panel III - Receiving Systems, and Panel IV - Field Tests. Panel IV was formed to make both quantitative and subjective tests on each of the systems, consistent with the recommendations of the other panels. See Appendix A for more information on the NAMSRC Organization.

The Committee submitted a "call for proponents" on October 3, 1975. In response to this and follow up calls, three proponents provided systems for study and test by the NAMSRC.

As a result of these requests, three systems (not the same as the original three) were ultimately studied by the panels and tested by the Field Test Panel. (A description of each of these systems follows this introduction.)

The following report is hereby being submitted to the FCC in order to provide the FCC Staff with the technical information necessary to evaluate competing systems of stereophonic broadcasting in the AM broadcast band.

The report includes: theoretical system studies, receiver and transmitter considerations, experimental data including tests of audio distortion, separation, and frequency response as well as compatibility with a range of monophonic receivers. In addition, testing focused on questions raised by observers for the FCC Broadcast Bureau, such as spectrum occupancy, and protection ratio , which compares stereo transmissions with signals in the existing monophonic service. Audio fidelity measurements were also made in stereo with existing broadcast transmitters. The report includes all the data taken in these tests as well as summary material designed to make the information more readable.

Testing was conducted at two local stations in the Washington, D.C. area, and one distant station in Charlotte, N.C. The NAMSRC field Test Site and receiving location was in Bethesda, MD, a suburb of Washington, D.C.

Financial support for these tests was supplied by the sponsoring organizations. There was a stipulation that the proponents deliver and adjust equipment representing their versions of the systems proposed. Each proponent supplied equipment, including an exciter unit, a wideband demodulator (in most cases the transmitter monitoring equipment) and a stereo receiver for the laboratory tests. For the over-the-air tests, the exciter was used at each transmitter site to generate the required stereo signal, and the stereo receiver was used at the laboratory site to demodulate the transmissions.

The Committee is grateful to the organizations and various equipment manufacturers who provided assistance for the tests, (a list of these organization appears in Appendix A.)

Thanks are due to the National Association of Broadcasters who supplied Chris Payne as Project Manager for the field tests. The Committee also expresses special appreciation to WGMS and WTOP, Washington, D.C. who supplied their facilities for the local signal tests and to WBT in Charlotte, N.C. for the use of their facilities for the sky wave tests.

Systems of Transmitting AM Stereo

The three AM Stereo systems tested by NAMSRC are in many ways similar. All systems for example, combine the audio in the left and right channels (L+R) and transmit it as amplitude modulation. All systems combine the left and right audio channels in a subtraction process (L-R) to modulate the transmitter with some form of frequency or phase modulation. These systems interface with the transmitter by identical connections to the audio input and to a low level radio frequency stage.

The systems differ basically in the form of frequency or phase modulation used. Each method also produces differences in transmitted R.F. spectrum and many other characteristics significant to the choice of modulation format.

A brief system description supplied by the proponents follows, while a more rigorous explanation appears in Appendices B, C, and D.

Magnavox AM/PM AM Stereo System Description

The Magnavox System is an AM/PM system which places L+R information on the AM channel and the L-R information on a linearly phase-modulated channel. The peak phase deviation will be 1 radian. The carrier is frequency modulated by a 5 Hz subaudible tone with a deviation of approximately ± 20Hz. This tone is for purposes of stereo identification.

Motorola C-Quam AM Stereo System Description

C-QUAM retains the significant noise performance advantages of quadrature modulation. A slight modification of the envelope modulation is made to achieve compatibility with monophonic receivers. First, a direct linearly-added quadrature modulation composite is generated with (1 + L + R) as the in-phase modulation of the carrier and (L-R)* as its quadrature modulation. This composite is then limited and again amplitude modulated by (1 + L + R). The resultant is simply an amplitude (1 + L + R) modulated carrier whose phase angle sidebands contain the stereophonic (L-R) information. Decoding the (1 + L + R) amplitude portion of the composite may be accomplished with envelope detection; the stereophonic quadrature angle modulation may be decoded by a quadrature detector whose output varies inversely with the cosine of the angle modulation.

* L-R also contains a pilot carrier of 4% 25 Hz.

Belar AM/FM AM Stereo System Description

The Belar AM stereo system is based on a modulation technique which produces an AM-FM signal. The left and right audio signals are combined in a matrix circuit to form the linear sum (L + R) and difference (L-R) products. The L-R component is pre-emphasized with a 100 usec time constant, and frequency modulates the RF input to the transmitter. The L + R component then amplitude modulates the RF carrier in the normal fashion. It can be shown that, with proper receiver design, the AM and FM components can be independently demodulated and decoded to yield high quality sterephonic signals. The composite modulation of the transmitted signal is compatible with existing monophonic receivers, and the occupied spectrum conforms to present FCC regulations.

Bandwidth of AM Sterephonic Transmissions

Because the standard broadcast band has been operating with established engineering standards for many years, and practical system for transmitting AM stereo should not require any change in these standards. This is especially true of the allocations standards relating to channel spacing, interference limits, power, and modulation. Also an AM stereo system should be compatible with existing AM radios and with existing transmitting equipment. Thus the bandwidth occupied by the stereophonic transmissions is of primary importance.

Occupied Bandwith Field Tests

The objective of this series of tests is to indicate what the effective bandwidth of stereo program transmissions would be. In addition, the interference potential was studied by observing noise received by a middle grade radio to co-channel, first, second and third adjacent channels with stereo and standard AM transmissions.

A modulating signal was chosen which was believed to approximate the spectral distribution of programming and which would be readily measurable and repeatable. The signal consisted of four tones each modulating at the following percentages: 400 Hz. @ 35%, 2500 Hz. @ 25%, 5500 Hz. @ 15%, and 9500 Hz. @ 10% modulation. The frequencies were chosen to be asynchronous so that they would cyclically add to 85% peak modulation and be symmetrical in terms of positive and negative modulation. The decending amplitude of the tones is believed to represent the modulation conditions occuring in the audio spectrum of program material. It is the power in the side-bands that is best correlated to destructive interference.

It should be noted that under Section 73.40(a) (12) of the FCC Rules an AM station may occupy up to plus and minus 15 kHz. with full sideband power thus permitting an AM station to fully modulate with audio signals out to 15 kHz. From 15 kHz. to 30 kHz. the emissions must be at least 25 dB below the unmodulated carrier, and from 30 kHz. to 75 kHz. attenuated at least 35 dB.

The four tone signal was used to modulate each proponent's stereo encoder as follows:

Left + Right @ 85% standard AM
Left - Right (as above with one phase reversed)
Left only @ 42. 5% AM
Right only @ 42. 5% AM

In addition, a modulating signal of 1000 Hz with a phase difference between left and right of 90 degrees resulting in approximately 60% amplitude modulation was employed to observe systems under quadrature audio conditions.

The transmitted spectra under the above modulation conditions were recorded using a spectrum analyzer and an X-Y recorder. Figure 1 shows the AM spectrum of a laboratory type signal generator and Figs. 2,3 and 4 show the Magnavox, Motorola and Belar systems each under left only condition: As can be observed from the spectrum plots, no system under and of the tested modulating conditions approaches the FCC limit on channel occupancy.

A further test was made to stress the bandwidth requirements. This consisted of a single 8 kHz. tone modulating the stereo transmitters at 85% left minus right which is all PM or FM and no AM. The spectrum charts are shown in Figs. 5,6 and 7 for Magnavox, Motorola and Belar respectively. As can be observed, under such a modulating condition, all systems are either slightly above or below the FCC specification at plus and minus 16 kHz. Any single continuous tone higher than 7.5 kHz and 85% L-R modulation would place a set of sidebands slightly above or below the FCC limit depending on the system.

Although this characteristic may place limitations of tone measurements performed on the air, it is believed that the 4 tone spectrum is more representative of the actual spectrum to be occupied by AM stereo stations. In order to place a sideband near the FCC limit, the program material must have an extreme concentration of high frequency energy only, such as a pure sine wave tone. If there were any other frequencies present, the depth of modulation available for the high frequency information would be

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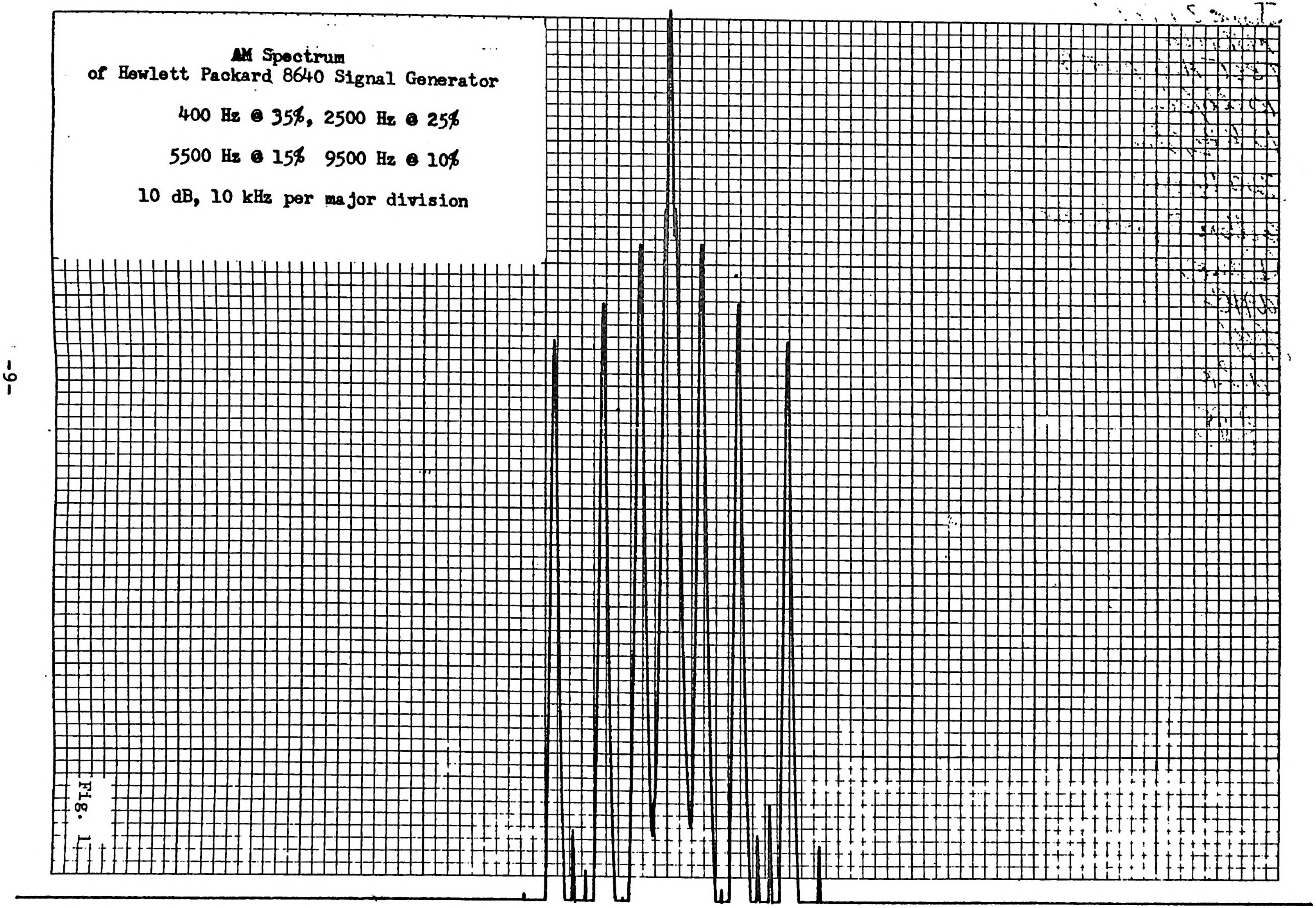


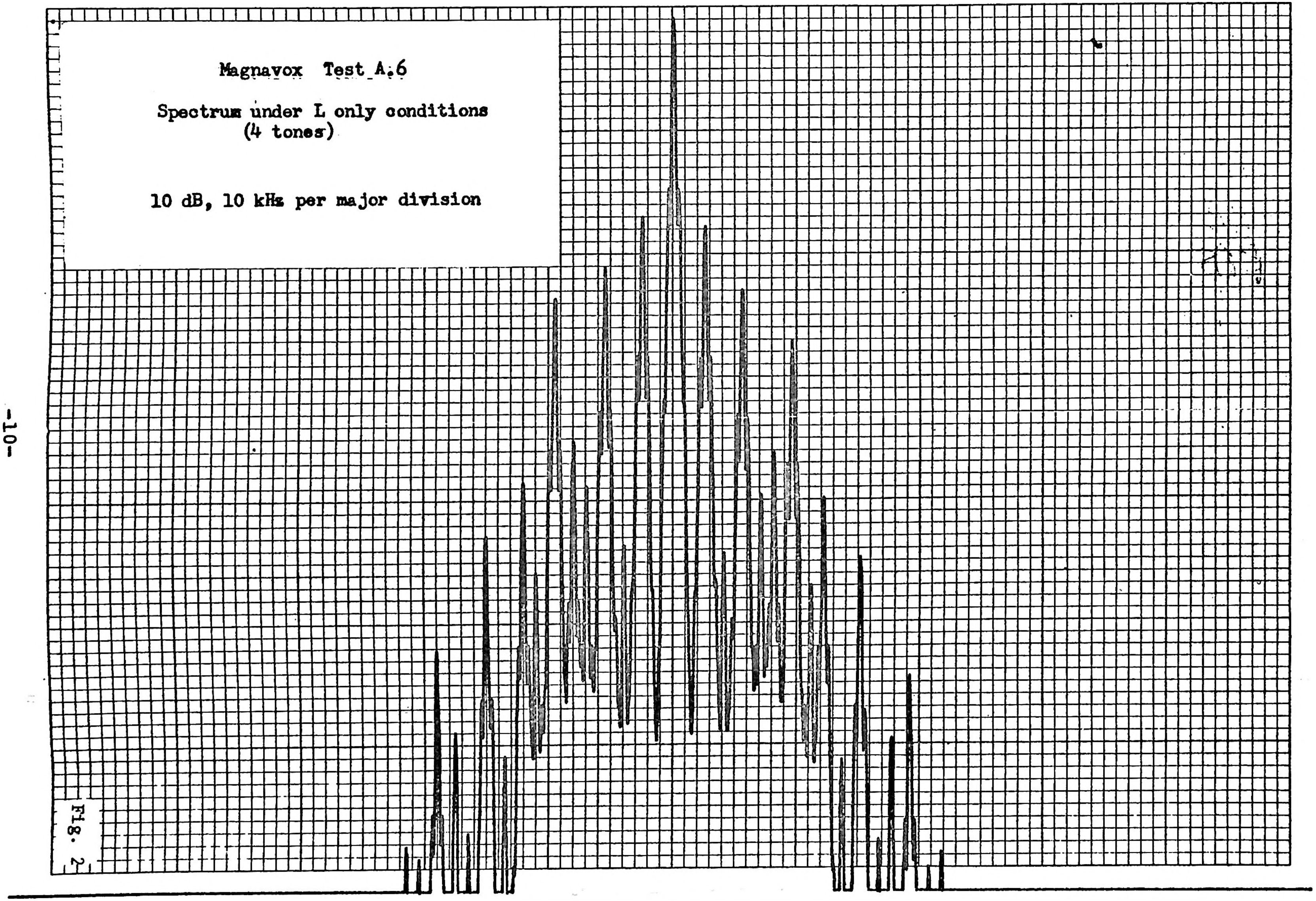
AM Spectrum
of Hewlett Packard 8640 Signal Generator

400 Hz @ 35%, 2500 Hz @ 25%

5500 Hz @ 15% 9500 Hz @ 10%

10 dB, 10 kHz per major division

Fig. 1

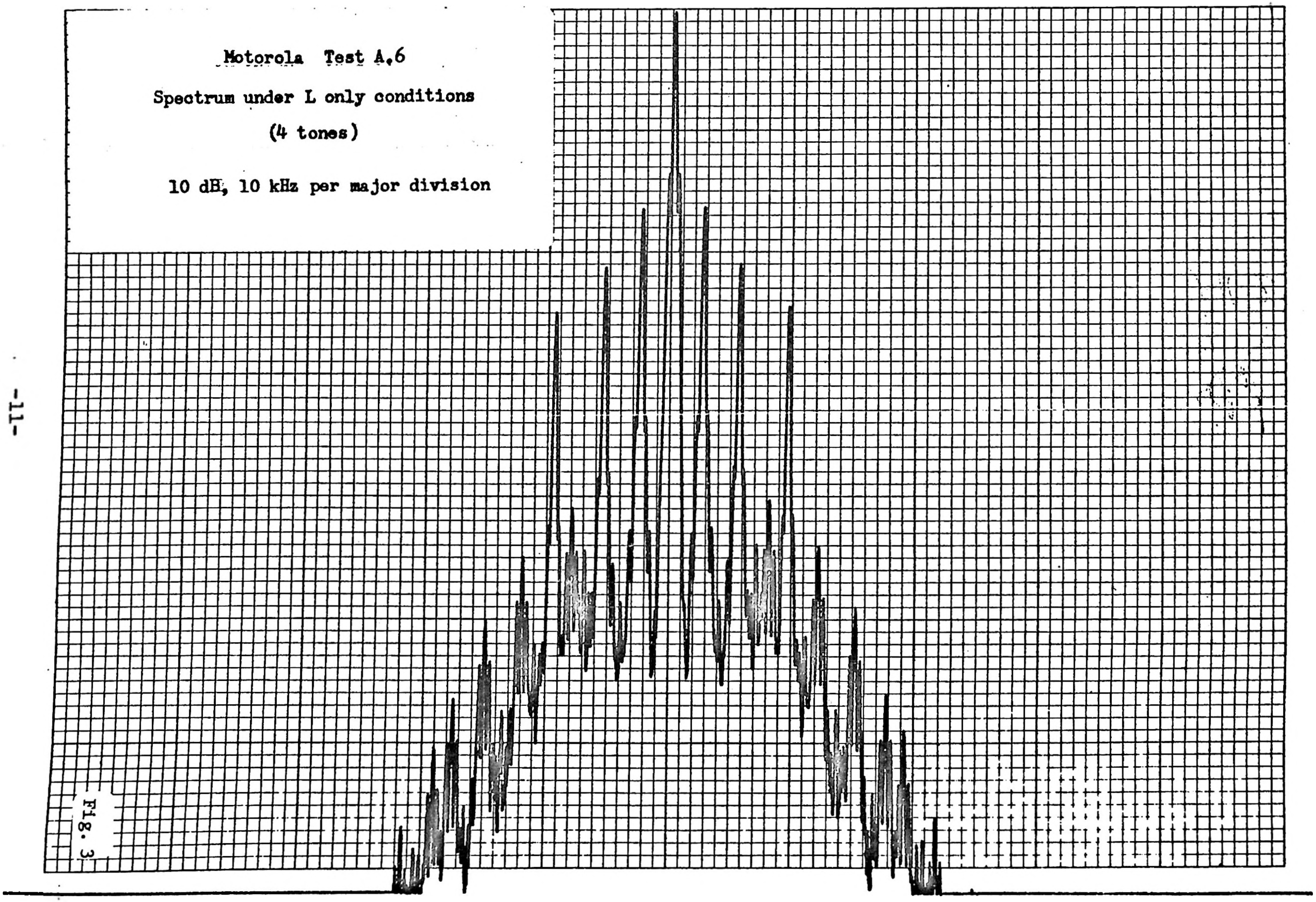


Magnavox Test A.6

Spectrum under L only conditions
(4 tones)

10 dB, 10 kHz per major division

Fig. 2



Motorola Test A.6

Spectrum under L only conditions

(4 tones)

10 dB, 10 kHz per major division

Fig. 3

Belar Test A.6

Spectrum under L only conditions

(4 tones)

10 dB, 10 kHz per major division

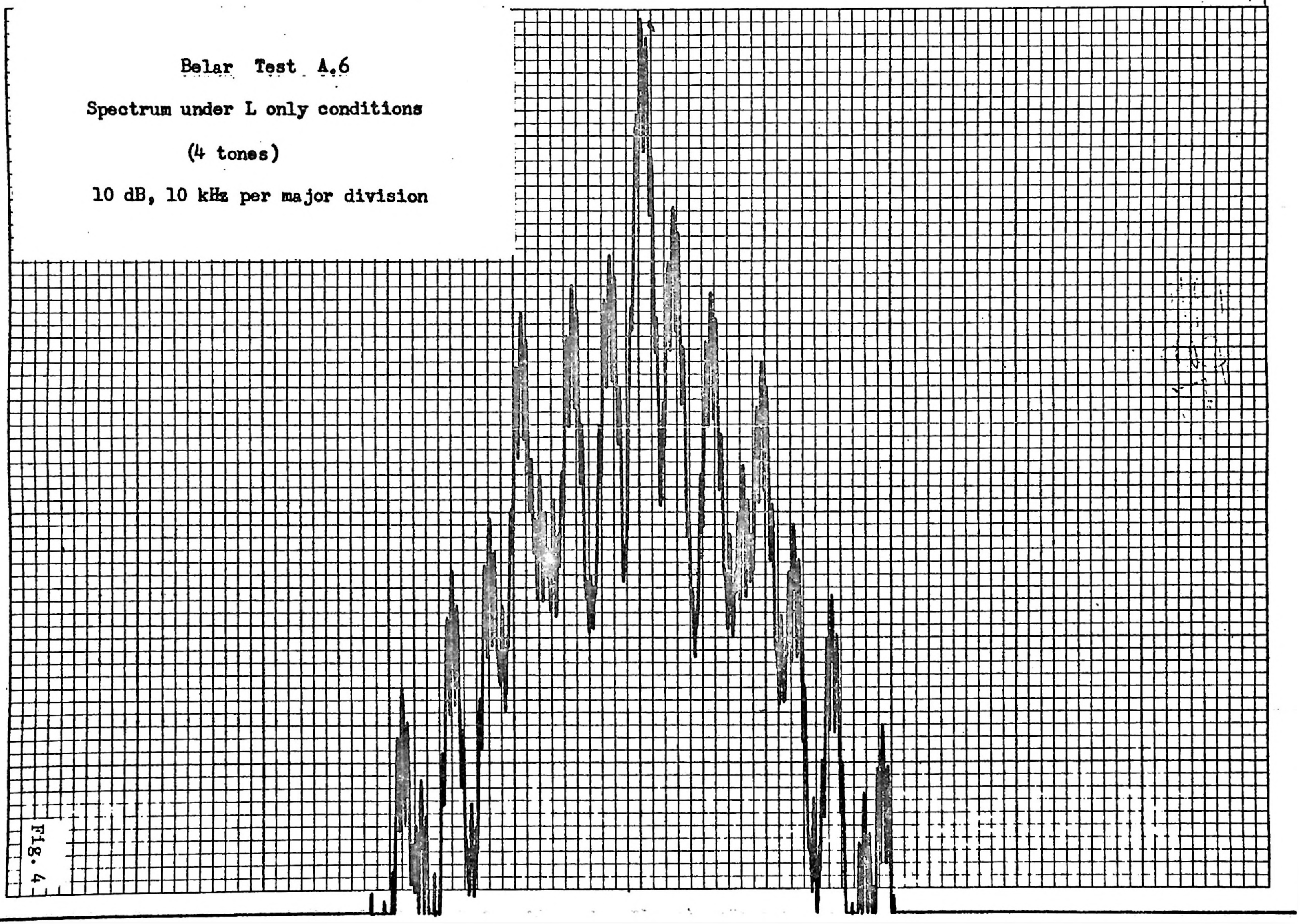


Fig. 4

Magnavox Test A.6

Spectrum under 85% L-R 8 kHz conditions

10 dB, 10 kHz per major division

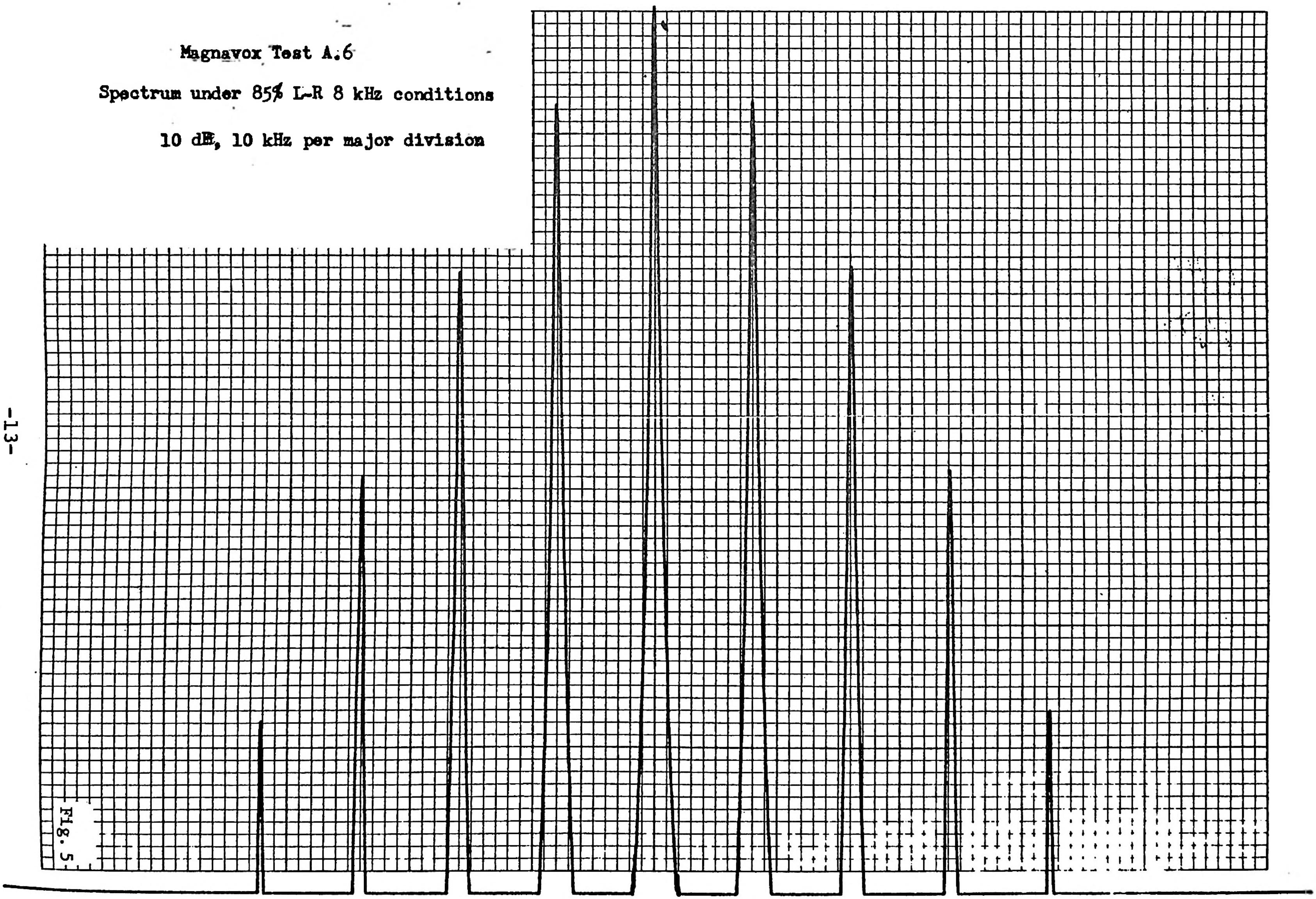
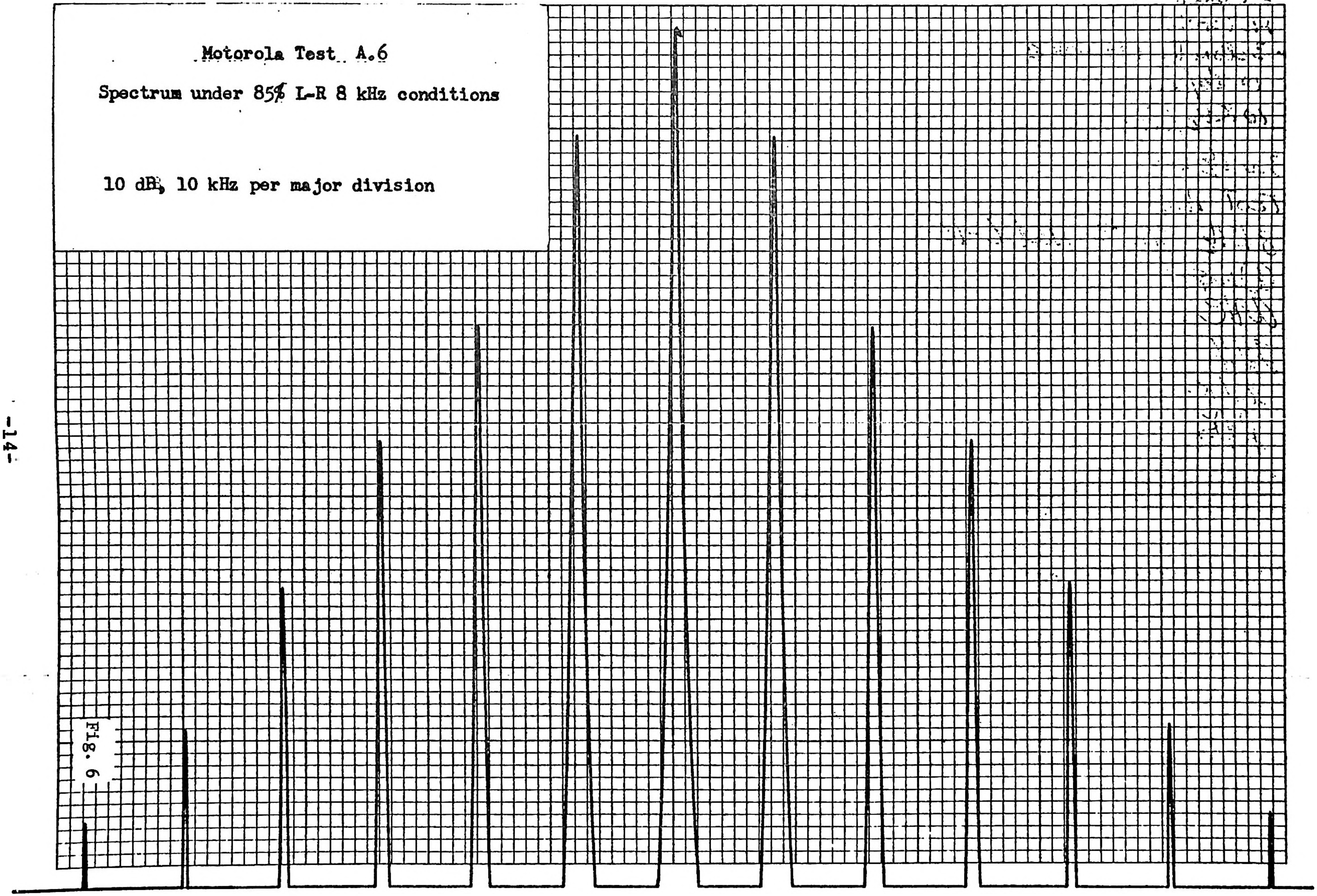


Fig. 5

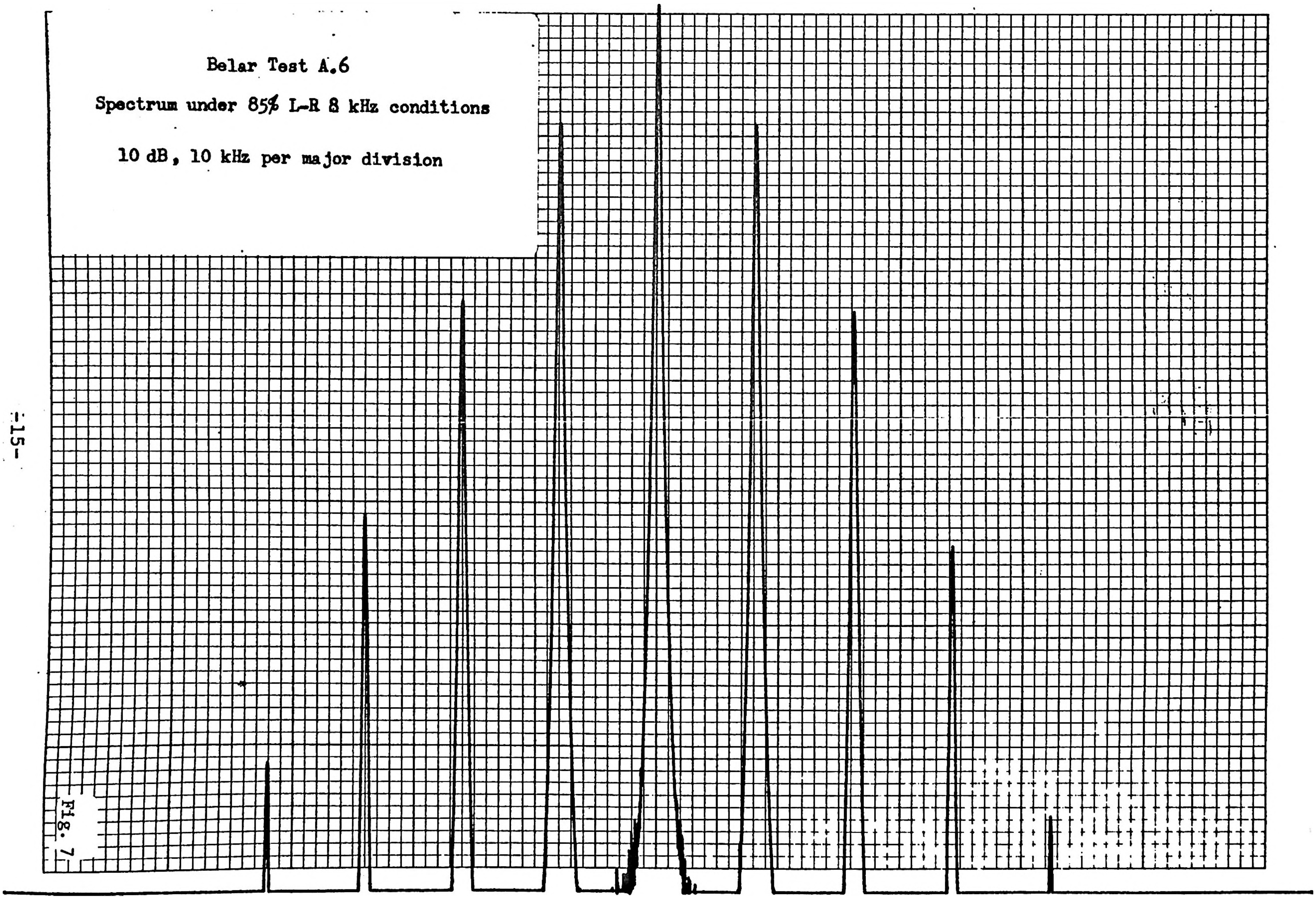


Motorola Test A.6

Spectrum under 85% L-R 8 kHz conditions

10 dB, 10 kHz per major division

Fig. 6



Belar Test A.6

Spectrum under 85% L-R 8 kHz conditions

10 dB, 10 kHz per major division

Fig. 7

Limited because the total peak value at any time must not exceed 100% L-R modulation. Even with modern music with multi-band limiting, it is improbable that the power in the sidebands would exceed the existing FCC limits.

Protection Ratios

The present engineering standards for allocation of standard broadcast (AM) stations place limitations on day and night co-channel radiation, and limitations on the first, second, and third adjacent channel groundwave signals. The origin of these standards appears to be in a paper by A.D. Ring in the April 1932 issue of the Proceedings of the Institute of Radio Engineers entitle "Empirical Standards for Broadcast Allocation." The standards were derived from the data on operating transmitting equipment and receivers. At that time, it was basically the selectivity of the receivers and the station's transmitting power and antenna characteristics that determined the permissible spacing of stations.

In order to verify the present day applicability of these standards, a limited study of the I.F. characteristics of presently manufactured radio receivers was performed by Panel III of the NAMSRC and is reproduced in Appendix G. The average 20 dB bandwidth of all the receivers tested was approximately 15 kHz.

The present daytime adjacent channel allocations standards prohibit overlap of the 0.5 mV/m contours on the first adjacent channels or a 1:1 ratio plus or minus 10 kHz. Thus a receiver could expect the worse case of first adjacent channel daytime interference to occur where the desired and undesired signals were the same amplitude. This would only be at the most distant point in the desired station's coverage area.

For all other locations the ratio improves in favor of the desired signal.

For the second adjacent channel daytime the 2 and 25 mV/m contours must not overlap. For the worst case, a 2 mV/m signal could expect to have an interferring signal 22 dB higher 20 kHz away. And for a third adjacent channel daytime, the 25 and 25 mV/m contours must not overlap. Thus a receiver tuned to a desired signal of 25 mV/m could have an equally strong interfering one 30 kHz either side of the desired one.

For groundwave nighttime service, stations are generally co-channel protected to their calculated interference free contour. The threshold of interference is considered to be a field intensity ratio of 20:1 (26 dB) between the groundwave signal and the root sum square (RSS) of the highest field intensity interfering signals. There is no protection from adjacent channel skywave interference.

Only Class 1-A and 1-B stations are afforded protection to their skywave coverage areas, and only on a co-channel basis. Other stations may be received at long distances, but the FCC Rules do not prevent destructive interference.

The NAMSRC tests employed a "middle grade" radio receiver and the FCC existing daytime protection ratios to determine if there would be any objectionable interference created by stereo transmissions. The test basically involved generating standard AM and stereo transmissions on 570 kHz, and measuring the noise from a compatibility receiver tuned to a second carrier unmodulated at the co-and adjacent channel frequencies.

For instance, in the second adjacent channel test, the quiet carrier would be generated at 550 (or 590) kHz and set to 2 mV/m. The stereo transmissions would be set to a level of 25 mV/m at 570 kHz. The 4 tones previously described would first modulate the 570 kHz signal as standard AM, and then in several modes of stereo operation. The noise level in the audio output of the receiver would be measured and a comparison made of the difference in noise created by stereo over AM.

The results of the tests on the "middle grade" compatibility receiver are shown in Figs. 8,9 and 10 for Magnavox, Motorola and Belar respectively. On the data sheet, the first line indicates that the reference amplitude of 0 dB is taken from the output of the receiver when a signal on that frequency (550 or 590 kHz in the above example)is modulated with the four tone combination. Thus all other data is referred to the 85% peak modulation on-channel signal. Note that in the co-channel case, the recovered modulation is not in the same amplitude relationship as is the co-channel field intensities of 20 to 1 or 26 dB. This is believed due to the quiet carrier of 25 mV/m not being synchronous generator. The two carrier frequencies were held within about 10 Hz of each other but because the receiver's detector was mixing the larger carrier with sidebands from the second non-synchronous source, the resultant demodulated signal would be of less amplitude than if the carrier and sidebands were generated by the same source.

Basically in all cases except one, the noise generated by the stereo signal was nearly the same as that of the standard AM case. For instance for Magnavox, and the other systems are similar, the AM signal

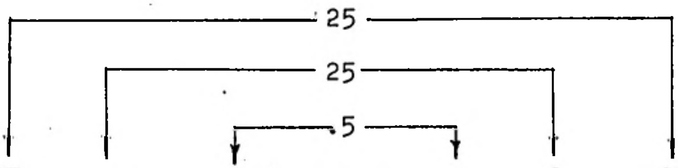
Proponent: Magnavox

Date: 7/20/77

Fig. 8

Protection Ratio

Noise Level in compatibility receiver
compared to 85% AM on channel



mv/m	25	2	.5	25,1.25	.5	2	25
Modulating Sig. Freq,	540	550	560	570	580	590	600
4 tone signal AM modulated on channel, output set to .78 volts = 0 db reference	0 db	0 db	0 db	0 db	0 db	0 db	0 db
4 tones all combined into L+R,85%AM	-44.6	-37.4	-16.9	-30.5	-17.0	-37.9	-45.9
4 tones all combined into L=-R (reverse phase of one channel as above)	-50.2	-33.0	-17.6	-31.2	-17.4	-32.7	-50.0
4 tones all combined into L only, 42.5% AM	-48.6	-35.1	-18.7	-33.8	-21.6	-36.3	-49.1
4 tones all combined into R only, 42.5% AM	-48.5	-36.2	-21.5	-33.6	-18.7	-35.4	-49.0
400 Hz and 9500 Hz combined into right channel for 45% AM, and 2500 Hz and 5500 Hz combined into left channel for 40% AM, 85% total AM	-44.8	-26.7	-15.7	-27.8	-12.7	-23.9	-46.1

Radio Tuned with 400 Hz, 400 Hz deviation FM signal for minimum output.
Noise Floor -49.7 dB

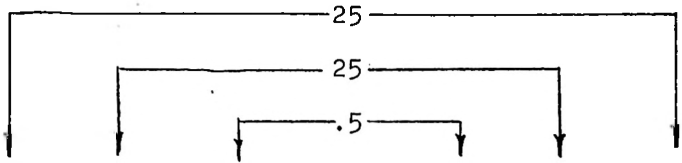
Proponent: Motorola Fig. 9

Date: 7/20/77

Test A.7

Protection Ratio

Noise Level in compatibility receiver compared to 85% AM on channel



mv/m	25	2	.5	25,1.25	.5	2	25
Modulating Sig. Freq,	540	550	560	570	580	590	600
4 tone signal AM modulated on channel, output set to .78 volts = 0 db reference	0 db	0 db	0 db	0 db	0 db	0 db	0 db
4 tones all combined into L+R,85%AM	-46.2	-36.9	-15.7	-30.4	-16.6	-37.2	-47.6
4 tones all combined into L=-R (reverse phase of one channel as above)	-50.0	-31.3	-17.1	-31.4	-18.5	-31.4	-49.9
4 tones all combined into L only, 42.5% AM	-49.2	-36.5	-19.7	-33.5	-19.1	-36.5	-49.7
4 tones all combined into R only, 42.5% AM	-49.1	-35.8	-18.9	-33.4	-19.3	-36.4	-49.6
400 Hz and 9500 Hz combined into right channel for 45% AM, and 2500 Hz and 5500 Hz combined into left channel for 40% AM, 85% total AM	-46.3	-26.1	-13.2	-27.6	-13.9	-27.4	-48.0

Radio tuned with 400 Hz, 400 Hz deviation FM signal for minimum output.

Noise Floor -49.9

Proponent: Belar

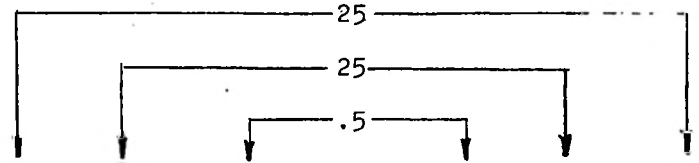
Date: 7/20/77

Fig. 10

Test A.7

Protection Ratio

Noise Level in compatibility receiver compared to 85% AM on channel



	540	550	560	570	580	590	600
mv/m	25	2	.5	25,1.25	.5	2	25
Modulating Sig. Freq,	540	550	560	570	580	590	600
4 tone signal AM modulated on channel, output set to .78 volts = 0 db reference	0 db	0 db	0 db	0 db	0 db	0 db	0 db
4 tones all combined into L+R,85%AM	-45.8	-36.7	-16.7	-30.4	-17.2	-37.2	-47.2
4 tones all combined into L=-R (reverse phase of one channel as above)	-49.7	-33.4	-20.1	-21.6	-21.6	-34.1	-49.5
4 tones all combined into L only, 42.5% AM	-48.7	-35.1	-19.5	-26.0	-23.0	-36.5	-49.2
4 tones all combined into R only, 42.5% AM	-48.6	-35.8	-22.3	-26.1	-19.9	-35.3	-49.1
400 Hz and 9500 Hz combined into right channel for 45% AM, and 2500 Hz and 5500 Hz combined into left channel for 40% AM, 85% total AM	-46.1	-27.6	-18.0	-21.2	-15.2	-25.8	-47.6

Radio tuned with 400 Hz, 400 Hz deviation FM signal for minimum output.
Noise Floor -49.5

caused noise 16.9 dB below an on-channel signal in the first adjacent channel of 560 kHz. Looking down the first adjacent column, the stereo L-R case was 17.6 dB, left only with 18.7 dB, right only with 21.5 dB and slightly more with - 15.7 dB on a mix of 400 and 9000 Hz in right and 2500 and 5500 Hz in left.

The case where the stereo signal produced higher noise in the receiver over standard AM, consistent for all systems was the second adjacent channel. For instance with Motorola, the other two systems are similar, on 590 kHz, the standard AM (left plus right generated by the proponents stereo equipment) case, a noise level of - 37.2 dB was generated, but with stereo the noise level was - 27.4 dB, about 10 dB higher.

It should be noted that the source of AM for these tests was the proponent's laboratory type generator typically having AM distortions of 0.2% and less. This is not representative of operating AM stations. where the high frequency distortion is more typically 3 or 4% and up to 7.5% is permitted. Thus the AM noise level of - 37.2 dB is probably unrepresentatively low. It is likely that the existing spectrum of a typical operating AM station at the second adjacent channels would be higher than the additional higher order sidebands generated by a stereo signal.

The protection ratio tests and the spectrum analysis measurements indicated that under realistic program and operating conditions, the systems of AM stereo measured by NAMSRC would not require any adjustment in the allocations criteria of the FCC and that no significant additional interference would be created.

Compatibility with Existing Receiving Equipment

Interference is one of numerous considerations for a new broadcast service. As was the case with color television and with FM stereo, the addition of new information within existing allocations must not obsolete existing equipment, especially receiving equipment. In the case of AM stereo, the three systems combine left and right and transmit the combination as amplitude modulation. On a normal AM radio receiver a correct monaural signal would be heard. The question that remains is whether the left minus right information transmitted as frequency or phase modulation will disturb the L + R signal in conventional AM receivers.

In a perfectly operating envelope detector, frequency or phase modulation is not detected at all because the complimentary sidebands in FM or PM are in phase opposition and when rotating do not produce a net amplitude change when added with the carrier.

However, when a transmission system has a limited bandwidth which may have unsymmetrical phase or amplitude characteristics, the complimentary sidebands will no longer be equal in amplitude when added with the carrier. Thus there will be PM or FM to AM conversion.

If an AM receiver had an R F and I F bandpass characteristic that was symmetrical in amplitude and phase, and it was center tuned, then the envelope detector would yeild minimal information from the angular modulation. A receiver with the above characteristics, tuned to an AM stereo signal would recover a minimal amount of L-R information.

Bandpass symmetry in a radio is affected by the characteristics of the RF and IF sections and, more importantly, by the accuracy in tuning. Many radio listeners presently do not carefully tune their AM radios, and in the event that AM stereo is adopted, it is not too likely that the tuning practices will change. Therefore it appears that compatibility and receiver tuning are quite interrelated.

The NAMSRC tests of monaural receiver compatibility primarily use receiver tuning to characterize the recovery of the L-R modulation. The receivers were chosen in an attempt to represent the cross section of typical consumer radios being manufactured today. They were: a K-Mart inexpensive pocket portable, a Panasonic medium quality portable, a Delco automobile radio, a Magnavox console-type chassis, and a McKay/Dymec "high fidelity" tuner. These receivers were all tested in accordance with typical receiver industry practices on March 15, 1977 at the Delco laboratory in Kokomo, Indiana before being sent to the NAMSRC lab in Bethesda, MD. The report of this test and the the retesting of the compatibility receivers and the proponents stereo receivers in the Monaural Mode is included in Appendix G of this report.

The compatibility test is performed by setting up a 400 Hz L+R modulation at 85% modulation and the compatibility receiver is tuned to that signal. In order to be able to more precisely tune the compatibility receiver, the receiver was actually tuned for minimum audio output to a signal generator which was FM modulated. The signal generator was only used as a device for determining the precise frequency of tuning of the receiver, Four types of information were recorded for each frequency of mistuning of the receivers; L + R recovered audio, L + R distortion, L-R recovered audio; and L-R distortion. This data was recorded in dB below the center frequency L + R recovered audio. Graphs of each proponent for one compatibility receiver are shown as Figs. 11A, 11B, and 11C.

As the receiver is mistuned, generally the L + R recovery begins to fall and the L - R recovery begins to increase. However, the L - R distortion continues to be lower or nearly the same as the L + R distortion. The basic effect of mistuning is not objectionable distortion, but a change in volume and, depending upon the system, a small change in the L + R center image. In other words, the left channel may slightly dominate the right, but it is a combination of linear effects which may not be objectionable.

The effects of mistuning vary with modulating frequency, stereo system, and the receiver. These various interrelated factors are expected to be discussed in the individual proponent filings with the FCC.

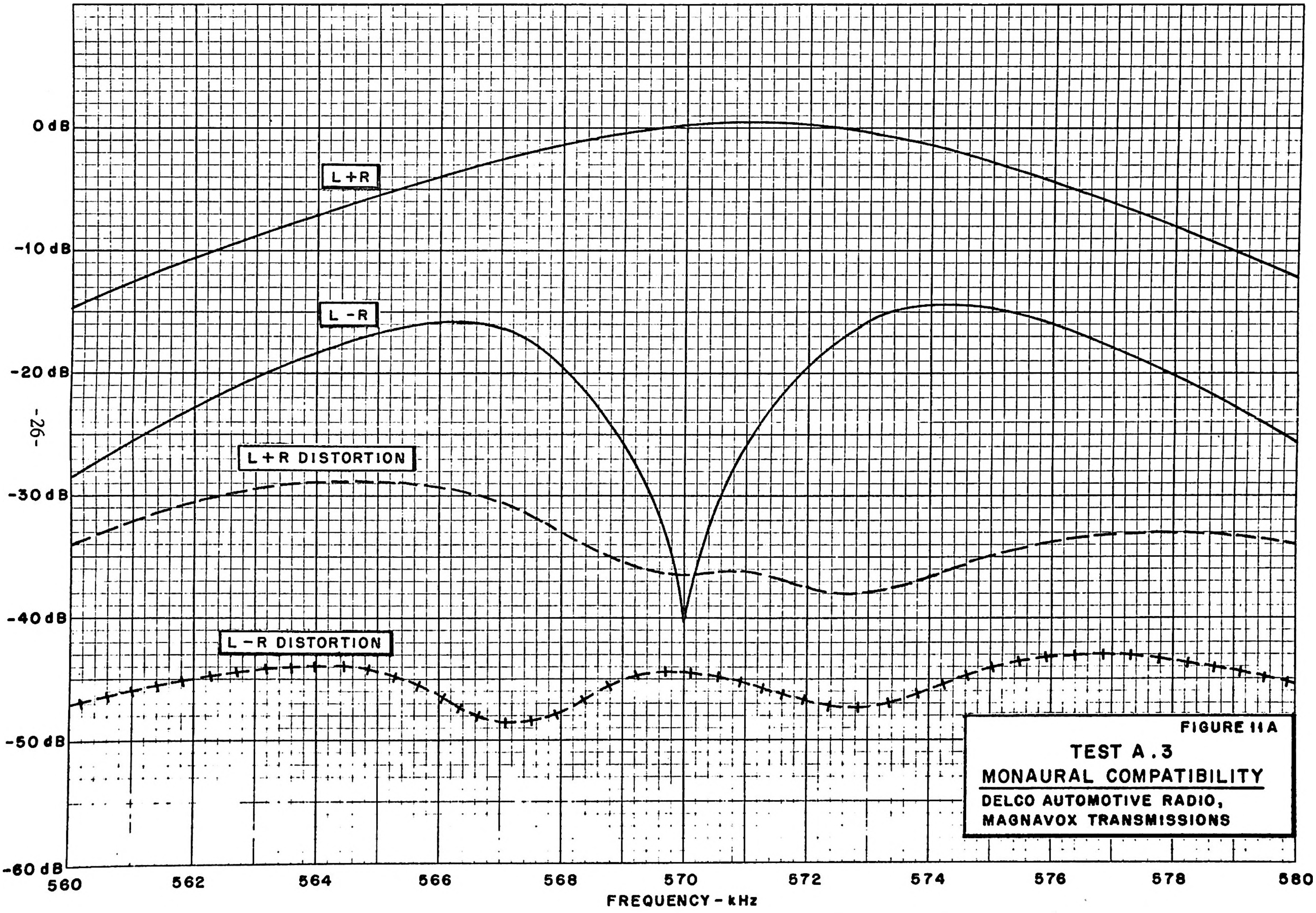


FIGURE 11A

TEST A.3

MONAURAL COMPATIBILITY

DELCO AUTOMOTIVE RADIO,
MAGNAVOX TRANSMISSIONS

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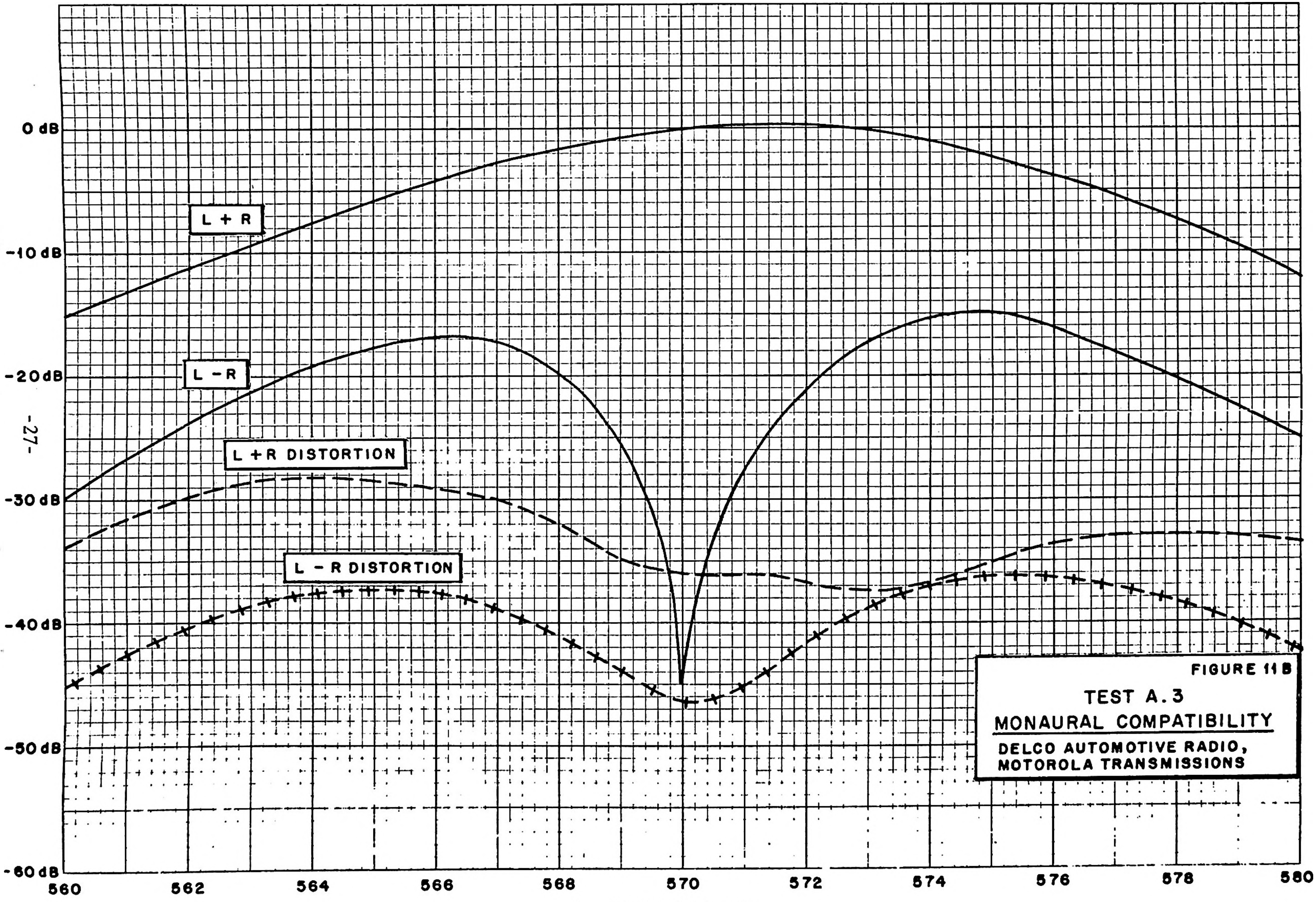

FIGURE 11B

TEST A.3

MONAURAL COMPATIBILITY

DELCO AUTOMOTIVE RADIO,
MOTOROLA TRANSMISSIONS

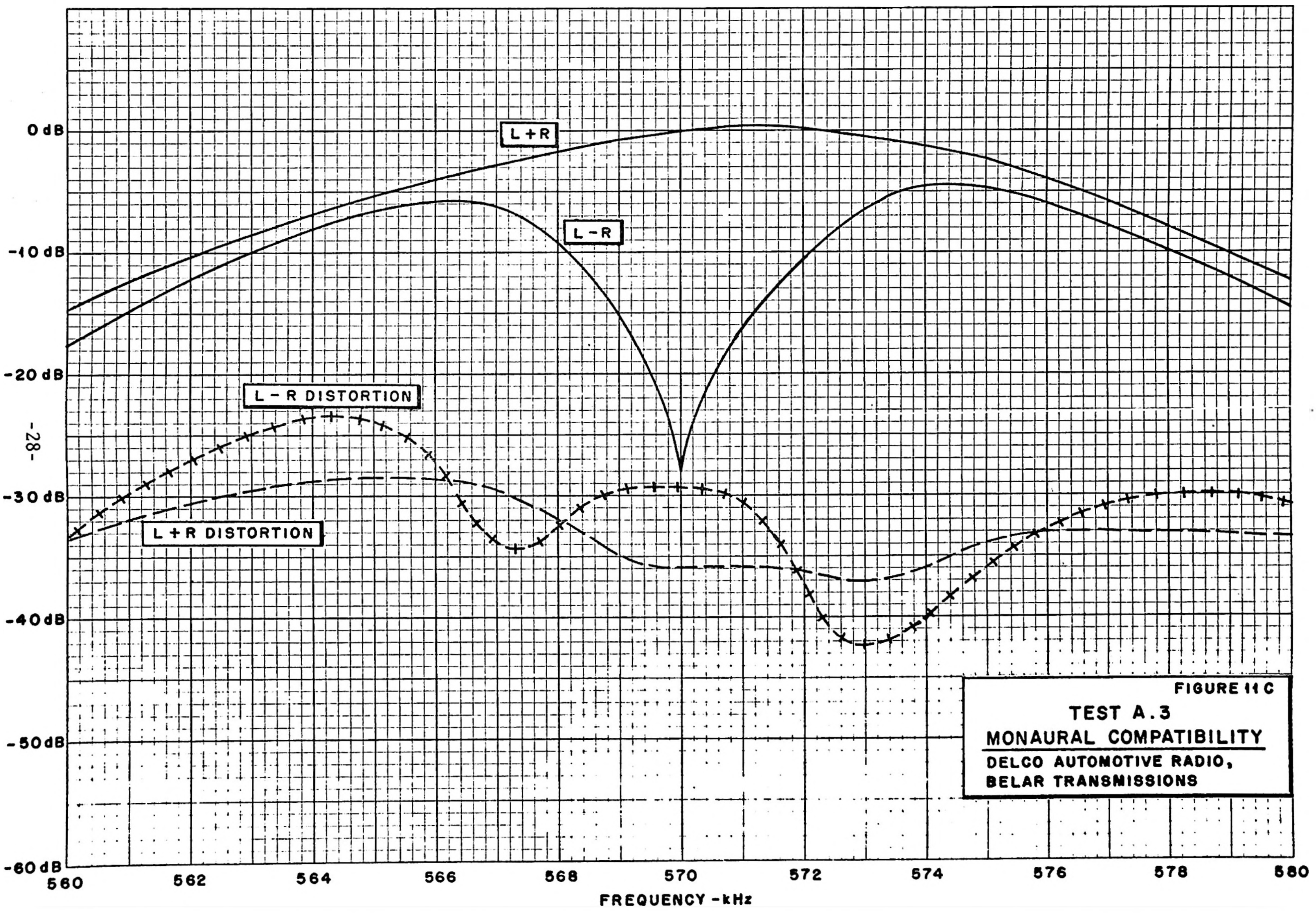

FIGURE 11 C

TEST A.3

MONAURAL COMPATIBILITY

DELCO AUTOMOTIVE RADIO,
BELAR TRANSMISSIONS

Compatibility with Existing Transmitting Equipment

All three systems tested by NAMSRC are connected to existing broadcast transmitters in the same way. The proponent's AM stereo encoder provides a L + R output which drives the normal audio input terminals of the transmitter, and the L-R audio phase or frequency modulates an oscillator which in turn replaces the crystal oscillator drive in the transmitter RF chain. Some schemes may involve frequency synthesis, frequency multiplication, division or heterodyning; but in general, the existing oscillator in the transmitter is not used, and the low level RF is taken from the stereo adaptor. This type of arrangement can be used with practically any known broadcast transmitter in use today.

In general, it can be stated that "stereo" can be obtained out of any transmitter but the transmitter will obviously have some effect on the quality or perfection with which the stereo is transmitted. The rather unique requirement is to both amplitude and angular modulate the same transmitter, both emissions not only with good frequency response, distortion, etc., but with identical time delays, over the entire audio frequency range.

There may be other effects such as incidential phase modulation during amplitude modulation, and incidental amplitude modulation during the angular modulation which cause cross talk between the L + R and L - R channels and affect the separation between left and right.

The technical details of these considerations appear in the section on Transmission Systems in Appendix F.

Audio Fidelity Characteristics

There is a widespread impression that the audio frequency response in AM broadcasting is restricted to a maximum of 5 kHz and thus is only suitable for voice and limited fidelity music. Some broadcasters think that the maximum frequency response is 7.5 kHz, because they do a "proof" to 7.5 kHz.

The facts are as follows: The frequency response required of AM braodcast stations is ± 2 dB from 100 to 5000 Hz[1]; that stations must measure the fidelity from 50 to 7500 Hz,[2] and are permitted to transmit out to 15 kHz.[3]

In practice there usually are two limitations to the frequency response of AM stations. One is the interconnecting facilities between the studio and the transmitter, and the other is the transmitter itself. Generally where the studio and transmitter are located in the same building, the frequency response in the vast majority of cases extends beyond 10 kHz. Where the studio and transmitter are separated, the usual means of program transmission between is an 8 kHz telephone circuit leased from the telephone company.

Although many AM broadcast stations transmit high-quality, wide-band program material, it is possible to recover the full transmitted audio range only in receiving locations where the desired station is much stronger than the stations on both the channels adjacent to it. The reason stems from the fact that AM stations are assigned channels at intervals of 10 kHz,

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[1] Section 73.40(a) (4) of the FCC Rules and Regulations
[2] Section 73.47(a) (1) ibid.
[3] Section 73.40(a) (12) ibid.

but are permitted to broadcast material containing audio frequencies out to as much as 15 kHz. Even though a station transmitting a 15 kHz audio bandwidth occupies a spectrum 30 kHz wide, most of the total energy content falls within the assigned center 10 kHz portion and negligible interference is caused to stations on adjacent channels.

A receiver designed to reproduce the full audio bandwidth of the transmitted material must have a bandwidth of 30 kHz, or three channel widths. No problem occurs if the receiver is located within the primary coverage area of the station to which it is tuned, because AGC developed by the strong desired station reduces sensitivity to the weaker adjacent-channel stations which also fall within the acceptance passband of the receiver. However, if the receiver is returned to a weaker station, or is in an auto which is driving away from the desired station, the receiver sensitivity will increase, and with it comes adjacent-channel interference which is quite annoying to the listener.

The receiver manufacturer cannot expect his product to be used only in areas where adjacent-channel interference cannot occur. This is especially true in the case of auto radios, since on a single trip the vehicle may pass by the antenna tower of a broadcast station and continue to a distant destination from which the station can no longer be heard. For this reason, the receiver designer must choose between two design alternatives: restricted bandwidth or variable bandwidth.

Choosing the restricted-bandwidth option results in a receiver having fewer components, greater reliability., reduced size and weight, and a lower cost to the purchaser.

The use of variable selectivity in AM receivers to permit reception of the full transmitted spectrum under appropriate receiving conditions is an old technique. Some receiver manufacturers in the past offered a top-of-the-line model having a dual-selectivity I.F. amplifier, with a WIDE-SHARP switch on the front panel. Many of these receivers even had automatic frequency control to minimize tuning errors. For AM stereo, these techniques may find renewed use.

The NAMSRC conducted extensive tests of the fidelity of the AM stereo equipment supplied by the proponents for the test. Nearly 300 charts of frequency response, distortion and separtion were taken by an automatic device. In addition, other characteristics such as noise level, and intermodulation distortion were extensively characterized.

It should be noted that there may be a difference between the theoretical nature of a proponent's AM stereo system, and the actual equipment brought for the tests, All the equipment represented laboratory versions of the system and the results represent the evolution of the system. In spite of the self-imposed deadline, all three systems demonstrated the practicality of AM stereo.

The measurements on actual equipment were divided up in a way to permit an examination of the effects of transmitters and receivers on each system. For instance, the closest embodiment of the theoretical system is in the tests of the laboratory type stereo generator driving an "ideal" detector which was not bandwidth limited. (System Performance - Monitor, A.1) The same generator was then used to drive a receiver. Also measurements were made with the stereo generator connected to a broadcast transmitter and then the whole system including the broadcast transmitter and the receiver.

System Performance-Monitor

Figure 12 is a chart of the System Performance-Monitor test on the three systems. This particular test was of the frequency response, and distortion on the left channel, and the separation which is the amount of signal appearing in the left channel when the right channel is driven. Obviously the characteristics are quite good with the frequency response well past 10 kHz and separations better than 30 dB over a wide frequency range. Distortion levels were around 1% or lower. There is no theoretical limit to the frequency response, or distortion and the limitations in separation are in the hardware implementation of encoding and decoding. Noise levels were measured as follows: Belar - 44 dB, Magnavox - 46.9 dB, and Motorola - 56.4 dB below 85% modulation. The intermodulation distortion using a 200 and 2500 Hz tones in a 4:1 ratio were as follows: Belar 0.65%, Magnavox 1.11%, and Motorola 2.5%.

The above data is not necessarily representative of the total system performance. The full description of the System Performance-Monitor test is contained in Appendix H along with the complete test data.

System Performance-Receiver

Although the section in this report on AM stereo receivers will discuss many of the design considerations in more detail, a brief discussion of the NAMSRC receiver testing will follow.

Each proponent was permitted to approach the design as he wished. The only requirements were that it must be tunable to the AM band, and that unweighted audio outputs for left and right must be provided with an

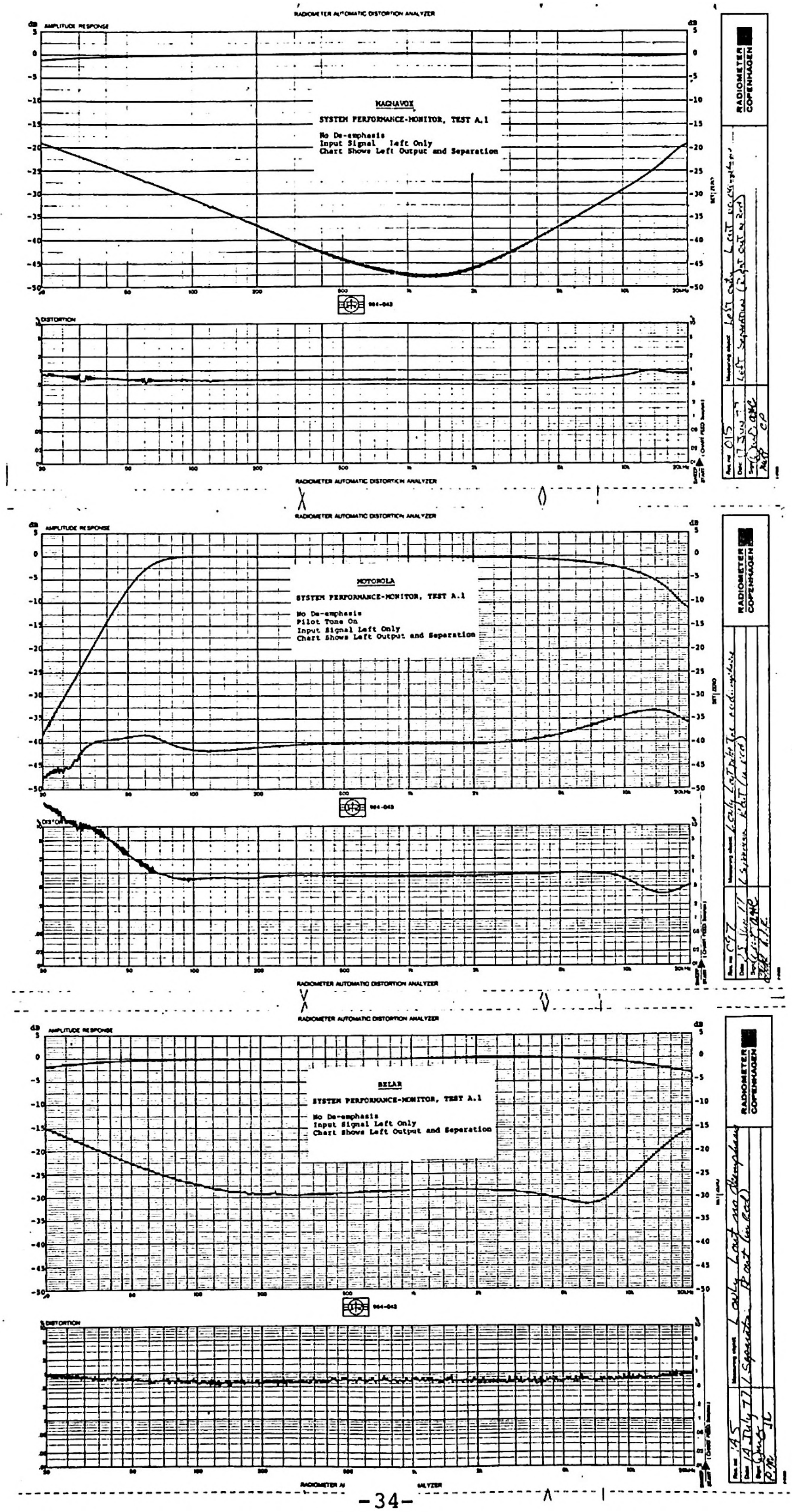
RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
20
50
100
200
500
1k
2k
5k
10k
20kHz
DISTORTION
964-043
RADIOMETER COPENHAGEN
MAGNAVOX
SYSTEM PERFORMANCE-MONITOR, TEST A.1
No De-emphasis
Input Signal Left Only
Chart Shows Left Output and Separation
Left only Lout no (Magnavox)
Left Separation (Right out in Red)
015
17 Jun 77
CP
MOTOROLA
SYSTEM PERFORMANCE-MONITOR, TEST A.1
No De-emphasis
Pilot Tone On
Input Signal Left Only
Chart Shows Left Output and Separation
L only Lout Pilot Tone
L separation R out (in red)
C47
15 Jun 77
BELAR
SYSTEM PERFORMANCE-MONITOR, TEST A.1
No De-emphasis
Input Signal Left Only
Chart Shows Left Output and Separation
L only Lout no de-emphasis
L Separation R out (in Red)
145
14 July 77
PM

Fig. 12

impedence of 1000 ohms at 1 volt at 85% modulation.

This left a wide discretion in receiver design which permits the designers to "do his own thing", but somewhat complicates the evaluation of receiver performance as related to a particular system. Three different approaches were taken. Magnavox chose to design a consumer product which they felt would be representative of the typical AM stereo receiver in the console market. The Magnavox receiver used capacitor gang tuning, two bandwidths, "normal" and "fidelity", and contained the power amplifiers to drive loudspeakers. The Motorola receiver consisted of a modified McKay/Dymec tuner also with capacitor gang tuning and an auxiliary section for demodulation of the AM stereo signal. The tuner has two bandwidths, though only the wide bandwidth was tested. Belar chose to use a heterodyne up/down system employing a frequency synthesizer for a local oscillator. The receiver would be usable as an off-the-air monitor for a broadcaster and employed the widest bandwidth of the three proponents. The choice of IF bandwidth is probably one of the largest variables affecting the NAMSRC tests of AM stereo receivers.

Another difference is Magnavox used a ferrite loopstick antenna as an integral part of the receiver front end tuning, whereas both Motorola and Belar used an external antenna input terminal. For the receiver tests, a screen room was used with the receiver and test equipment inside, and the proponent's stereo generating equipment outside. The tests were performed on 570 kHz which required substantial attenuation of the local WGMS signal especially for the radiated signal for Magnavox. This was readily done however in the double screen room. The radiated signal for Magnavox was 25 mV/m and an equivalent receiver input value was used for Motorola and Belar.

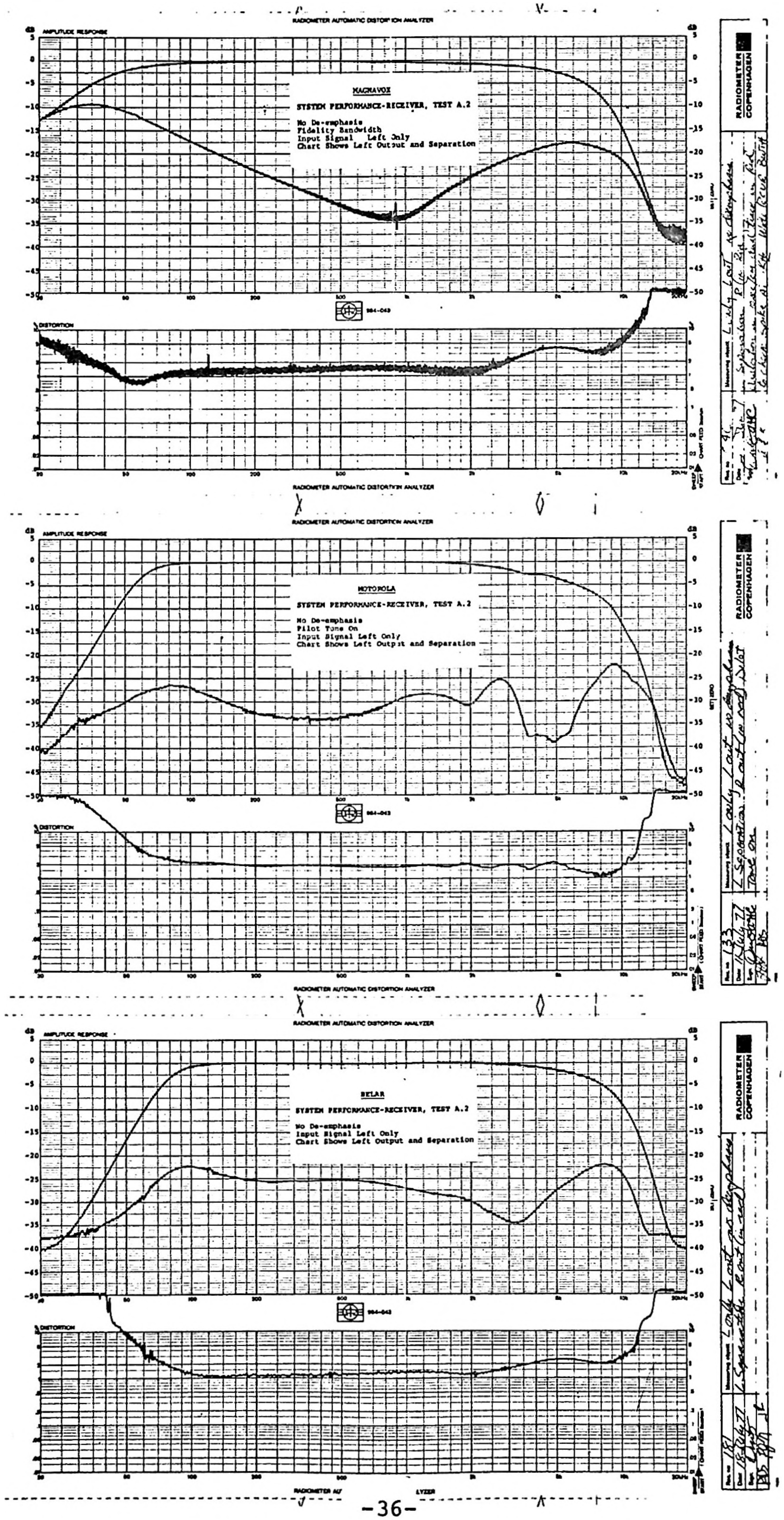
RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
DISTORTION
MAGNAVOX
SYSTEM PERFORMANCE-RECEIVER, TEST A.2
No De-emphasis
Fidelity Bandwidth
Input Signal Left Only
Chart Shows Left Output and Separation
MOTOROLA
SYSTEM PERFORMANCE-RECEIVER, TEST A.2
No De-emphasis
Pilot Tone On
Input Signal Left Only
Chart Shows Left Output and Separation
BELAR
SYSTEM PERFORMANCE-RECEIVER, TEST A.2
No De-emphasis
Input Signal Left Only
Chart Shows Left Output and Separation
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
20
50
100
200
500
1k
2k
5k
10k
20kHz
984-043
RADIOMETER COPENHAGEN
Rec. no.
Date
Sign.
Measuring object
133
11 July 77
181
18 July 77
Only L out no deemphasis
L Separation R out (in red) Pilot
Tone on
Only L out no deemphasis
L Separation R out (in red)

Fig. 13

Figure 13 shows the left channel response, distortion, and separation for the Magnavox, Motorola, and Belar systems respectively. The complete set of receiver data is reported in Appendices H and I. Tests of the Magnavox narrowband position is also in Appendices H and I.

In addition to the graphs of response, separation and harmonic distortion, the data taken for all three proponents on noise and intermodulation distortion (IMD) are as follows: Magnavox: Noise -39.8 dB, IMD 2.8%, Motorola: Noise -49 dB, IMD 4.8% and Belar: Noise -39.7 dB, IMD 1.7%. Complete performance measurements are reported in Appendices H and I.

Because all of the performance measurements were taken at one RF input level, further data was taken to show the relationship between separation and RF input level. This characteristic indicates the receiver's ability to decode left and right and maintain separation with changing signal strength. Although many schemes are possible now, and many more will probably be developed in the future, a simple technique is to detect the AM signal (L+R), detect the angular modulation signal

(L-R) and add and substract the two signals producing 2L and 2R. This works well providing that L+R and L-R are precisely equal in amplitude and experience the same time delay. However, because the output of an AM detector will vary with signal strength (except for a perfect AVC), while the output of many phase or frequently demodulators is essentially independent of input level, adding or subtracting the two outputs will give varying results with changes in RF input level.

In the tests of separation vs. RF input level, Magnavox had a separation at 25 mV/m of 35.6 dB but at 0.44 mV/m it is 21.3 dB in the wideband position and a change from 38.8 dB to 29 dB in the narrow position. Motorola went from 29.35 dB to 23.0, and Belar from 27.7 to 27.0. The complete set of data on this test appears in Appendix H.

Transmitting Antenna Effects

AM broadcasters have become acutely aware of the antenna system's effect on the transmitted signal fidelity, especially on the high frequency response and distortion. The bandwidth and input impedance becomes more limiting typically with a high gain directional antenna system, although some omnidirectional antennas display a comparatively narrow bandwidth also.

For the NAMSRC tests, a special bandpass filter was constructed which would be representative of the input impedances of typical broadcast antenna systems. Actually what was desired was a transfer characteristic which would present at its output, a representation of the radiated signal after passing through a bandwidth limited directional antenna system. The network was originally designed to provide a series of specified "Q's" and delays but a sample of the voltage appearing across the dummy resistance was brought out as a representation of the power in the radiated field which would be the power delivered to the real component of the impedance. The real component in the tuned dummy impedance would represent both the loss resistance in the antenna tuning system and towers, and radiation resistance which would be related to the power radiated.

The test was designed simply to apply a limited bandwidth filter function to the AM stereo emissions and was not designed to test a particular AM stereo generator when driving a complex impedance. It is believed that a typical AM station performance would be due to both factors; i.e. the band pass characteristics of the antenna system, and the transmitter's ability to operate successfully into a complex impedance which varies with frequency.

During the AM stereo tests, each of the proponents laboratory encoders was connected through an amplifier and the bandpass filter to their respective "ideal detector." The filter was set for a carrier phase shift and a Q of 30. The bandpass characteristic was symmetrical in resistance and reactance. It was found that generally the effect of the filter on the audio performance characteristics of all three systems was minimal and about what might be expected with standard monophonic AM. The high frequency response, distortion, and separation were degraded a small amount. The results of these tests are shown in Appendix I.

It appears that any AM station which suffers from additional high frequency distortion due to the antenna system will probably experience the same difficulties with AM Stereo. The only difference is that separation will also be degraded, but primarily on those audio frequencies which are affected under AM conditions. There appears to be no basis or need for large scale antenna modifications in preparation for AM stereo.

Coverage

AM stereo coverage is possibly more complex than most of the other characteristics studied. Coverage is among other things, a function of the transmitted signal and also a function receiver configuration. Also the coverage for existing monophonic receivers may not be the same as the coverage for stereo receivers.

The first point that should be made is that FM stereo is transmitted as a subcarrier of the main channel and the total FM carrier modulation is "shared" between the main and the stereo information. Thus the main channel or monaural modulation must be reduced from 100% in order to accommodate the stereo pilot and the stereo information.

In AM stereo, the process is quite different. Two separate forms of modulation are used; amplitude modulation is employed for transmitting left plus right channel information, and some form of frequency or phase modulation is used to transmit the left minus right information. The existence of the FM or PM places no limitation on the ability to amplitude modulate the same carrier.

To demonstrate this point, the Committee conducted an "Envelope Modulation Limit Test" which consisted of transmitting two tones in monaural and also in stereo with increasing modulation levels and measuring the corresponding intermodulation distortion with a non bandwidth limited, measurement-quality AM detector. Three modes of operation were measured: two tones combined and transmitted as L + R, one tone in the left channel only. The distortion was measured at modulation levels from 50% to 98% amplitude modulation. Generally, the distortion gradually increased with modulation level but there was no indication that the amount of amplitude modulation was limited when stereo is present. The results of this test are contained in Appendix H.

Stereo Receiver Noise Performance

In the field tests, the receiver noise performance test is a test which would be applicable to coverage due to the receiver. Again, however, it is not only a test of the nature of a transmission system, but also a test of the particular equipment brought for the lab tests.

The noise performance test was designed to compare the receiver signal to noise ratio under noisy or low RF level conditions under standard AM and then under AM stereo conditions. This was not a competition in receiver sensitivity, but a comparison of the stereo detectors under noise conditions. It was desired to develop a factor of signal to noise ratio change of AM stereo compared to AM.

To accomplish the comparison between AM and AM stereo demodulation, an external combining network is used to sum the left and right channels and cancel out the contribution of the L-R detector. The L+R ratio of signal plus noise plus distortion to noise plus distortion is measured at the output of this network. This represents the AM case. For AM stereo measurements, the S+N+D/N+D ratio is measured at the left and right outputs individually. At the L or R outputs, the signal and noise is the result of both AM and angular modulation detectors.

Because of possible threshold or capturing effects, the test was performed by establishing the required RF levels to produce S+N+D/N+D ratios of 30, 24, and 18 dB respectively under AM conditions. Then, employing the same RF levels, the S+N+D/N+D was measured at the left and then the right outputs of the receiver. Also the tests were performed at different AM modulation levels.

Some AM receivers display a "squelching" and/or a distortion characteristic under low RF level conditions because the IF level to the diode detector falls below the conduction curve of the diode and this non-linearity attenuates the noise. This characteristic affects the validity of the stereo sensitivity tests so that an additional mode was tested. An RF input level of around 1 millivolt was introduced to the receiver and a noise generator was employed to create the 30, 24 and 18 dB respectively S+N+D/N+D ratio.

Some results of the receiver noise performance test are as follows: for the noise injected case and the middle RF input level creating the 24 dB S+N+D/N+D ratio, at 85% amplitude modulation the noise and distortion level changed from 24 dB to 21.3 dB for Motorola, 24 to 16.5 dB for Belar and from 24 to 14.1 dB for Magnavox in the fidelity bandwidth case. This data was taken from the left output, the right output data is similar.

The complete description of this test and the results are contained in Appendix H.

The discussion of the results of the receiver noise test will be contained in the information filed by the individual proponents with the FCC.

Negative AM Modulation and the Stereo Receiver

Momentary zero carrier or near zero carrier conditions have varying effects on different L - R detectors. This is not so much related to the particular system of transmitting AM stereo as it is related to the nature of the L - R detector chosen to demodulate the signal. Generally it is possible to use a phase-locked-loop (PLL) to demodulate any of the tested AM stereo systems. It also appears to be possible to use a dual IF receiver with any of the three systems tested, and with an appropriate phase shifting network and/or matrix, to recover left and right audio channels. It can be expected that a number of new techniques will be developed for AM stereo demodulation, especially taking advantage of integrated circuit technology. The point is that the operation of AM stereo under heavy negative modulation conditions is related to the particular detection method as well as the system.

The proponents disagree as to the degree that detection methods and system parameters relate. It is expected that proponents will address this subject in their separate filings.

However, in AM and in AM stereo, it is good engineering practice to control the negative amplitude modulation so that zero carrier never occurs.

Audio Processing

For, the NAMSRC tests, a special arrangement of two limiting amplifiers was used which sampled L + R and reduced the gain in the L and R channels identically. The attack time of this setup was about 2 milli-seconds and the L + R feed to the transmitter was then clipped to hold the negative modulation. Many schemes are expected to be developed which might work with various logic combinations of L and R, L + R and L - R. Phase reversing L and R simultaneously so that L + R is polarized for high positive modulation is possible.

It is recommended that AM stereo stations limit negative amplitude modulation to a peak value of 95%. AM stereo places no limitation on positive modulation. The existing FCC standard of 125% maximum positive modulation can be maintained.

For further information, Appendix F contains an extensive discussion of audio processing for AM stereo.

Relative Loudness

The above recommended 95% negative peak modulation limitation should make no difference in the loudness of programming received in monaural receivers, provided that there is no change in average modulation.

AM stereo receivers, when tuned to AM stereo stations should produce a noticeable increase in loudness over standard AM stations from 0 to 6 dB, with the average expected to be around 2 to 3 dB.

Skywave Tests

All three proponents brought their stereo encoding equipment to the transmitter site of WBT in Charlotte, N. C. A switching system was devised so that the stereo encoding equipment could be quickly switched between proponents. The NAMSRC test tape was transmitted one selection at a time using each propenent's transmitting equipment. At the receiving site in Bethesda, Md., tape recordings were made of the stereo transmissions on each of the respective stereo receivers and of the middle grade compatibility receiver. In addition, a chart recording of relative fields intensity was made from the AVC of a Collins communications receiver. The tape recordings and other pertinent data will be made available to the FCC. Comments on the skywave tests will be made by the proponents in their individual filings with the FCC.

NATIONAL AM STEREOPHONIC RADIO COMMITTEE (NAMSRC)

CHARTER

The objective of the NAMSRC will be to report to the FCC the Committee's evaluation and final technical conclusions regarding AM stereophonic broadcast transmission. The report will be based on studies that:

1. Determine the basic channel requirements from the sound reproduction standpoint.
2. Clarify the technical issues between possible systems that meet these requirements through appropriate field tests.
3. Determine AM signal specifications based on these field test data and the best scientific information available.

The NAMSRC intends to obtain this information as a service to the Public, the FCC and the industry. The results of its studies will be made public as soon as the studies have been completed.

(2) The methods of adapting the proposal to existing broadcast transmitters.

(3) The nature of devices needed to monitor stereophonic transmissions.

(4) The technical characteristics of connecting circuits between program origination points and the transmitter proper.

B. Recommend to Panel IV items to be tested.

PANEL III -- <u>RECEIVING SYSTEMS</u>

CHAIRMAN: Thomas Prewitt
Delco Electronics,
Division General
Motors Corporation

VICE-CHAIRMAN: Albert Kelsch
Magnavox Consumer
Electronics Company

SCOPE: A. Study the system proposals referred to it by Panel I, with particular regard to:

(1) The performance of existing monophonic receivers when tuned to the signal.

(2) The performance of the proposed system receiver designed for the proposed system.

(3) The performance of the proposed system when tuned to monophonic signals.

B. Recommend to Panel IV items to be tested.

PANEL IV -- <u>FIELD TESTS</u>

CHAIRMAN: George Bartlett
National Association
of Broadcasters

VICE-CHAIRMAN: John Bowman
Frazier, Gross, & Clay

SCOPE: Develop a field test procedure which will demonstrate the performance of each system.

Field test each system referred to it by Panel I.

ORGANIZATION OF THE NATIONAL AM STEREOPHONIC RADIO COMMITTEE (NAMSRC)

STEERING COMMITTEE

CHAIRMAN:	Harold Kassens A.D. Ring & Associates
VICE-CHAIRMAN:	Jim Gabbert Radio KIOI; National Radio Broadcasters Association

COMPOSITION: Chairman, Vice-Chairman and Secretary, as well as Chairman of each panel.

SCOPE:

(1) Co-ordinate the activities of the Panels.

(2) Formulate, in the form of a report to the FCC, the NAMSRC's evaluation and final technical conclusions.

NOTE: Upon completion of the assigned project by a panel, a final report stating both the majority and minority opinions, together with a complete record of all meetings, will be submitted to the Steering Committee for its approval.

PANEL I -- SYSTEM SPECIFICATIONS

CHAIRMAN:	Carl Eilers Zenith Radio Corporation
VICE-CHAIRMAN:	Norman Parker Motorola, Inc.

SCOPE: Develop broadcast standards for AM stereophonic transmission by:

(1) Analyzing all system proposals submitted to the Committee.

(2) Referring systems and system related questions to other panels for specific studies.

PANEL II -- TRANSMISSIONS SYSTEMS

CHAIRMAN:	Granville Klink, Jr. WTOP Radio
VICE-CHAIRMAN:	Emil Torick CBS Technology Center

SCOPE: A. Study the system proposals referred to it by Panel I, with particular regard to:

(1) The feasibility of the proposed transmission method.

PANEL AND COMMITTEE MEMBERSHIP AND MAILING LIST*

KEY: C---CHAIRMAN M---MEMBER
VC--VICE-CHAIRMAN A---ALTERNATE(May not have attended meetings)
S---SECRETARY O---OBSERVER
BLANK---RECEIVED COMMITTEE MAILINGS AND/OR ATTENDED MEETING.

NAME AND COMPANY	Panel 1	Panel 2	Panel 3	Panel 4	Steering Committee
K. Abe Sansui Electronics Woodside, NY					
E.M. Arakelian Delco Electronics Kokomo, IN					
Harold Banick Heath Company Benton Harbor, MI					
Frank Bateman Jefferson Pilot Broadcasting Charlotte, NC					
George Bartlett National Association of Broadcasters Washington, DC				C	Representative of NAB (Sponsor) M
R.J. Beaudry Dept. of Communications Ottawa, Ontario, CANADA					
O.E. Beckman Zenith Radio Corporation Glenview, IL			M		
E.A. Bingham Jefferson Pilot Broadcasting Charlotte, NC					
John Bowman Frazier, Gross, & Clay Bethesda, MD				VC	M
John Brozda U.S. Pioneer Moonachie, NY					
Dick Cassidy National Public Radio Washington, DC					
D.C. Connor Gates Radio Company Quincy, IL					
Tom Creighton Time, & Frequency Technology Riverton, NJ		M			
Floyd Daisey WFBR Radio Baltimore, MD					

*NOTE: A number of persons listed here received Committee mailings and did not participate in the Committee's activities.

NAME AND COMPANY	Panel 1	Panel 2	Panel 3	Panel 4	Steering Committee
A.G. Day Canadian Broadcasting Company Ottawa, Ontario, CANADA					
Leonard J. DeCostenzo Panasonic Company Secaucus, NJ					
Flemming Dias Hewlett Packard Palo Alto, CA					
Ralph Dippell Cohen & Dippell (Consulting Engineers) Washington, DC					
Robert M. Donough Harris Corporation Quincy, IL					
Ted Dorf National Radio Broadcasters Assn. Washington, DC					
Calvin Eckels Time, & Frequency Technology Riverton, NJ					
R.W. Edmonds Bell Telephone Labs. Holmdel, NJ					
S. Edwardson British Broadcasting Corporation New York, NJ					
Carl Eilers Zenith Radio Corporation Glenview, IL	C				M
Keith Elkins Marconi Electronics, Inc. Northvale, NJ					
Donald G. Everist Cohen & Dippell (Consulting Engineers) Washington, DC		M			
Leonard Fledman L. Feldman Electronics Labs. Great Neck, NY					
Joe Fitzgerald Wilkinson Electronics Trainer, PA					
Clifford Foote KNEW Radio Oakland, CA					
Jim Gabbert Radio KIOI & NRBA San Francisco, CA					Representative of NRBA (Sponsor) VC

NAME AND COMPANY	Panel 1	Panel 2	Panel 3	Panel 4	Steering Committee
John Gable American Broadcasting Company Washington, DC					
Bill Gilmore American Broadcasting Company Washington, DC		M		M	
Thomas Gluyas RCA Corporation Gibbsboro, NJ	M	M	M	M	
Charles Goodrich McMartin Industries, Inc. Omaha, NB		M			
Norman Graham WBZ Radio Boston, MA					
Ralph Green CBS Radio New York, NY					
Paul Gregg Sparta Electronic Corporation Sacramento, CA					
R. Gressman European Broadcasting Union Bruxelles, BELGIUM					
Fred Griffin Atlantic Research Springfield, VA					
J.P. Grosjean Ford Motor Company Taylor, MI			M		
Jeff Grycz London Company Cleveland, OH					
Clifford Hall Potomac Instruments, Inc. Silver Spring, MD			M		
David G. Harry Potomac Instruments Silver Spring, MD		M		M	
John R. Hawkins WKAR Radio Lansing, MI					
William A. Hayes Comm Associates, Inc. Hicksville, NY	M	M			
Howard Head A.D. Ring & Associates Washington, DC					Representative of IEEE (Sponsor) M

NAME AND COMPANY	Panel 1	Panel 2	Panel 3	Panel 4	Steering Committee
David L. Hershberger Harris Corporation Quincy, IL					
Frank Hilbert Motorola, Inc. Schaumburg, IL			M	M	
Howard E. Holman Audiodyne, Inc. Fort Worth, TX					
Thomas Humphrey McMartin Industries, Inc. Omaha, NB	M				
Warren Johannesen Harmon Kardon, Inc. Plainview, NY					
Don Johnson Canadian Dept. of Commerce Ottawa, Ontario, Canada					
Richard B. Johnson CETEC Sparta Sacramento, CA					
Leonard Kahn Kahn Communications, Inc. Freeport, NY					
Eric Kamayatsu Hitachi Sales Corporation Compton, CA					
Harold Kassens A.D. Ring & Associates Washington, DC					C
James D. Kearney General Electric Company Syracuse, NY					
Albert Kelsch Magnavox Consumer Electronics Company Fort Wayne, IN	A	A	VC	A	M
H.L. Kirby, Jr. Collins Radio Group Richardson, TX					
Stephen W. Kirshner Delta Electronics, Inc. Springfield, VA					
Granville Klink, Jr. WTOP Radio Washington, DC		C			M
Jerry LeBowe Frank Barth, Inc. New York, NY	M			M	

NAME AND COMPANY	Panel 1	Panel 2	Panel 3	Panel 4	Steering Committee
Henry Lee General Electric Company Syracuse, NY					
Joe Lee General Electric Company Syracuse, NY	M				
Guy M. Lewis RCA Corporation Camden, NJ					
Chic Leyh WGMS Radio Rockville, MD					
Sidney Lidz Lloyd's Electronics, Inc. Edison, NJ 08817					
Thomas P. Little Wells-Gardner Electronics Corp. Chicago, IL					
E. Noel Luddy RCA Broadcast Systems Washington, DC					Representative of EIA Communications Div. (Sponsor) M
John Marchetti Panasonic Company Secaucus, NJ	M		M		
D.J. Meares BBC Research Kingston Warren, ENGLAND					
Geoffrey N. Mendenhall Harris Corporation Quincy, IL					
Richard Mertz Jefferson Pilot Broadcasting Charlotte, NC					
Arno Meyer Belar Electronics Devon, PA	M	M	M	M	
W.D. Mitchell Continental Electronics Mfg. Company Dallas, TX					
David M. Montag East Los Angeles College Monterey Park, CA					
M.H. Montgomery Carl T. Jones Associates Springfield, VA					

NAME AND COMPANY	Panel 1	Panel 2	Panel 3	Panel 4	Steering Committee
John Moseley Moseley Associates Goleta, CA		M			
George McKay, Jr. McKay/Dymek Pomona, CA					
J.B. McPherson WMAL Radio Washington, DC					
J.B. O'Brien Motorola, Inc. Schaumburg, IL					
S. Oniki Sony Corporation of America Long Island City, NY					
James Orre WAMS Radio Newark, DE					
George Owen, Jr. Motorola, Inc. Schaumburg, IL					
J. Park Heath Company Benton Harbor, MI					
Norman Parker Motorola, Inc. Schaumburg, IL	VC				M
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Robert Burkhardt Federal Communications Commission Washington, DC			O		
Lawrence C. Middlekamp Federal Communications Commission Laurel, MD	O				
Neal K, McNaughten Federal Communications Commission Washington, DC	O	O	O	O	O
John Reed Federal Communications Commission Washington, DC	O	O		O	
John Reiser Federal Communications Commission Washington, DC		O			

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John M. Taff Federal Communications Commission Washington, DC	O				
Carl Weber Federal Communications Commission Laurel, MD				O	
L. Glen Whipple Federal Communications Commission Laurel, MD	O				
E.M. Tingley Electronic Industries Association - Consumer Electronics Group	S	S	S	S	S
Technicians contracted by the NAMSRC for the Closed circuit and over the air field tests. * * * * Arnold Carter Vienna, VA Dennis Overstreet Accokeek, MD					

The National AM Stereophonic Radio Committee appreciates the services provided and equipment loaned for the field tests of AM stereo. The following is a list of those firms which assisted.

A. D. Ring, and Associates
Ampex Corporation
Crown
Delco Electronics
General Electric Company
Harris Corporation
Hewlett-Packard Corporation
Jefferson Pilot Broadcasting Co., Inc. (WBT)
London Company
McKay/Dymec
McMartin Industries
Panasonic
Post Newsweek Stations, (WTOP)
RCA Corporation
RKO General Broadcasting, (WGMS)
Tektronix
Time and Frequency Technology
Thomson CSF
Zenith Radio Corporation

THE MAGNAVOX SYSTEM
FOR
STEREOPHONIC AM BROADCAST

The system for AM Stereophonic broadcast which is being proposed by the Magnavox Company utilizes a combination of Amplitude Modulation and Phase Modulation. The left and right stereophonic program material is matrixed into (left plus right) and (left minus right) signals for transmission. The (left plus right) signal will be used to amplitude modulate the carrier, and forms the signal heard by the monophonic audience, as is the current practice in FM Stereophonic broadcast. The (left minus right) signal will be used in phase modulating the carrier wave. Magnavox is proposing a low frequency stereophonic identification signal with its system. This stereophonic identification tone may also be used to carry low speed digital data, such as station identification.

The phase modulation will utilize a peak phase deviation of one radian. Such a deviation is large enough to provide detection by several means and to reduce restrictions encountered in the receiver, but not so large as to generate an unwieldy sideband spectrum. The stereophonic identification tone is a 5Hz signal which frequency modulates the carrier to a peak deviation of 20Hz.

TRANSMITTER TECHNIQUES

The AM Stereophonic signal is broadcast by disabling the oscillator in the AM broadcast transmitter, and driving the transmitter with an AM Stereo RF signal. It is also necessary to supply (L + R) audio to the normal audio system of the broadcast transmitter.

SIMPLIFIED TRANSMISSION SYSTEM

The Magnavox stereophonic broadcast signal is most easily understood by considering the signal generation as a three step process. First, the carrier is frequency modulated with a 5Hz low frequency tone to generate the stereophonic identification signal, as shown in Fig. A. A frequency deviation of about ± 20Hz is used, which corresponds to about a 4 radian phase deviation. This signal is then applied to a phase modulater which adds the (left minus right) audio component to the overall phase variation of the carrier. The phase variation due to the (L - R) audio signal is held to a peak deviation of one radian. This phase modulated signal is applied to a low level stage in the standard broadcast transmitter RF chain, such as an oscillator or buffer stage. The phase modulated signal is amplified by the RF chain to the full carrier power. It is then amplitude modulated by the (left plus right) audio signal using the modulation circuitry already present in the standard AM transmitter. A delay network in the proper audio line (L - R or L + R) will equalize the audio delays and establish the proper time relationship between the transmitted (left plus right) and (left minus right) signals.

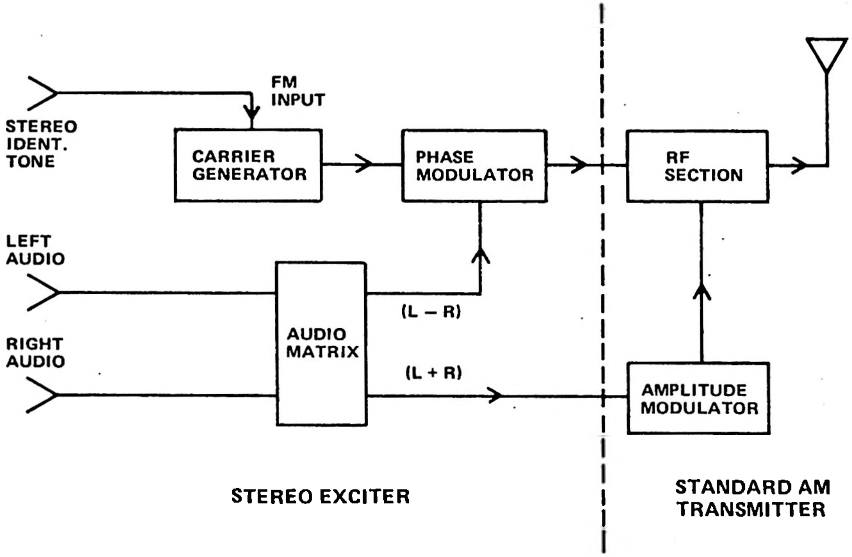

FM
INPUT
STEREO
IDENT.
TONE
CARRIER
GENERATOR
PHASE
MODULATOR
RF
SECTION
LEFT
AUDIO
AUDIO
MATRIX
(L – R)
RIGHT
AUDIO
(L + R)
AMPLITUDE
MODULATOR
STEREO EXCITER
STANDARD AM
TRANSMITTER

FIG. A

THE ACTUAL TRANSMITTER ADAPTER

The photograph of Fig. B shows the actual equipment used by Magnavox to adapt existing broadcast transmitters for AM Stereo transmissions, and to monitor the transmissions. This equipment was used in the WFWR Radio tests on file with the Commission, and in all the tests of the National AM Stereophonic Radio Committee.

The monitor is at the top of the rack, and is a commercially available and approved monitor (the Belar AMM-3, Approval No. 3-231) which has been modified for AM Stereophonic operation. The audio outputs from the monitor are on the panel directly below the monitor. The monitor is an untuned broadband device.

At the bottom of the rack are a pair of synthesized signal generators. These units are the determinant of the operating frequency of the AM Stereo signal. With the design used, an AM Stereo signal can be generated on 100Hz incremental steps at any frequency between 200KHz and 2MHz. No retuning is required for either the monitor or the entire AM Stereo signal generator. Such a design allows this equipment to be used as a laboratory AM Stereo signal generator for receiver design research, as well as at any broadcast station.

Above the synthesizers is the actual transmitter adapter which generates the stereophonic identification signal, the audio functions, and the various amplifiers to drive a standard broadcast transmitter. The only front panel adjustments required are the RF drive level to the standard broadcast transmitter and the audio (L + R) level which will AM modulate the standard broadcast transmitter.

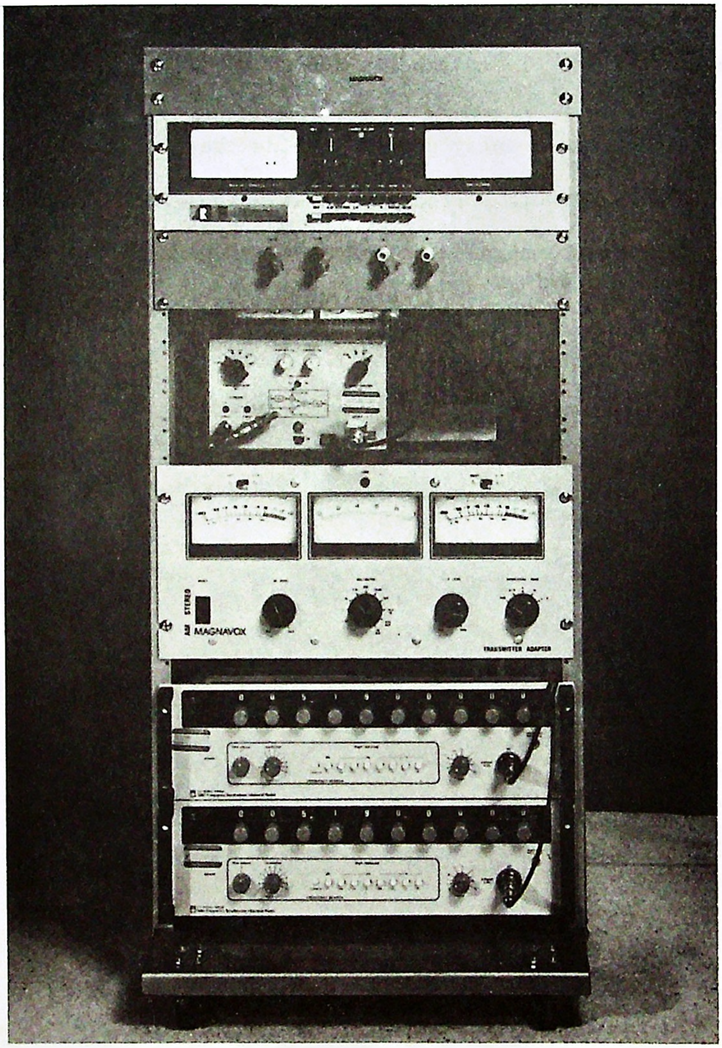


FIG. B

Above the transmitter adapter is a low power high linearity AM modulator. The unit is commercially available, and is manufactured by the Clarke-Hess Company (Model 200). This modulator takes the place of the standard broadcast transmitter for closed circuit tests.

There is also an audio delay network beside the Clarke-Hess modulator. This audio delay network corrects for variations in the time required for the (left plus right) signal and the (left minus right) signal to go through their respective parts of the standard broadcast transmitter. Delays are selectable from zero to 77.5 microseconds in 2.5 microsecond steps, and can be placed in either the L + R or L - R audio lines.

The equipment which Magnavox has demonstrated in the various tests is far more versatile than would be required for each standard broadcast station.

THE OVERALL TRANSMIT SYSTEM

Figure C shows the block diagram of the overall transmitting equipment utilized to produce AM Stereo. It should be noted that this equipment was designed to produce a stereo signal on any frequency (in 100Hz increments) between 200KHz and 2MHz. It is therefore, somewhat more complex than would ultimately be required by a broadcast station.

The synthesizers are used in conjunction with the broadbanded exciter circuitry, as is the audio delay circuitry. These items are discussed in detail with the exciter.

BLOCK DIAGRAM - OVERALL TRANSMIT SYSTEM

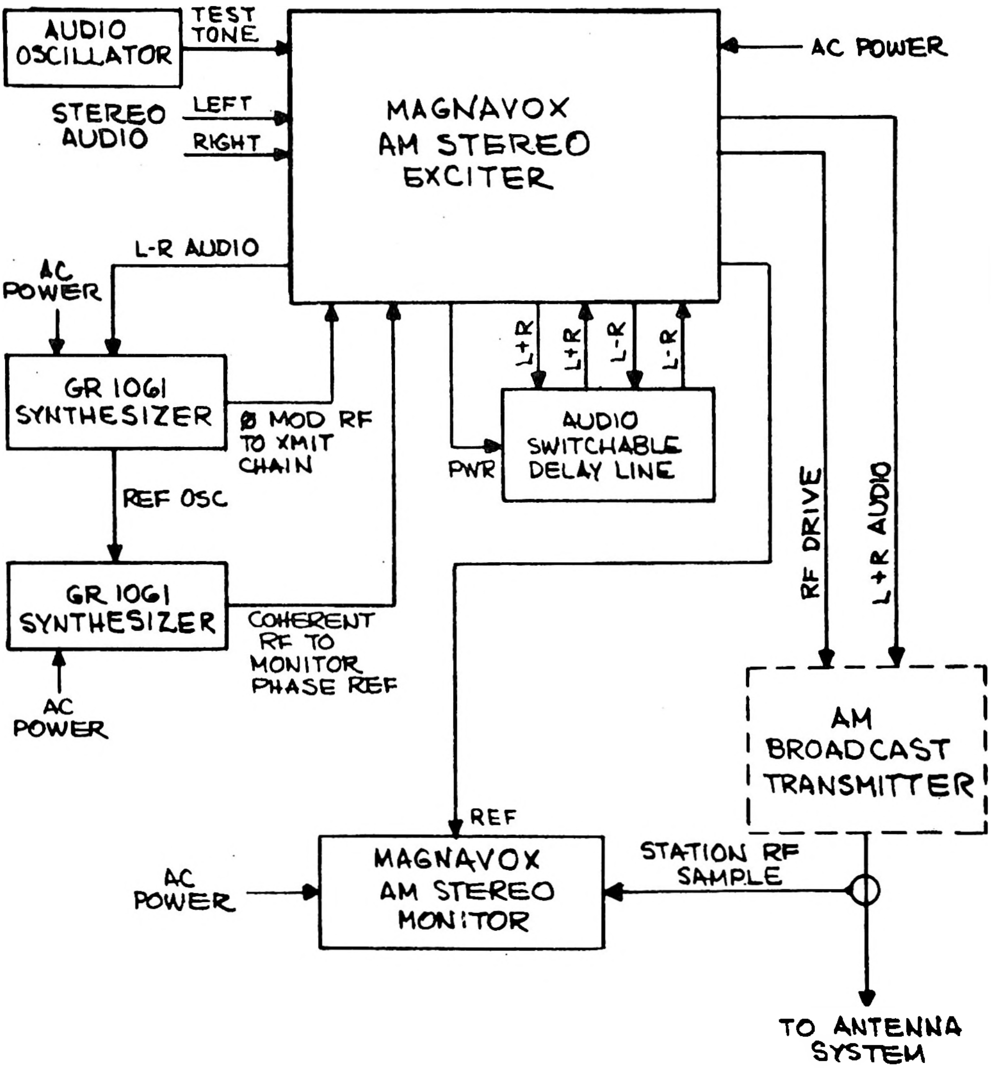


FIGURE C
MAGNAVOX

EXCITER

The exciter for AM Stereo is the equipment which is added to the broadcast transmitter to convert it for stereophonic use. A block diagram is shown in Fig. D. The audio matrix circuitry and low level RF drive amplifiers are contained in the exciter, as well as various operational monitoring circuits.

The audio circuits are transformer isolated and contain a resistive signal attenuator to compensate for high program levels. A conventional matrix circuit develops L+R and L-R signals from the input L & R signals. Peak reading full wave rectified metering is provided on the audio matrix inputs and outputs so that program stereo content can be monitored. Through a front panel switch, a separate external test signal can also be put on any audio function (L,R, L=R, L-R) as an aid in testing and alignment.

The exciter also includes an audio delay circuit which can produce uniform time delays from zero to 77.5 microseconds in steps of 2.5 microseconds. This audio delay can be inserted in either the L+R or L-R signal, as required, to compensate for time delays encountered in the broadcast transmitter circuitry. The L+R output is amplified and transformer isolated so that it may be connected to the existing monaural program line to the transmitter. Output levels of up to + 14dbm can be obtained at very low distortion levels.

The exciter RF circuitry operates at a frequency above the broadcast band. The signals developed are then hetrodyned down to the proper broadcast frequency. A five hertz oscillator develops the tone used for the stereo indicator light in the receiver, and frequency modulates a temperature compensated crystal controlled oscillator. The 5Hz peak input level is monitored to determine the frequency deviation, which is held at ± 20Hz.

The frequency modulated output is then split into two paths. Although a single fixed oscillator in conjunction with a phase modulator could be used to hetrodyne the signal into the broadcast band, the current design is considerably more flexible. It is broadbanded, and allows the frequency range of 200KHz to 2MHz to be covered with external synthesizers as the hetrodyne frequency source. For convenience, a pair of synthesizers is used. One of the synthesizers contains a built-in phase modulator, and is phase modulated with the L-R audio. This synthesizer then hetrodynes the 5Hz frequency modulated signal to the broadcast band, and is amplified to a 2 watt level to drive the standard broadcast transmitter. This signal contains the phase-modulated L-R audio and the 5Hz frequency modulated (± 20Hz) stereophonic indicator signal. The second synthesizer is operated in a coherent mode with the first by cross-strapping the reference oscillator. The second synthesizer hetrodynes just the 5Hz frequency modulated stereophonic indicator signal to the broadcast band, and is set to the same frequency as the first synthesizer. This signal serves as a reference to the broadband modulation monitor.

This method of generating the stereophonic signal, while not necessary for ultimate broadcast service, represents an extremely convenient technique for operating on any broadcast channel. Such a capability yields a very useful piece of test equipment for use in a general design capacity, both with receivers and transmitters.

The exciter also contains several internal monitoring features. These features permit convenient checking of the operational status of the exciter, and aid in diagnosis of malfunctions, should any occur.

BLOCK DIAGRAM - AM STEREO EXCITER

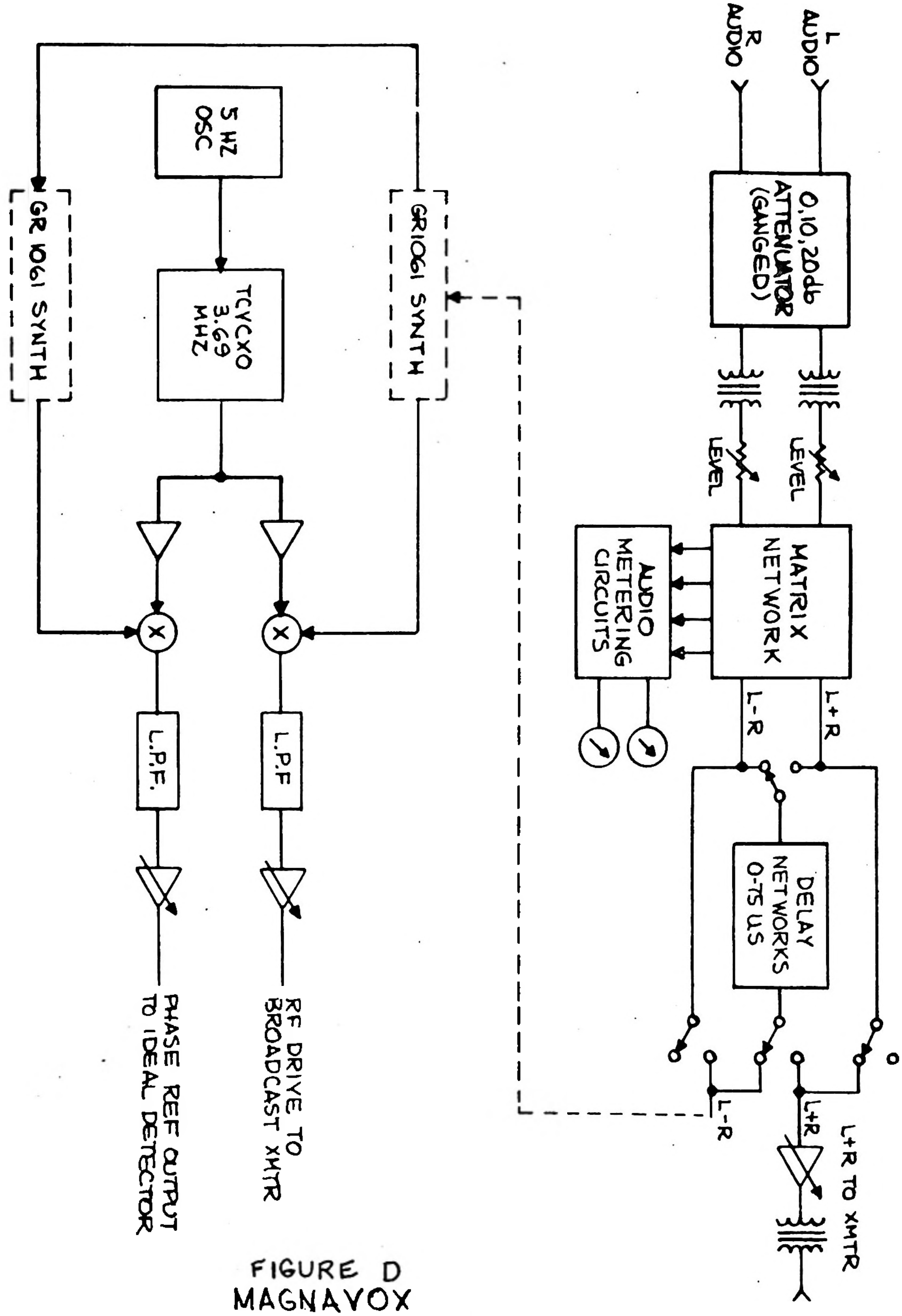


FIGURE D
MAGNAVOX

MONITOR

The modulation monitor and "Ideal Detector" have been combined into one instrument for the Magnavox AM Stereo System. A block diagram is shown in Fig. E. The monitor and detector represent the highest level of performance currently obtainable in demodulating the transmitted stereophonic signal and in measuring the stereophonic operation of any broadcast transmitter. The unit is based on one of the best available broadcast monitors for standard AM, and has been extensively modified for stereophonic transmitter monitoring and recovery of the stereophonic signal.

The standard AM modulation monitor functions have been preserved, so that instantaneous indication is available when envelope peaks exceed selected levels. This function is quite helpful in verifying program modulation levels. The positive modulation is continuously monitored on a peak reading meter. Carrier shift and carrier level metering is also available.

The negative AM modulation peak reading meter is utilized in reading the composite (advance and retard) audio phase modulation level, as well as the negative AM modulation peaks. This meter may also be switched to read left and right detected audio levels.

Special circuitry has been included to accurately measure moderate and low level modulation on both AM and phase modulation signals from the broadcast transmitter. This feature permits the convenient verification of crosstalk levels between the AM and PM modes of transmission, as well as residual noise levels.

The full audio signal group is made available, including L+R, L-R, and R. The audio circuitry has been designed to minimumize the various types of distortion products.

The monitor has been designed to be widebanded, and requires no retuning or component replacement to cover any frequency in the standard broadcast band. This is accomplished by obtaining a reference signal from the exciter which contains the signal tone modulation, but no audio modulation. When the reference is phase-compared to the broadcast signal, only the phase variations of the audio are accurately measured by a calibrated phase detector output.

BLOCK DIAGRAM - AM STEREO IDEAL DETECTOR

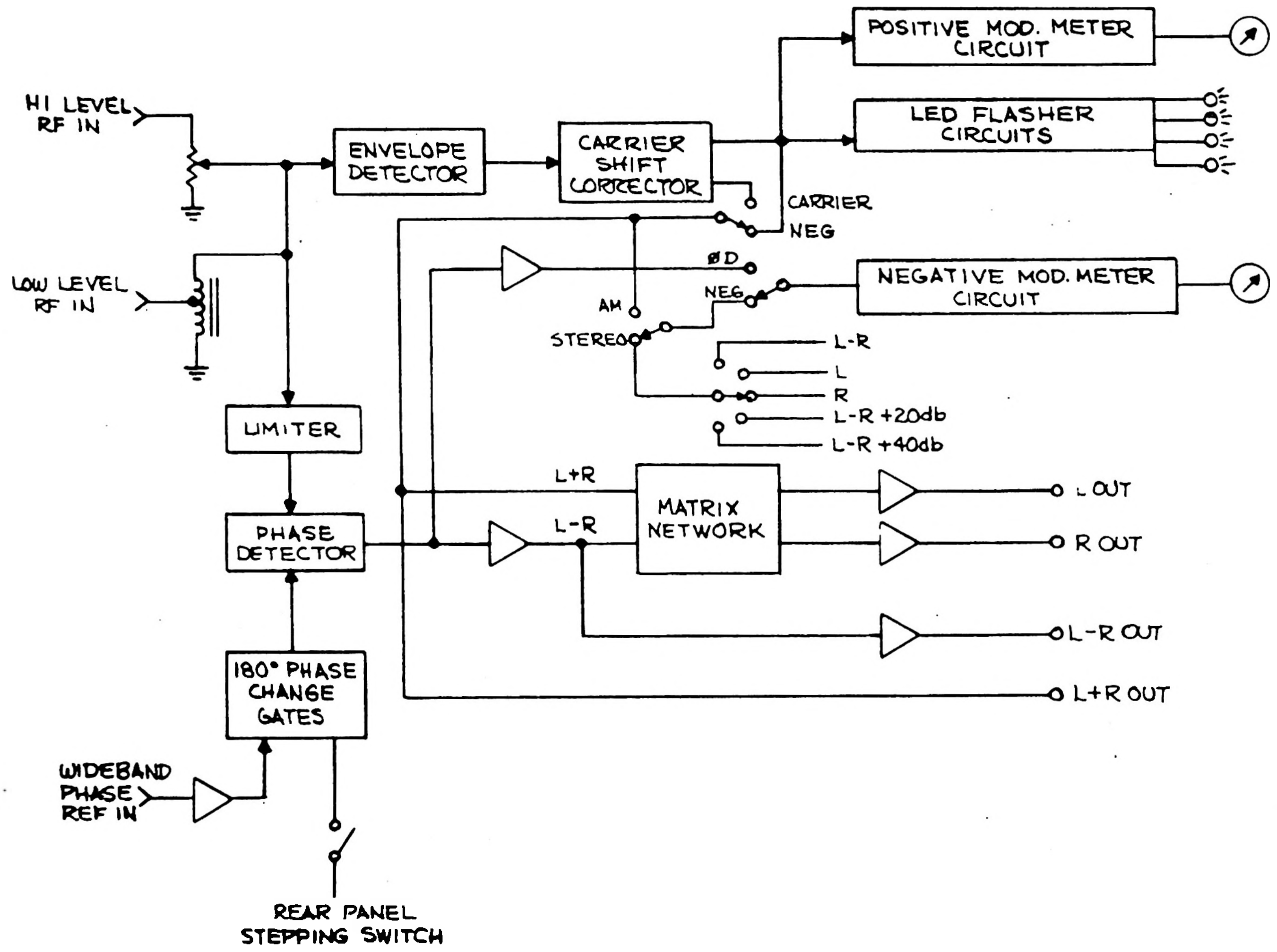


FIGURE E
MAGNAVOX

TRANSMITTED SIGNAL

The transmitted signal will contain amplitude and phase modulated components. A simple equation of the transmitted signal is:

$$\left[1 + (L\ (t) + R\ (t))\right] \qquad \cos(W_c t + (L\ (t) - R\ (t)\ ) + 4 \sin 10 \pi t)$$

With terms: ↑ Amplitude modulation ↑ ↑ Phase Modulation ↑

Where L (t) is the left channel signal

R (t) is the right channel signal

W_c is the angular carrier frequency $(2 \pi f_c)$

$4 \sin 10 \pi t$ represents the stereophonic identification signal

and the levels of L and R are assumed to be adjusted to obtain full modulation.

It should be noted that the phase modulation sideband levels are independent of audio frequency, and depend only on the amplitude of the audio signal, just as is the case for amplitude modulation.

The generalized equation for the transmitted signal is given in the NAMSRC report, and is:

$$E_c = A_c \left[1 + \sum_{n=1}^{n=\infty} C_{sn} \text{Cos}\ (W_{sn} + \phi_{sn})\right]$$

$$\text{Cos} \left[W_c t + \sum_{n=1}^{\infty} C_{DN} \text{Cos}\ (W_{DN} + \phi_{DN}) + 4 \sin 10 \pi t\right]$$

It should be noted that the placement of cosines and sines is arbitrary. The entire equation could, for instance, have been written exclusively with sines (providing the ϕ_{xn} values are adjusted to properly represent the audio input function).

RECEIVER TECHNIQUES

A receiver technique for the Magnavox Stereophonic AM system will detect the amplitude and phase variation of the signal separately, and then use a matrix network to obtain left and right audio signal. A block diagram of the receiver is shown in Fig. F.

The received signal is first amplified and converted as presently done in standard AM receivers, utilizing essentially the same circuitry. The additions for stereophonic reception will take the IF signal and detect the phase variations by any one of several techniques. This will result in the recovery of the (L - R) audio, and the stereophonic indication signal. The IF signal will also be detected by a conventional amplitude modulation detector to recover (L + R) audio. The (L + R) and (L - R) audio will then be combined to obtain left and right audio, which will be amplified to the necessary power for the speakers. A stereophonic indicator light will identify a stereophonic broadcast. It should be noted that the block diagram described can be implemented with either a synchronous or non-synchronous type of receiver. Thus, the receiver design can be as simple or versatile as desired.

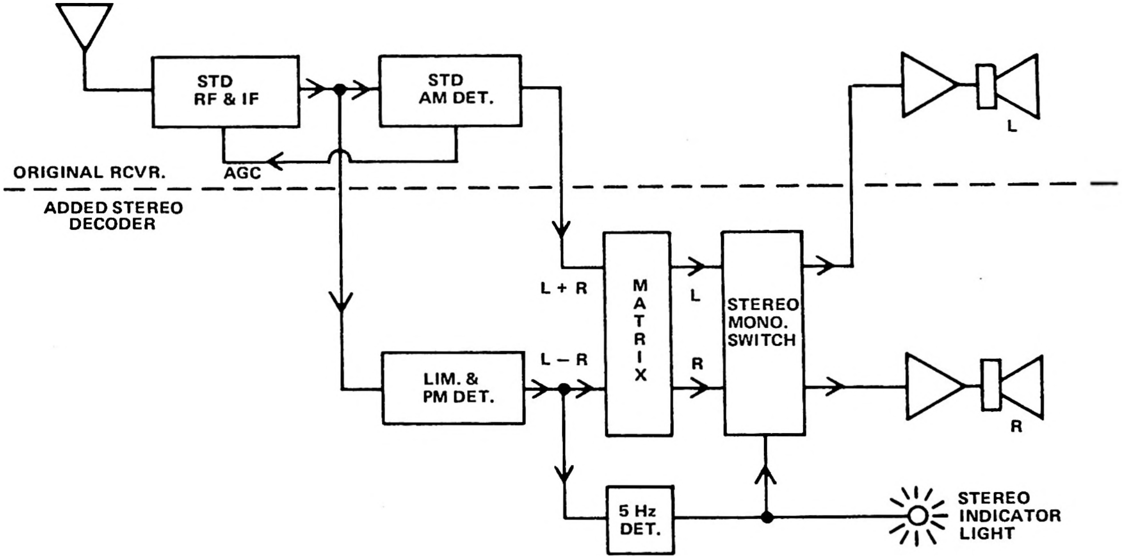

STD
RF & IF
STD
AM DET.
AGC
ORIGINAL RCVR.
ADDED STEREO
DECODER
L + R
L − R
MATRIX
L
R
STEREO
MONO.
SWITCH
LIM. &
PM DET.
5 Hz
DET.
L
R
STEREO
INDICATOR
LIGHT

FIG. F

THE ACTUAL AM STEREO RECEIVER

The receiver that Magnavox used in all the field tests is shown in Fig. G. This receiver was designed to operate as a typical consumer product, and utilizes a ferrite loop stick for signal pickup, as do virtually all non-automotive AM receivers today. Under all test conditions, this receiver was operated in the same manner as one would expect in a "typical" consumer home environment. The receiver is complete, and contains stereophonic 12 watt audio amplifiers to drive external speakers.

The front panel has all the operational controls required for receiver operation. Both signal strength and center tuning meters are provided, and a full length tuning scale and continuous frequency tuning system are provided. The receiver has two bandwidths one (normal) providing a high frequency 3db point of 3Khz, and the other (fidelity) providing a high frequency 3db point of 6Khz. The indicator for stereophonic broadcasts is below the dial scale. The receiver is equipped with a mute switch, which makes the tuning transients inaudible, a stereo/mono function switch and a 10Khz whistle filter.

The audio controls include a loudness switch, balance, bass, treble, and loudness controls. Such controls are typically found on high quality consumer products today.

The rear panel contains the speaker connection terminals, a speaker on/off switch and the special audio outputs required by the National AM Stereophonic Radio Committee. These outputs are direct from the detector & matrix network, and include (L+R), (L-R) left, and right. All committee data was taken from these special outputs to avoid the question of audio response shaping.


MAGNAVOX
AM STEREO
M 77
55
60
70
80
100
120
140
160
kHz
MONO
OFF
ON
NORMAL
FIDELITY

FIG. G

RECEIVER

The Magnavox receiver was designed to present one of the possible implementations for a receiver, and to demonstrate that such an implementation can be made in a consumer-useable form. The receiver is one which will operate in a typical home environment, under the conditions of use which would be found in such a home environment; and which could be operated by a consumer without requiring special skills or training. The receiver was built with two IF bandwidths, "Fidelity" and "Normal", to provide improved fidelity for local groundwave service and yet satisfactory performance for skywave service. A detailed block diagram is shown in Fig. H.

The broadcast signal is always received by a ferrite rod antenna (loop stick) which is part of the RF stage input tuned circuit. The RF stage is an FET of design typically found in component-grade "Hi Fi" Tuners. The mixer and local oscillator use bipolar transistors, and translate the signal to the 455kHz IF frequency. The front end circuits are typically aligned at 600kHz and 1400kHz.

The IF section consists of a dual bandwidth filter system, a dual AGC loop, signal level and center tuning meters, and a wide dynamic range IF amplifier section. Designs like this may be found in component-grade tuners. Both the IF filters have a sharp skirt rolloff response and low passband ripple. The "Normal" filter bandwidth is about 6kHz and the "Fidelity" bandwidth is about 12kHz. The dual AGC system prevents various sections of the receiver from overloading, while maintaining excellent control characteristics and proper individual stage performance. The signal level meter and center tune meter are included for user convenience and information. The output of the IF section drives a full-wave envelope detector to recover the AM modulation (L + R) and the phase modulation detector circuit.

The phase modulation is detected by first stripping the envelope modulation with a currently available IC limiter (MC 1355), and then utilizing a phase locked loop to recover the phase modulation and stereophonic indication tone. The characteristics of the phase locked loop are used to obtain some preliminary filtering between the (L - R) audio, which is obtained from the error signal output from the phase detector (MC 4044); and the stereophonic signal tone, which is obtained from the signal drive to the VCO.

The (L -R) audio signal from the phase detector is equalized in level with the (L + R) signal from the envelope detector, and the (L -R) signal is passed through a squelch gate. The squelch gate mutes the (L -R) audio during the tuning process, so that the various transient signals will not be audible. The (L -R) audio is also muted in the monaural receiver mode. The (L + R) and (L -R) signals are buffered and supplied to the rear panel as well as being supplied to the dematrix network. The L + R signal is delayed 16 microseconds to compensate for the delays in the L - R circuitry. The output of the dematrix network is the left and right channels, and these are buffered and supplied to the rear panel for use in measurement, as well as going to the left and right audio channels.

The left and right audio channels are identical, and have features found in quality consumer receivers. These include loudness compensation, stereophonic balance, bass, treble, and loudness controls. Each channel is capable of 12 watts audio output (RMS).

The stereophonic indicator light is operated by a high speed digital detector circuit. This circuit is designed to provide rapid sensing of the presence of a 5Hz signal. A signal level detector on the AGC circuit prevents the indicator light from falsely operating on inter-station noise, and forms an operating threshold for the indicator.

The mute circuit for the (L - R) audio operates from a high speed noise detector, and the signal level detector. This mute system can be defeated by a front panel control for the purpose of demonstrating the behavior of a coherent angular modulation detector when operated without a mute circuit.

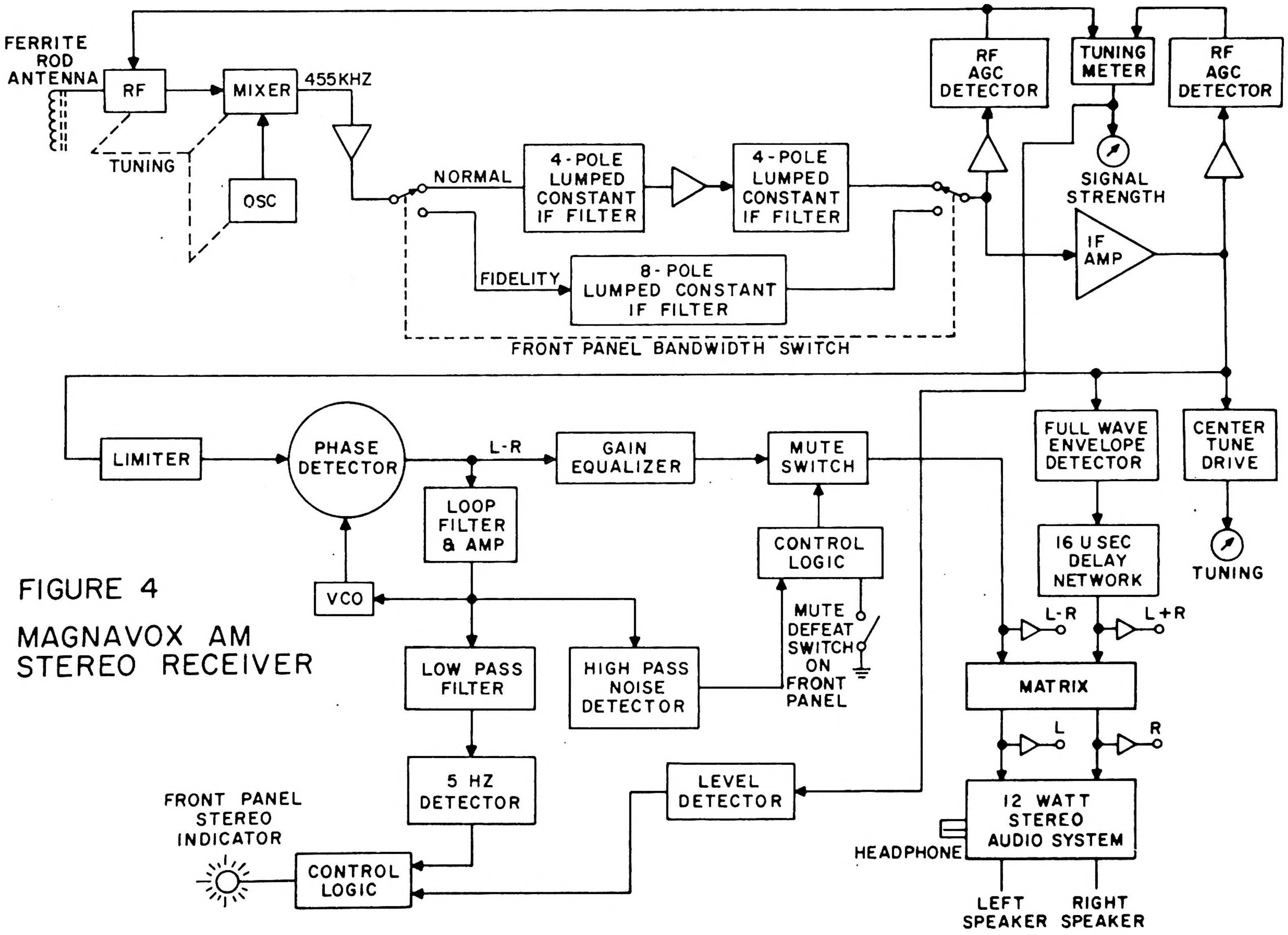


FIGURE 4

MAGNAVOX AM STEREO RECEIVER

FIG. H

C-QUAM

COMPATIBLE QUADRATURE AMPLITUDE MODULATION

I. Abstract

C-QUAM is an AM stereo system design approach which recognizes and retains the system performance advantages of quadrature modulation while rendering the highest degree of compatibility with monophonic receivers. These advantages are:

a. Noise Performance or Coverage:

C-QUAM offers an (L-R) performance that is on a par with quadrature modulation, i.e., free of noise characteristics that are a function of the amplitude modulation present. AM/FM and FM/PM systems suffer a severe noise performance penalty under conditions of amplitude modulation.

b. Spectrum Efficiency:

The process of generating compatible quadrature modulation yields a minimum amount of spectrum spreading totally consistent with F.C.C. standards for AM broadcasting.

c. Compatibility:

C-QUAM has shown itself to be equal or better in compatibility to all systems tested to date, both at the transmitter and at the receiver.

d. Decoding Versatility:

C-QUAM lends itself to numerous methods of decoding, allowing a maximum of freedom for the receiver designer to address all levels of performance/price relationships.

e. Pilot Tone:

C-QUAM includes a pilot tone to maximize the feature possibilities at the receiver. The pilot tone noise performance also shares the C-QUAM characteristic of being independent of amplitude modulation.

II. GENERAL DISCUSSION AND DEVELOPMENT OF C-QUAM

Radio broadcasting in the AM band has historically employed double sideband amplitude modulation. The system evolved largely because of the ease of accomplishing the modulation of a carrier by audio signals to produce a double sideband signal and also the ease with which the audio signal can be recovered from a signal current rectifier (usually a one-half wave envelope detector).

The recently revived interest in the broadcasting of two independent signals for stereo broadcasting on the existing channels has brought forth several proposals for modified broadcasting rules permitting compatible stereophonic braodcasting on the AM band.

The system described herein was devised by Motorola to provide a stereophonic broadcasting system with a compatible monophonic signal. The spectrum resembles that of the existing monophonic transmission as closely as is consistent with the proper transmission of stereo information, in order to insure the highest degreee of compatibility with existing monophonic receivers. The noise performance is free of the limitations introduced by AM/FM or AM/PM systems. A pilot tone is also included.

In addition the system is designed to provide a minimum of transmitter modification and a stereo receiver of relatively simple design, with optional pilot tone features.

QUAM

Because of the severe restriction on bandwidth for each broadcast channel, a practical stereo system in the AM band cannot afford the luxury of transmitting a second signal on a separate carrier or subcarrier, and the system accepted by the FCC will be required to transmit both signals on the same carrier.

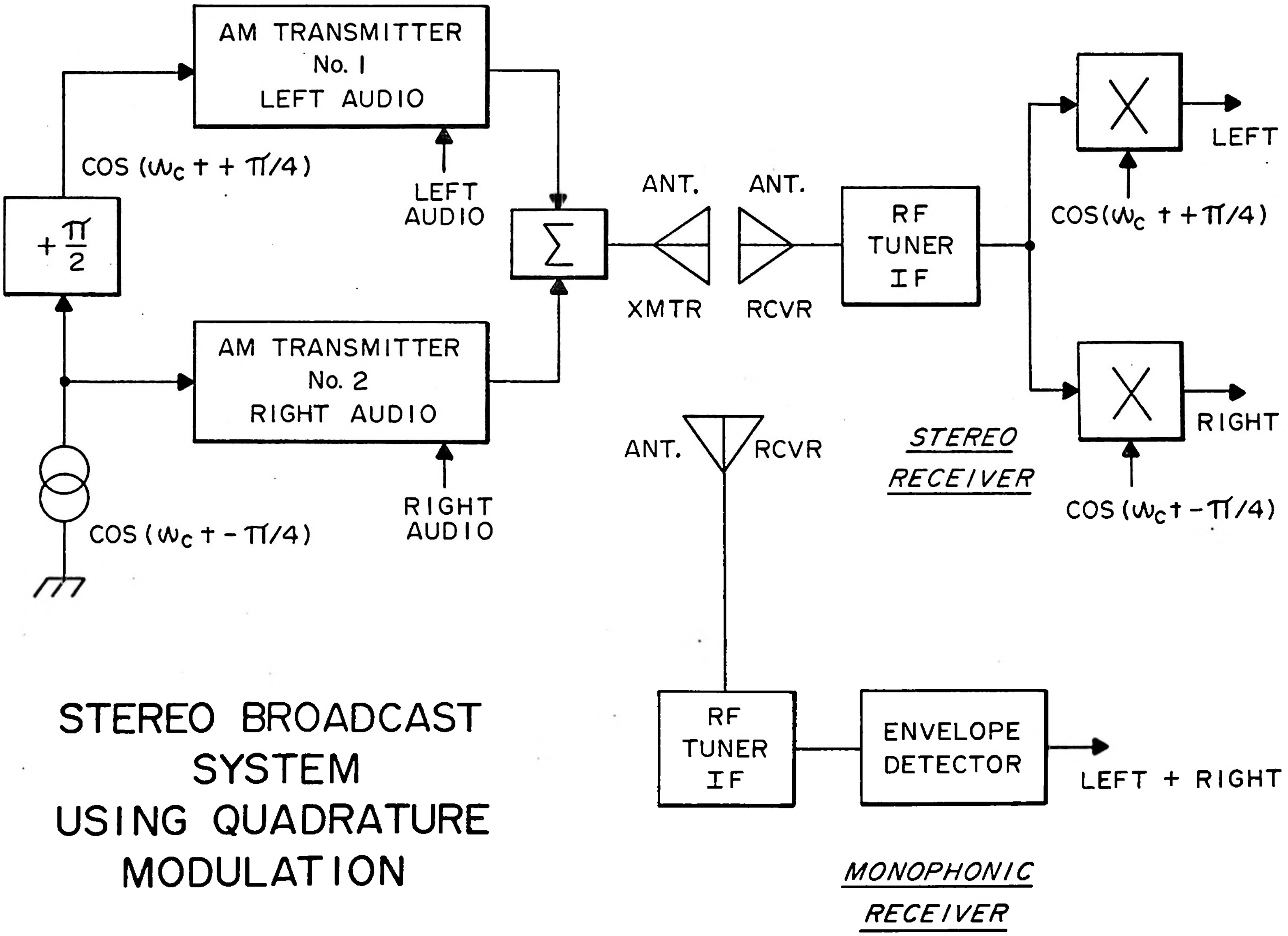
One of the most convenient ways of transmitting two signals on one carrier is to separately modulate two carriers of the same frequency, chosen to be in phase quadrature with each other.

This method is probably best known as the method by which the two separate color signals are separately transmitted on a single subcarrier for color television. It has well known significant advantages in the areas of noise performance and matrixing. Noise in the quadrature channel is not a function of the modulation in the in-phase channel (independent). Further, matrixing can be accomplished either after detection or in the process of detection (so-called RF matrixing) by choice of the angle of synchronous detection.

A transmitter arrangement for generating two signals in quadrature is shown in Fig. 1. In this system two separate transmitters are supplied from a single crystal carrier frequency generator with carrier signals in quadrature. The transmitters are modulated with separate left and right signals respectively, and the power output of each transmitter is combined in a common antenna load. In the monophonic receiver both carriers are received and detected in an envelope detector so that the output of the detector is a compatible L(t) + R(t) signal.

At the stereo receiver each carrier can be detected separately by means of two synchronous detectors. Each detector demodulates one of the modulated signals so that left and right may be derived directly.

The receiver for synchronous detection is quite simple, but the requirement that two transmitters be used to generate the signal makes this an impractical



STEREO BROADCAST SYSTEM USING QUADRATURE MODULATION

FIG. 1

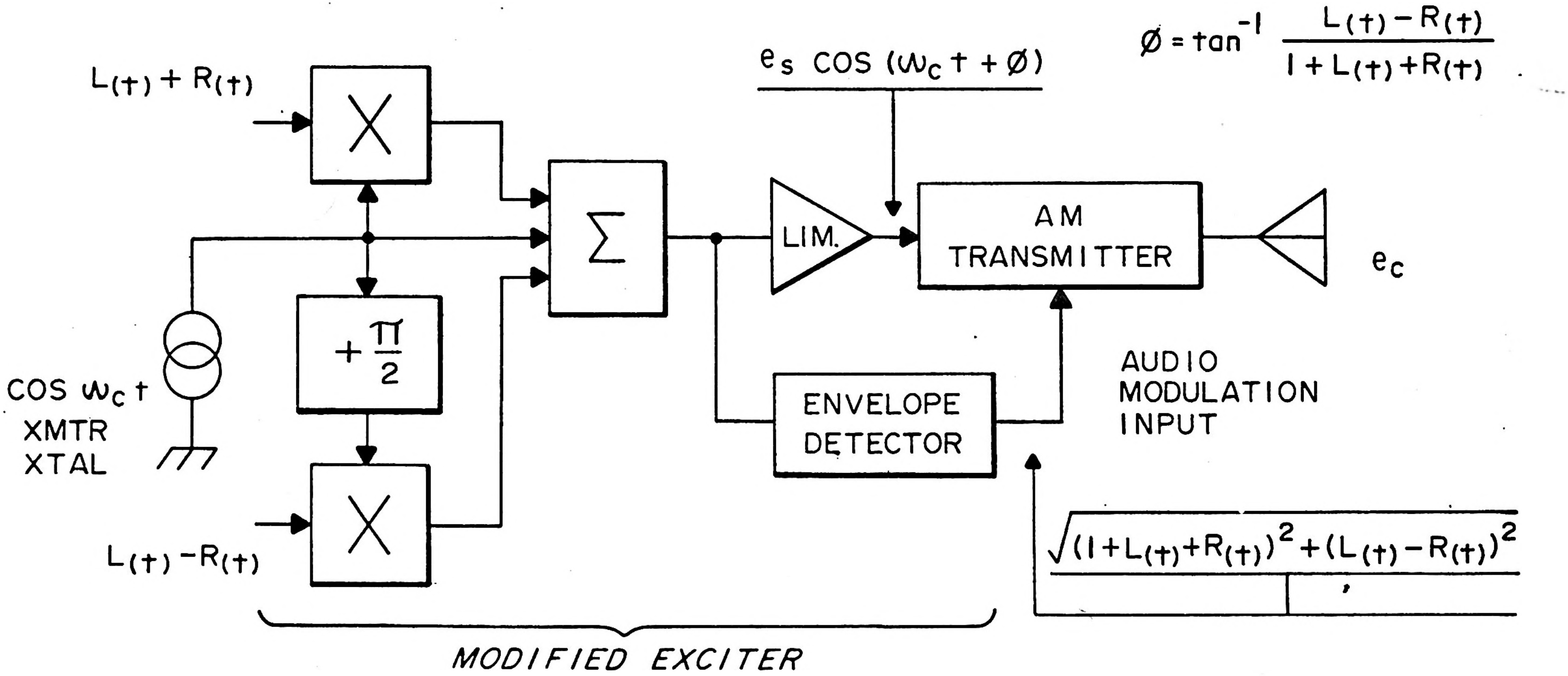
arrangement for the transmitter.

Fig. 2 shows a block diagram of a modification of a single transmitter providing a quadrature signal identical to the one supplied by the combined transmitters of Fig. 1.

The transmitter crystal oscillator feeds a first balanced modulator deriving a suppressed carrier, double sideband signal representative of the sum signal, L(t) + R(t). The double sideband signal and the carrier signal derived from the oscillator together provide a double sideband signal, amplitude modulated with L(t) + R(t). When the carrier is also shifted 90° and supplied to a second balanced modulator, sidebands representing L(t) - R(t) components are generated in quadrature with the L (t) + R(t) signals. When these signals are combined in a summing device, the output of the summing device is a low level quadrature signal identical to the output of the two transmitter system. It can be seen from the equations representing the output signal that the signal can be represented by either the sum of two separately modulated signals or a single carrier phase modulated by Ø and an envelope described by the square root of the sum of the squares of the sum and difference signals. By using a limiter the phase modulation component can be added to the signal directly at the transmitter exciter input. The required envelope can be derived from the composite signal with an envelope detector and used as the audio input to the modulator.

Systems of quadrature modulated stereo were extensively field tested in the New York area in the early 1960's by both CBS and Philco, using a transmitter scheme similar to the one described here.

The ability to generate QUAM (quadrature amplitude modulated signal) by simple modifications to the exciter of an existing transmitter, and the ability



$$e_c = \frac{1}{\sqrt{2}}(1+L_{(t)}) \cos(\omega_c t + \pi/4) + \frac{1}{\sqrt{2}}(1+R_{(t)}) \cos(\omega_c t - \pi/4$$

$$e_c = \sqrt{(1+L_{(t)}+R_{(t)})^2 + (L_{(t)}-R_{(t)})^2} \cos(\omega_c t + \phi)$$

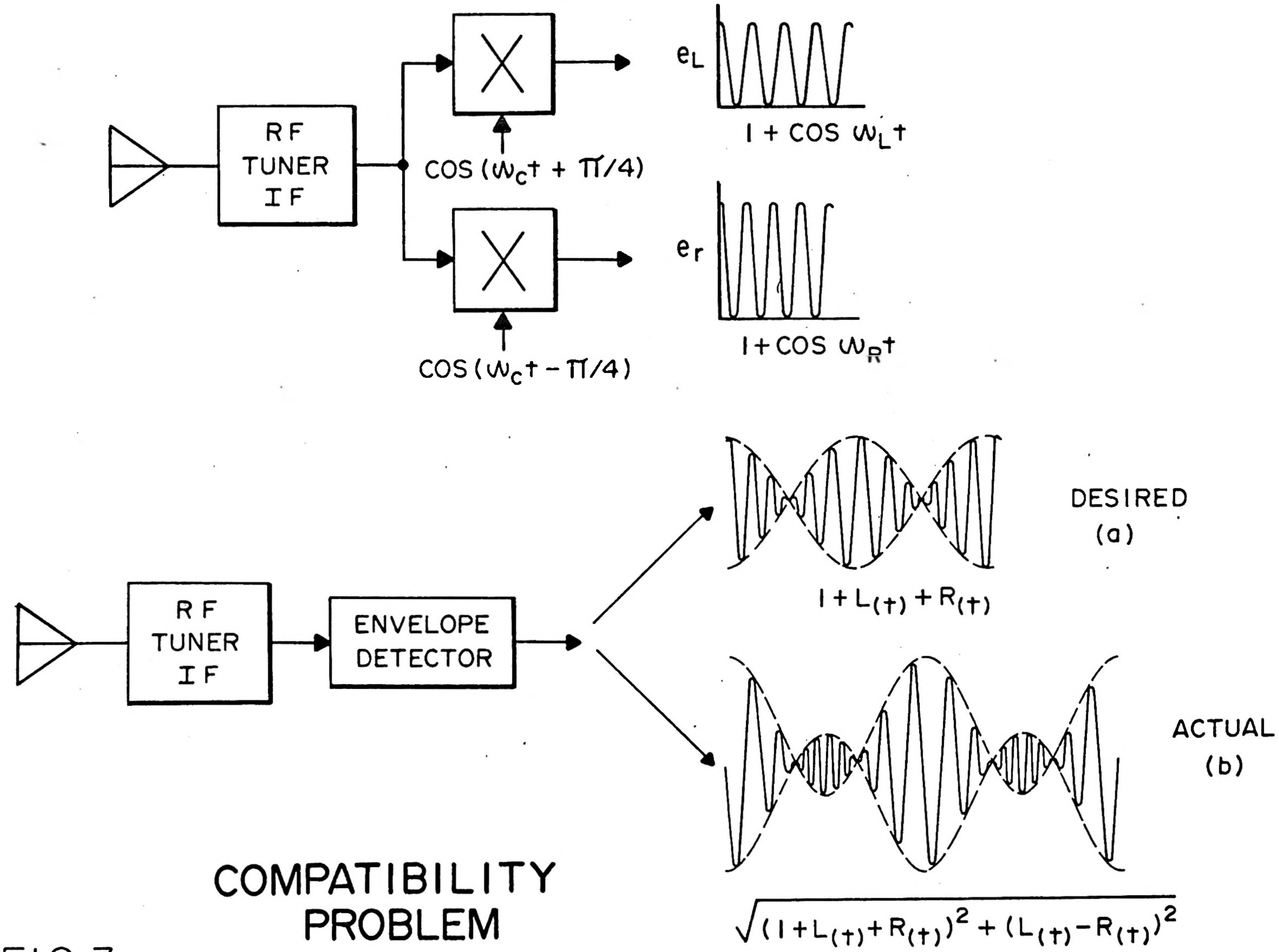
FIG. 2 SINGLE TRANSMITTER QUAM SYSTEM

to receive the sum signal on existing receivers, together with the simplicity of decoding makes this system of stereophonic broadcasting very attractive. It has well-known advantages of spectrum efficiency, noise performance, and matrix decoding options.

The problem with this system arises in the monophonic receiver when the transmitted signal contains a significant amount of stereo information.

Fig. 3 shows the conditions that exist in a receiver designed to receive stereo signals when the transmitter is modulated with two separate signals. One signal modulates the Right channel and a second signal (different in frequency) modulates the Left channel. Both signals are equal in amplitude and the sum of the two fully modulates the transmitter on peaks. While the stereo receiver separates the two signals into their original Left and Right signal content, the monophonic receiver is required to deliver a signal which is the sum of the two.

A linear sum of the two simple harmonic functions of equal amplitude should provide a signal exhibiting simple beats as shown at (a) as the desired signal. This signal consists of peaks which fully modulate the transmitter and occur when the sum of L and R are maximum, together with nulls which occur when the difference of L and R is zero. The actual recovered signal, however, is derived from the modulating audio signal which is the envelope equation shown at (b). If in the envelope equation the two signals are equal, i.e., L=R, and the transmission is basically monophonic, then the signals recovered at the L and R outputs of the stereo receiver are identical. At the same time the L(t)-R(t) term in (b) is defined as zero and envelope equations of (a) and (b) are identical. When L≠R, i.e., when stereo is present, the signal recovered from the envelope detector is not the linear sum of Left and Right but contains a significant amount of distortion (about 14% I.M.). This is shown in (b) where, at the nulls in the L(t) + R(t) signal which are maximum for L(t) - R(t), a double frequency signal



COMPATIBILITY PROBLEM

FIG. 3

is added and the null is distorted.

Hence, the difficulty with this simple QUAM system is the distortion generated in existing receivers when the stereo content of the broadcast signal is significant.

C-QUAM

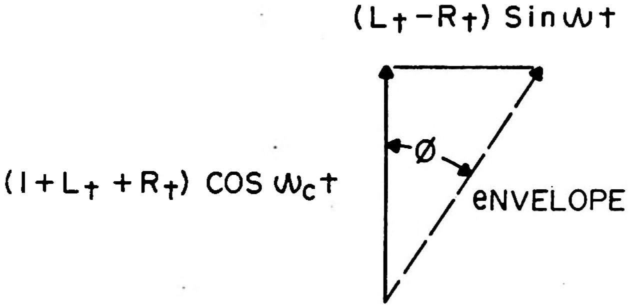
Fig. 4 shows how the QUAM signal can be modified so that the envelope detector receives a compatible sum signal. C-QUAM is generated by amplitude modulating (L+R) a carrier which retains the phase information of the above described QUAM signal. At the receiver, the phase information is utilized to restore C-QUAM to QUAM in the decoding process.

Mathematically the modified system provides compatible QUAM or C-QUAM by modulating both the in-phase and quadrature terms of QUAM by the cosine of the modulation angle, thus retaining the transmitted QUAM phase while producing a compatible envelope. Practically, this is accomplished by generating QUAM, limiting, and then re-modulating with 1+L+R.

As shown in Fig. 5 the transmitter modification is less complex than that required for the transmission of QUAM on a single transmitter. The exciter is fed with the same phase modulating signal, however, no envelope detector is required and the transmitter is modulated with the monophonic compatible sum signal L(t) + R(t).

Fig. 6 shows the relationship between the monophonic receiver and the modified stereo receiver. The output of the envelope detector corresponds to the modulation input to the transmitter and is thus compatible for stereophonic broadcasts without distortion when separate signals are used in Left and Right. At the stereo receiver the C-QUAM signal is divided by the cosine of the angular

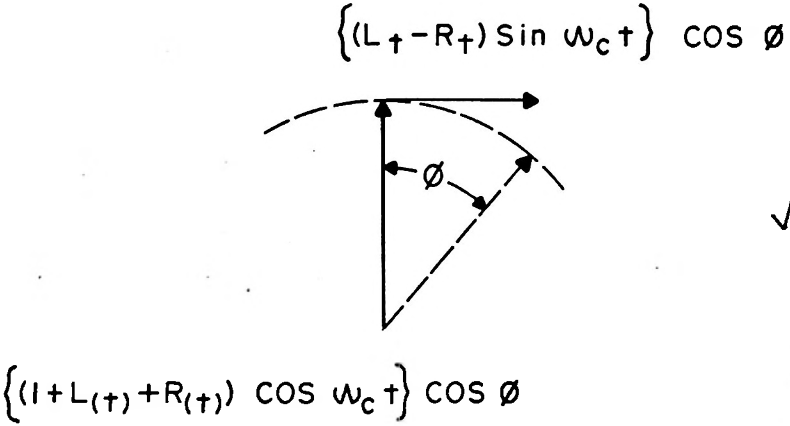
C-11



$$e_\Sigma = \overbrace{\sqrt{(1+L_{(t)}+R_{(t)})^2+(L_t-R_{(t)})^2}}^{\text{ENVELOPE}} \quad \overset{\text{CARRIER PHASE}}{\cos(\omega_c t+\phi)}$$

$$\phi = \tan^{-1}\frac{L_t-R_t}{1+L_t+R_t}$$

QUAM

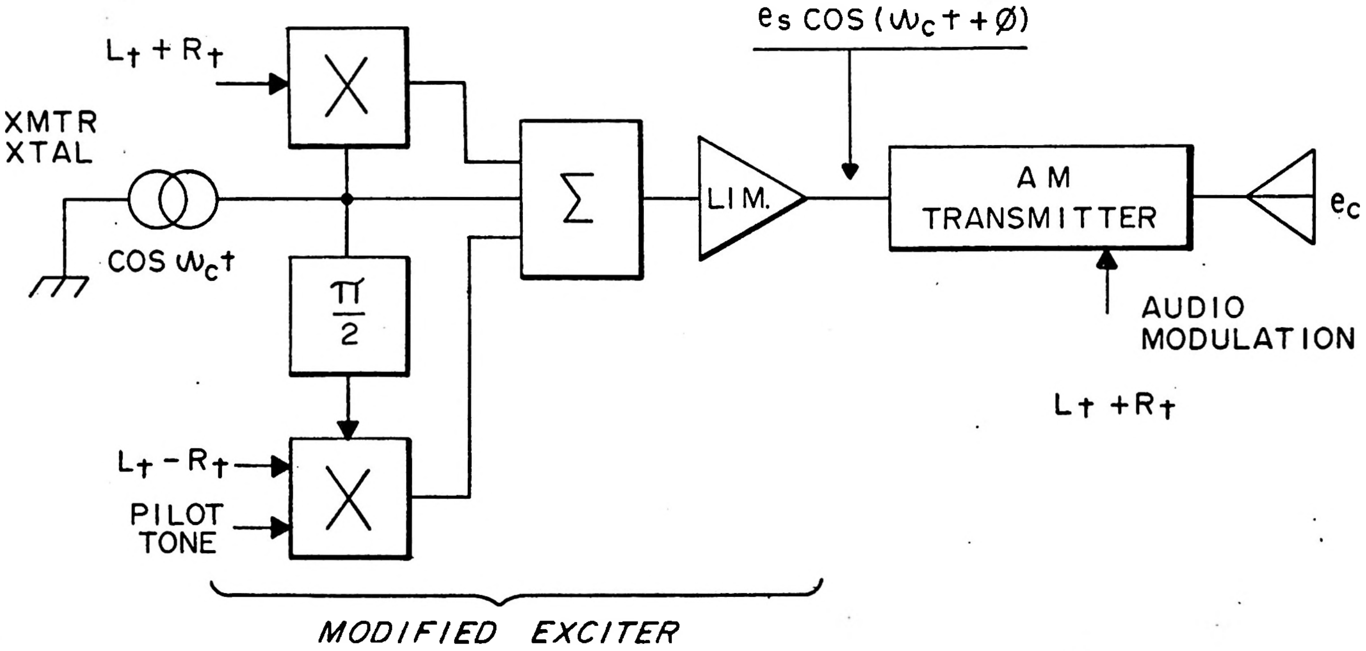


$$\sqrt{(1+L_t+R_t)^2+(L_{(t)}-R_{(t)})^2} = \frac{1+L_{(t)}+R_{(t)}}{\cos\phi}$$

$$e_\Sigma = \overbrace{(1+L_{(t)}+R_{(t)})}^{\text{ENVELOPE}} \quad \overset{\text{CARRIER PHASE}}{\cos \omega_c t+\phi}$$

FIG. 4

C-QUAM



$$e_c = A_c(1+L_t+R_t)(\cos \omega_c t + \phi)$$

$$\phi = \tan^{-1} \frac{L_t - R_t}{1 + L_t + R_t}$$

FIG. 5 C-QUAM TRANSMITTER

STEREO RECEIVER
MODULATOR
RESTORES QUAM

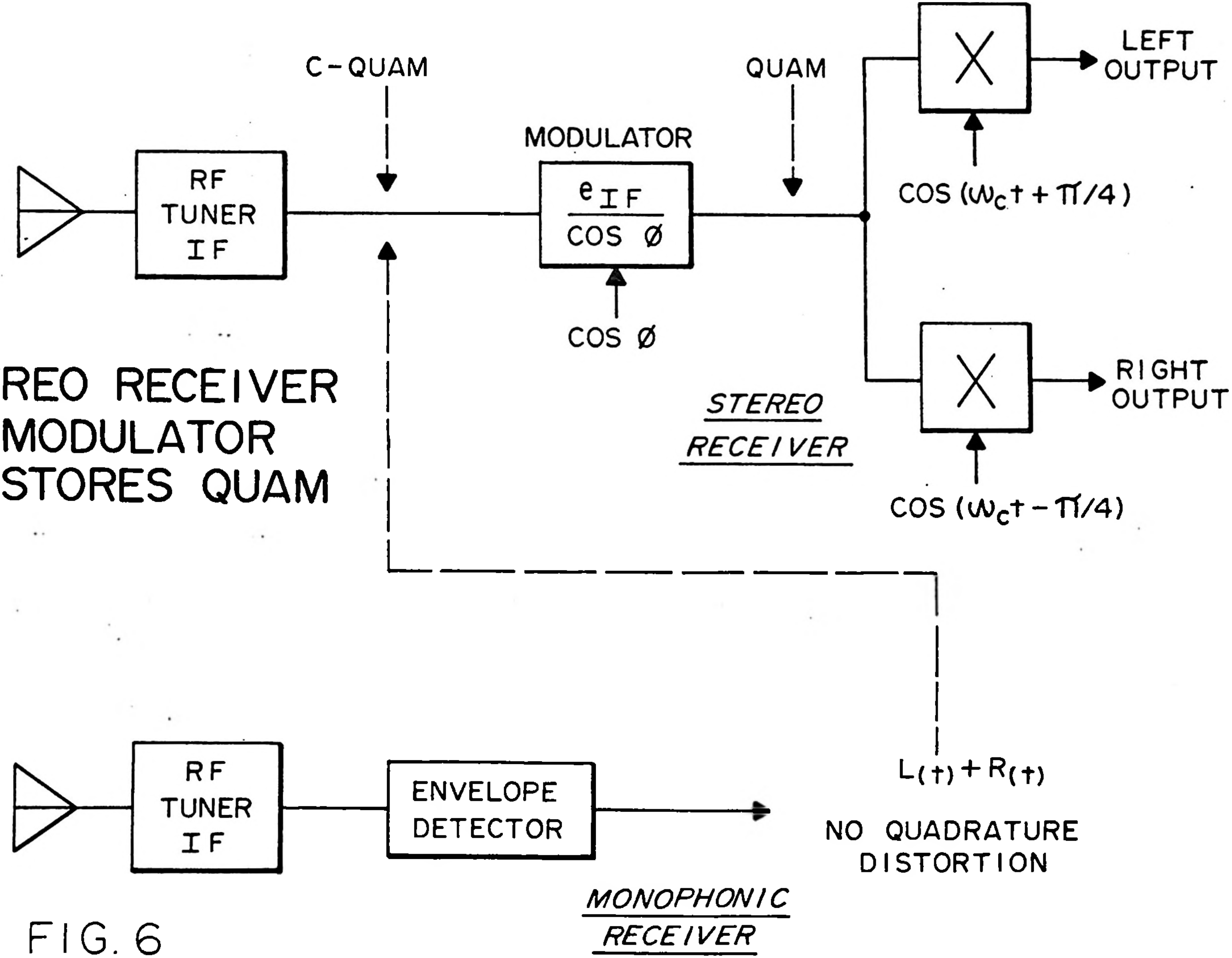


FIG. 6

modulation so that the original QUAM signal can be restored and detected by a pair of quadrature detectors. This process could occur after demodulation as well as before.

A block diagram of one possible receiver realization is shown in Fig. 7. Here the output of the IF amplifier is applied to a carrier level modulator and a limiter. The V.C.O. which is locked in phase quadrature with the IF carrier (sin $w_c t$) is used with the limiter output to provide input signals to a phase detector circuit. The phase detector and low pass filter provide the control signal which maintains the V.C.O. locked in phase quadrature relationship with the IF carrier signal. The V.C.O. output is shifted 90° to provide a signal in phase with the IF carrier (cos $w_c t$). When the phase shifted V.C.O. signal is used together with a signal from the limiter to supply the phase detector, a signal proportional to cos $\emptyset$ is derived. The cos $\emptyset$ signal may be used to supply the carrier level modulator which restores QUAM signals at its output. The Left and Right signals can then be demodulated by synchronous detectors (balanced modulators), supplied with signals at cos $(w_c t \pm \pi/4)$ to derive Left and Right directly since the signals are QUAM at their inputs (that is, RF matrixing could be employed).

Since most QUAM or phase modulation receivers use both an in-phase and a quadrature detector, the quadrature to control the V.C.O., and the in-phase for squelch or bandwidth control of the P.L.L., the only additional element in the C-QUAM receiver is the carrier level modulator.

Fig. 8 shows one of the possible methods which may be used to convert the signal current for the Left and Right demodulators from C-QUAM to QUAM. The output of the IF amplifier is supplied to the differential amplifier formed by T_1 and T_2. T_1 and T_2 act as current sources supplying signal current to the

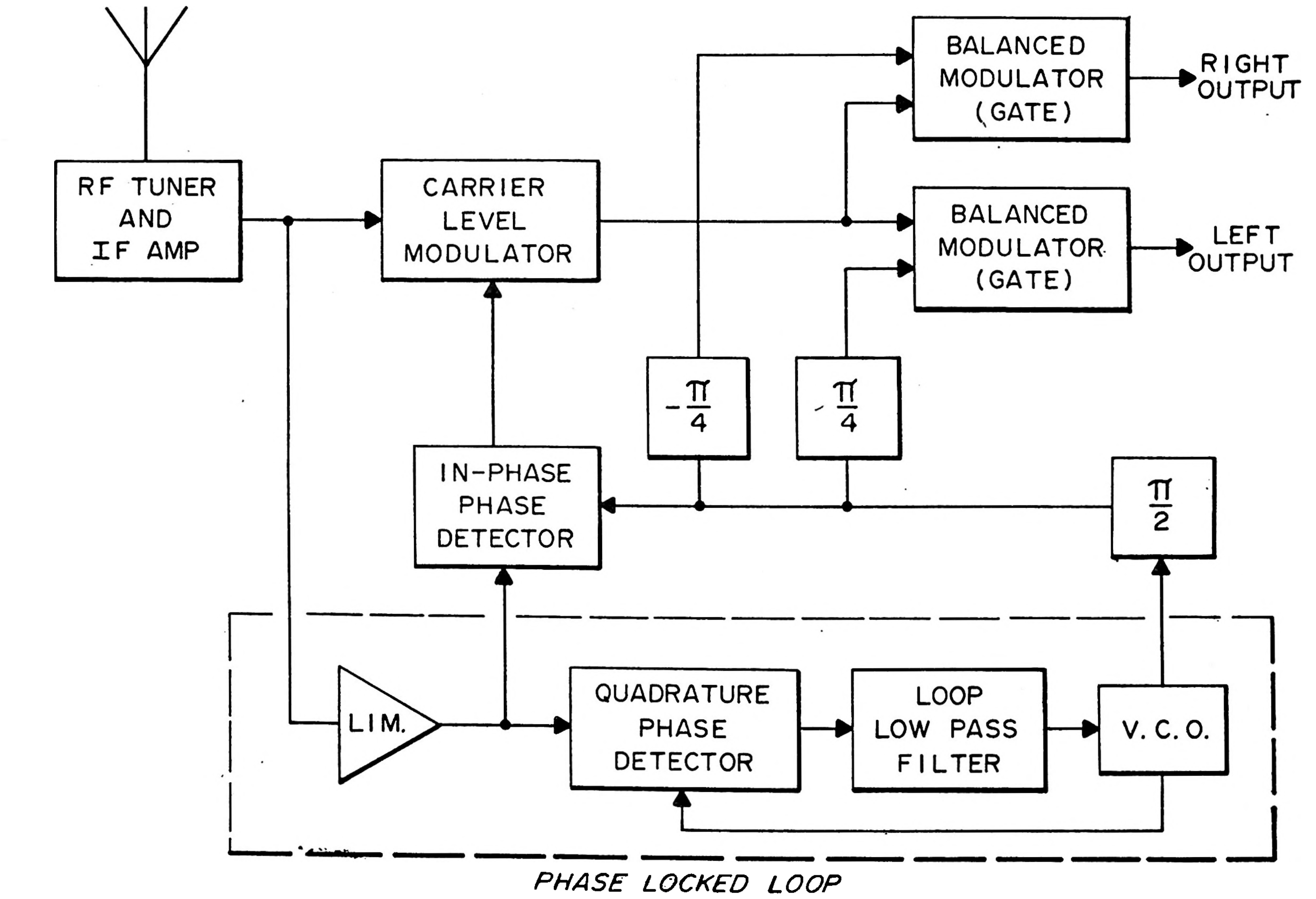


FIG. 7

C-QUAM RECEIVER

C-15

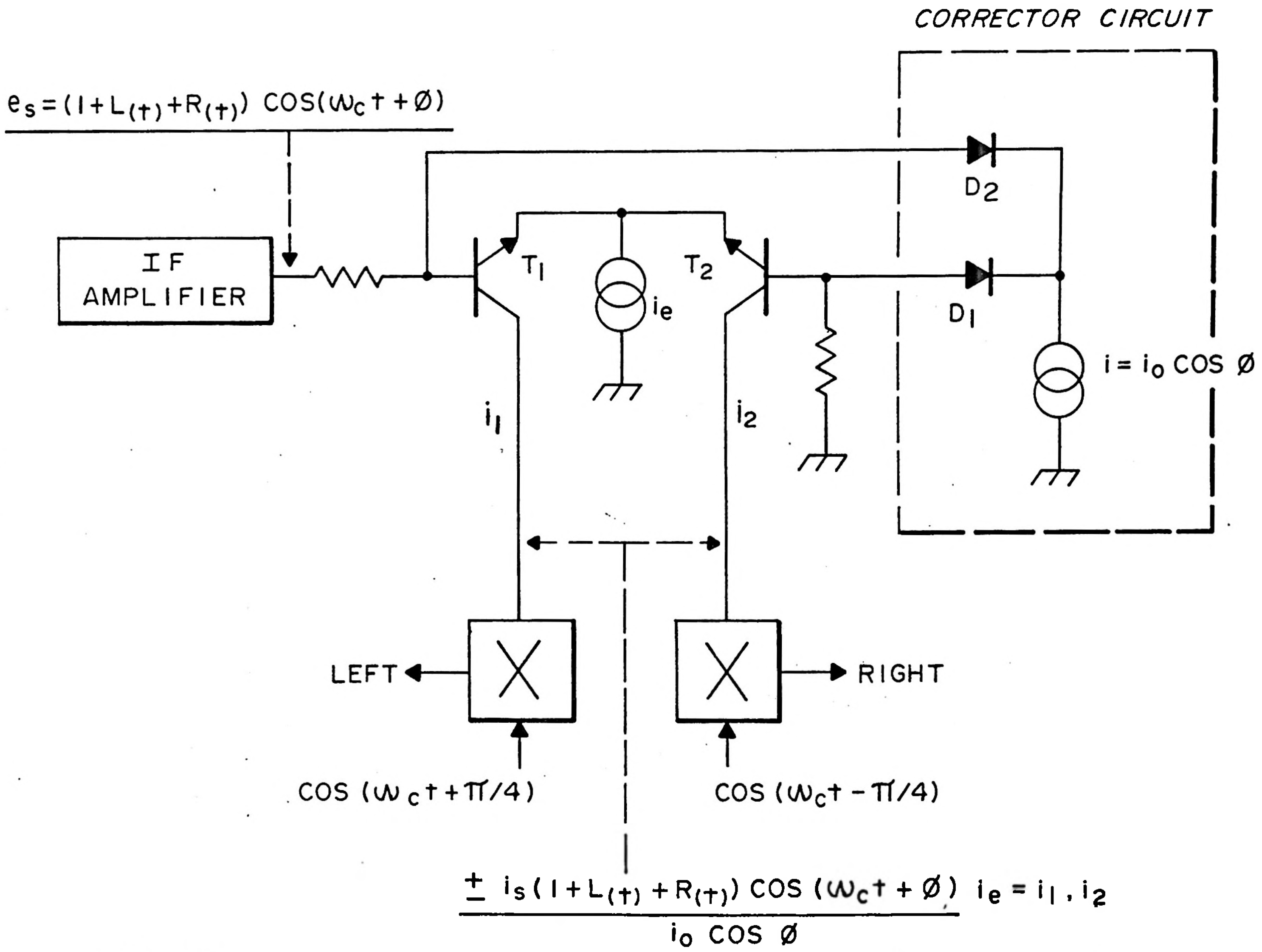


FIG. 8

ANALOG MODULATOR OR DIVIDER

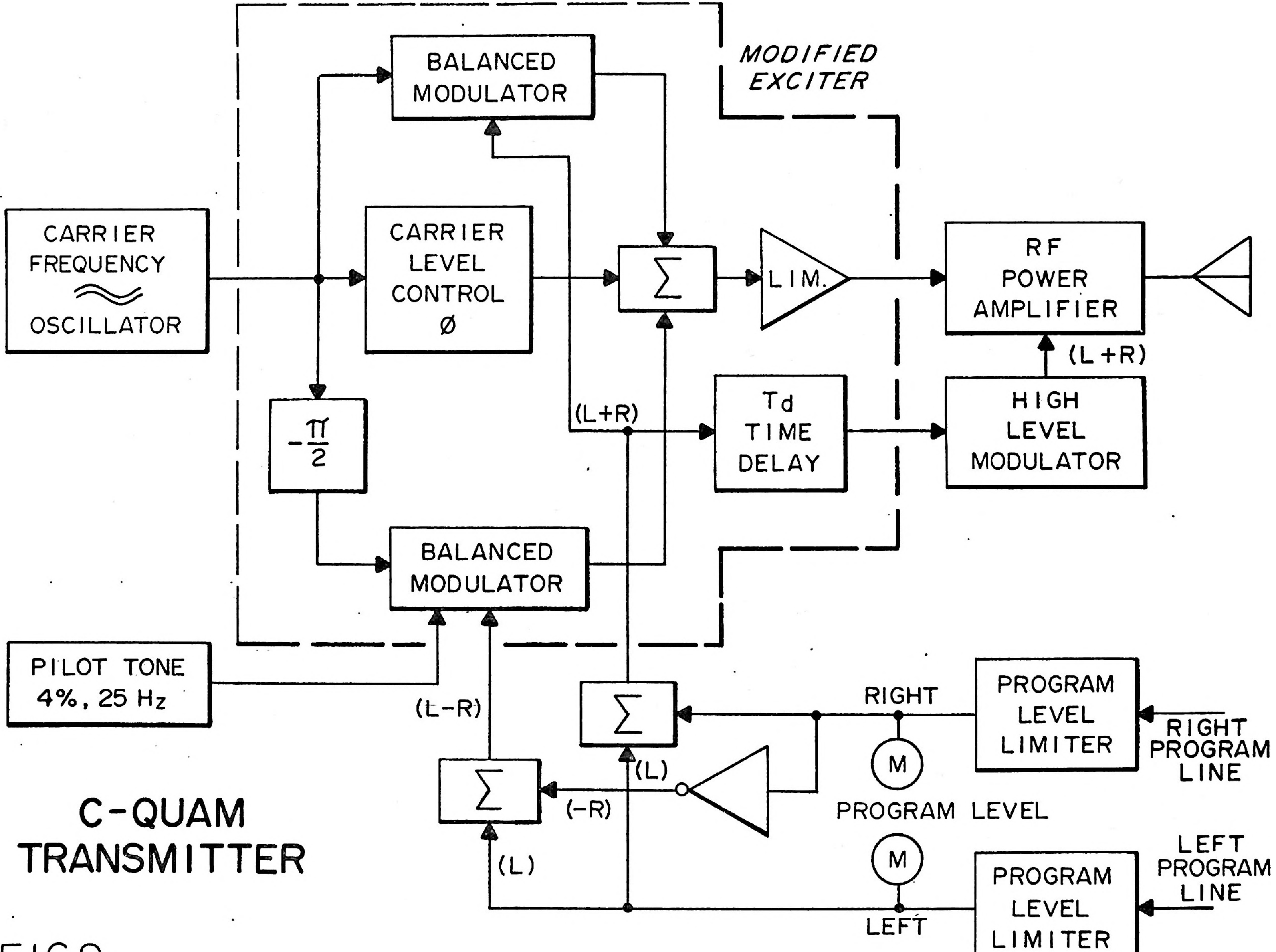
switching gates controlled by the demodulating reference signal. These current sources are present in the QUAM receiver, the only added elements are the diodes D_1 and D_2 together with the base resistors fed by the current source $i_0 \cos \emptyset$. Since the current source $i_0 \cos. \emptyset$ is derived from the in-phase detector already used in the receiver. The only new elements are the two diodes and two resistors which perform the signal transformation. This type of analog divider is commonly used in commercially available IC designs, and has been shown to function extremely well.

Fig. 9 shows a block diagram of a method of implementing a complete transmitter. The Left and Right signals are passed through program limiters to the indicators M. The Left signal is supplied to two summing devices while the Right signal is supplied together with L to form L + R signals. The phase of the Right signal is reversed and combined with L in the second summing device to provide L - R signals. The carrier frequency is supplied to a balanced modulator together with the L + R signals to provide L + R sidebands. An adjustable level carrier of L + R phase is added to the L + R sidebands to provide an AM signal with the appropriate degree of modulation. The second balanced modulator is fed by L - R and the phase shifted carrier frequency oscillator signal and provides the quadrature signal at the output of the carrier frequency summing device. The L - R modulator also includes a 4%, 25Hz pilot tone.

The limiter provides the proper phase modulation at the transmitter exciter input and the L + R is used to modulate the transmitter after a time delay sufficient to compensate for the delay in the phase modulated signal in the transmitter power amplifier stages.

CONCLUSIONS

The C-QUAM system thus provides a simple means of eliminating the distortion usually associated with the reception of a stereo AM signal by a monophonic



C-QUAM TRANSMITTER

FIG.9

receiver, while at the same time maintaining all of the system performance advantages of quadrature modulation. In addition, a pilot tone is included for potential receiver features.

C-QUAM may be decoded with a variety of methods. This discussion has illustrated one, and the following hardware implementations used in the NAMSRC Field Tests show another. Several additional alternatives are being explored in the Motorola Laboratories, and will be described in the near future.

III. C-QUAM ENCODER AND MONITOR

The Motorola C-QUAM encoder and monitoring equipment used at the NAMSRC Field Tests were designed to function as a self-contained unit. This package contained a universal encoder and the equipment necessary to monitor its performance. See figure 1. The top of the relay rack contains a Tektronix TM506 rack, with a SC502 dual trace oscilloscope, a MR501 X-Y monitor, a SG502 oscillator and a Motorola C-QUAM monitor. Below this rack is a HP331A distortion analyzer. Under this is a Motorola C-QUAM encoder. Under the encoder are two 801B1 variable delay lines. The bottom of the rack contains a Clarion audio amplifier, for listening purposes.

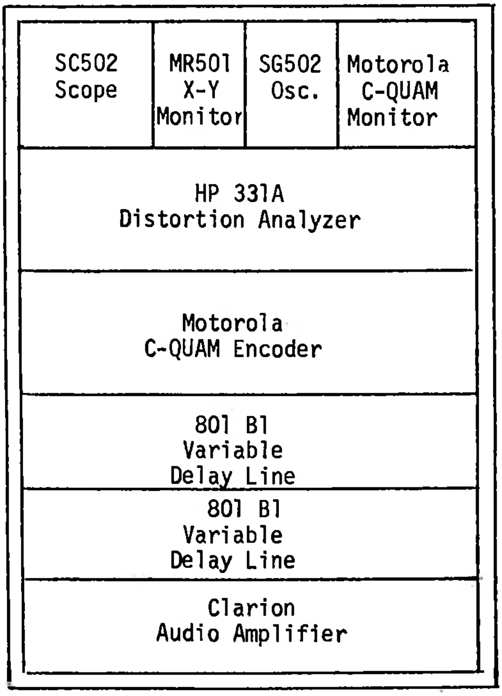


Figure 1

MOTOROLA C-QUAM ENCODER

The Motorola C-QUAM encoder was designed to be as versatile as possible. A block diagram is shown in figure 2. Left and right balanced 600Ω transformers go to gain controls feeding two variable delay lines. This allows the L + R (amplitude) matrix or the two (L + R, L - R) RF phase matrixes to be switched to direct or delayed audio. This gives a means to correct for any group delay differences between the audio modulation system and the RF system of any AM transmitter. Field experience on five transmitters has shown that in the future one small delay circuit in the RF exciter line will probably be adequate.

A transmitter is fed R + L audio modulation through a 600Ω balanced transformer. Two balanced modulators (1496 IC's) are fed L + R, audio with D.C. offset, L - R audio, and RF carrier at 0° and 90° respectively. This quadrature RF carrier comes from a Johnson counter fed by a crystal oscillator running at 4 x F_C. The outputs of the two balanced modulators are linearly added and then filtered with a single tuned bandpass. The bandpass output is then limited, amplified and filtered with another single tuned bandpass. This is the phase modulated RF signal that feeds the RF exciter of a transmitter. The limited RF signal also feeds another 1496 balanced modulator with D.C. offset that is used as a small transmitter.

The modulator used in the NAMSRC tests has extra features for convenience and signal analysis. There are right and left VU meters with precision gain stops, and a switchable meter for monitoring R + L level, RF out, exciter out, and AGC gain (not used in any tests). Several internal test points are brought out to BNC jacks; carrier CW, R + L balanced modulator and R - L balanced modulator. There are switches for inverting audio phase, for making R = L, delay line switches, gain controls for correcting delay line loss, and a switchable negative audio limit. There is also a switch that feeds a 25Hz pilot tone into the L - R balanced modulator at a 4% level.

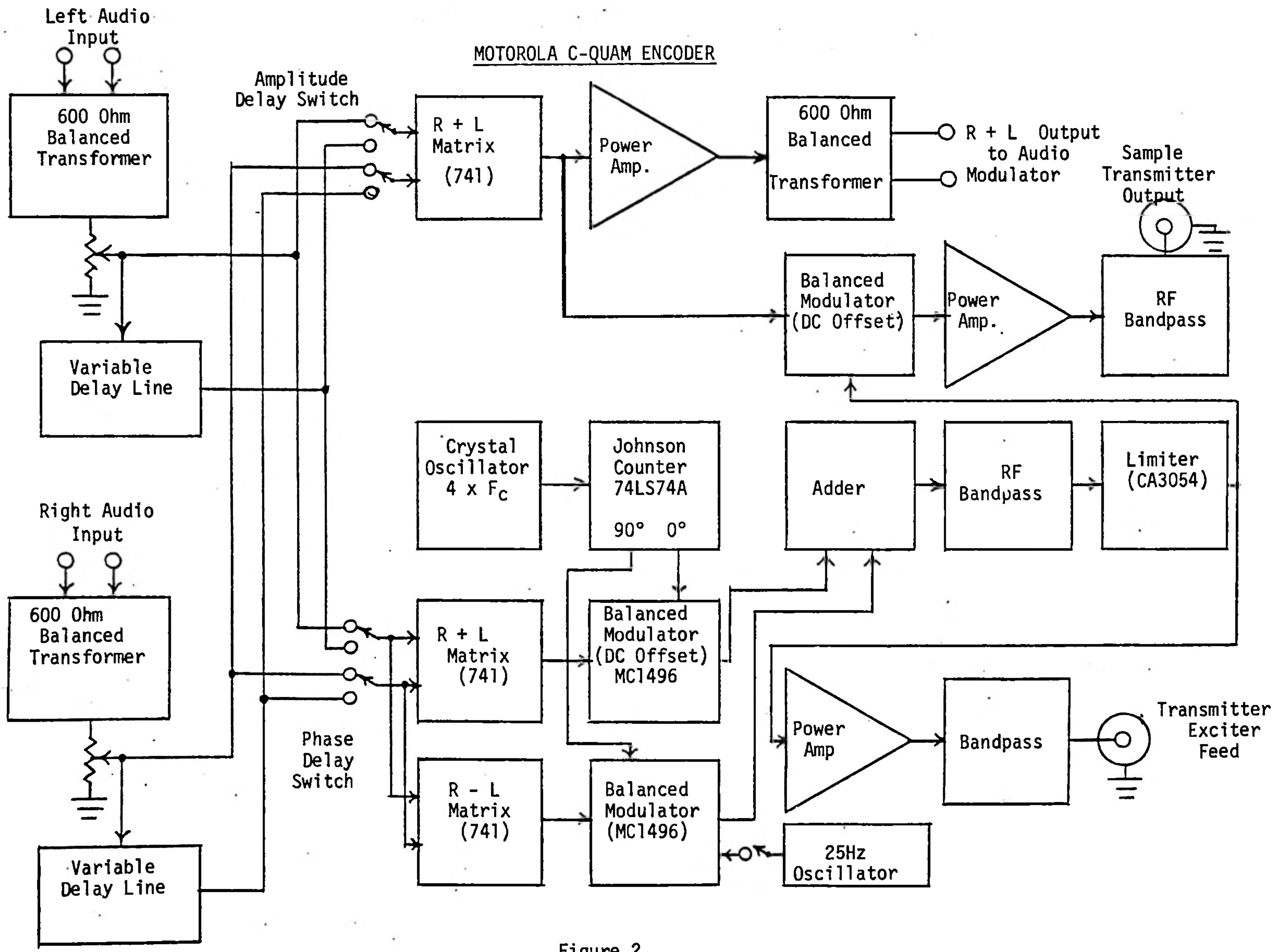

MOTOROLA C-QUAM ENCODER
Left Audio Input
600 Ohm Balanced Transformer
Variable Delay Line
Right Audio Input
600 Ohm Balanced Transformer
Variable Delay Line
Amplitude Delay Switch
Phase Delay Switch
R + L Matrix (741)
Power Amp.
600 Ohm Balanced Transformer
R + L Output to Audio Modulator
Sample Transmitter Output
Balanced Modulator (DC Offset)
Power Amp.
RF Bandpass
Crystal Oscillator 4 x F$_c$
Johnson Counter 74LS74A
90° 0°
Adder
RF Bandpass
Limiter (CA3054)
R + L Matrix (741)
Balanced Modulator (DC Offset) MC1496
R - L Matrix (741)
Balanced Modulator (MC1496)
25Hz Oscillator
Power Amp
Bandpass
Transmitter Exciter Feed

Figure 2

MOTOROLA C-QUAM MONITOR

The Motorola C-QUAM monitor decodes an RF signal into right and left audio output and also has output jacks at several intermediate circuit locations. A block diagram is given in figure 3. The RF signal is fed into the three balanced demodulators (MC1496 IC's). The first demodulator, feed with RF and limited RF, is used as an envelope detector of the AM information. The second demodulator detects the quadrature component of the RF by means of the 90° output of a Johnson counter fed by a crystal VCO running at 4 x F_c. The VCO is controlled by low pass filtered R - L signal. This feed back loop also has a 25Hz filter for pilot tone detection and since the filter has 180° phase shift at 25Hz, a portion is added to the loop to cancel any 25Hz that might get through the low pass filter. The third demodulator detects the cos of the RF phase angle. It is fed with limited RF and the 0° output of the Johnson counter filtered through a single tuned bandpass. The quadrature component is fed into an analog divider built with a MC1495 IC and 741 op. amplifier. It is divided by the cos angle detector, the output being R - L. The matrixing of the envelope information L + R and L - R gives the R and L output terminals. The envelope detector, quadrature detector, cos detector and L - R are also brought to output terminals for further testing and analyzing of the system.

MOTOROLA C-QUAM MONITOR

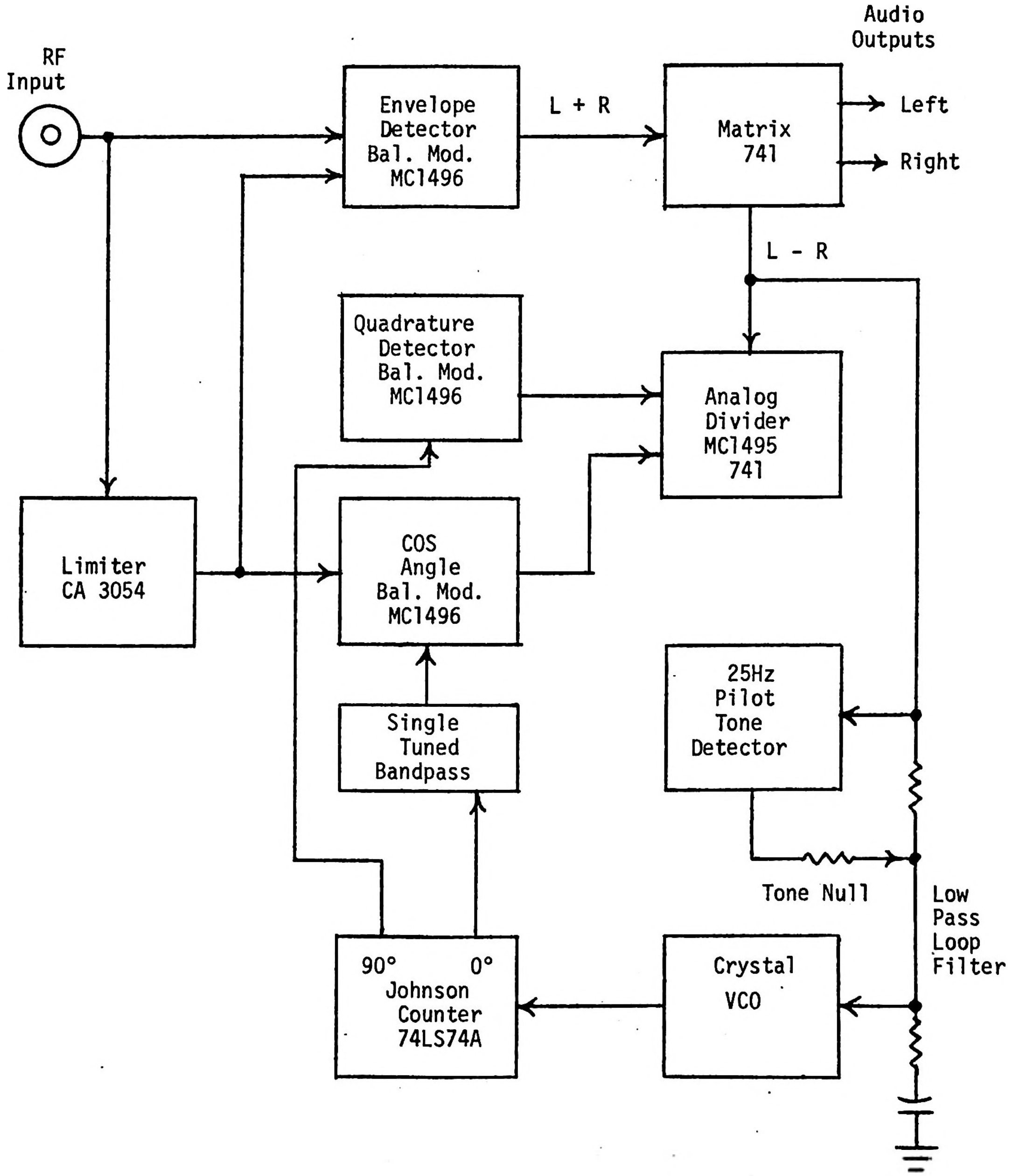


Figure 3

IV. MOTOROLA C-QUAM RECEIVER

The Motorola C-QUAM receiver used at the NAMSRC Field Tests consisted of three elements assembled into a single cabinet. Two of these elements,the AM receiver and the power amplifier, are commercially available units which have been modified slightly in order to interface with the Motorola C-QUAM decoder. The modifications were required to make the three elements function as a composite receiver.

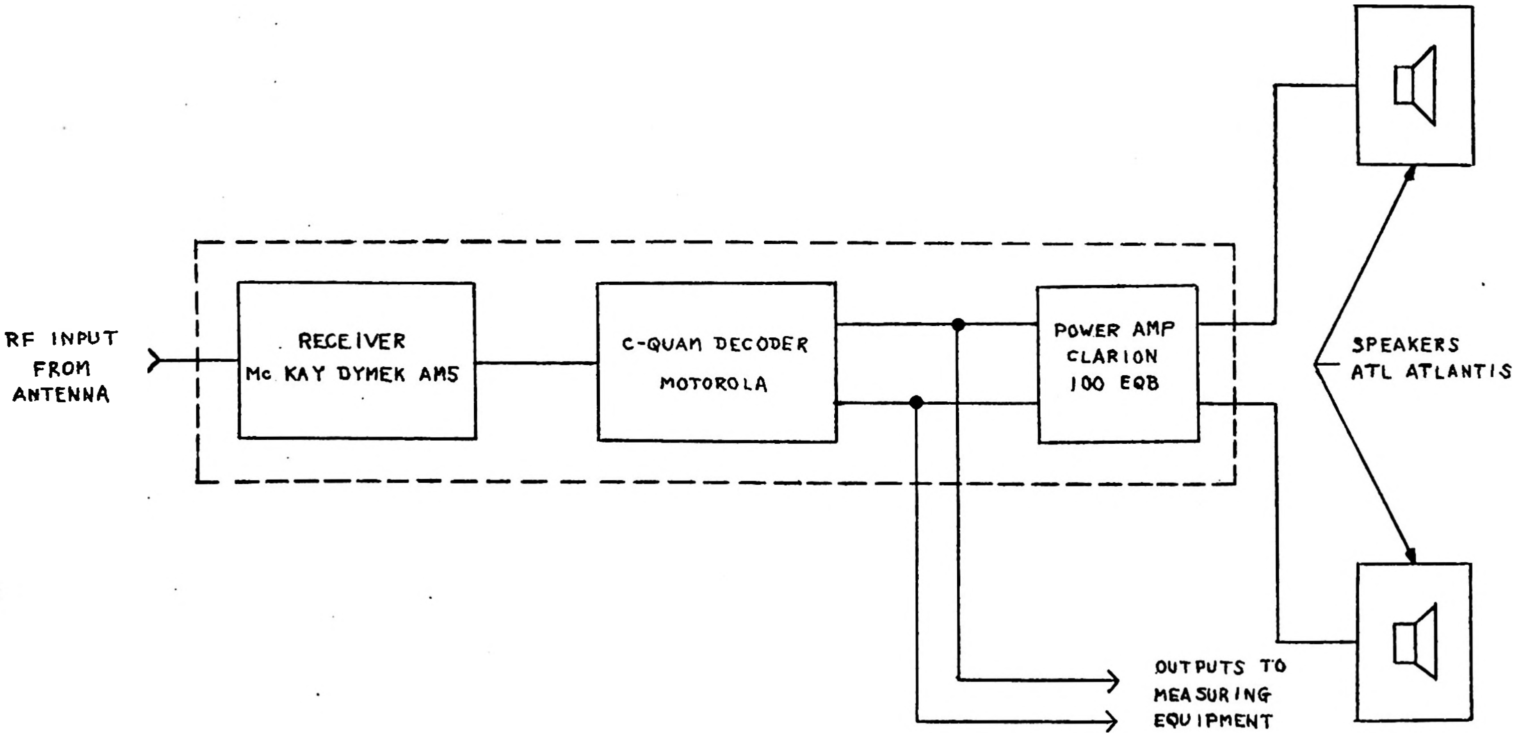
Although the speakers were a fundamental part of the receiving system, they were mounted outside the receiver cabinet. This was done so that the speakers could be physically set apart to more easily demonstrate the stereophonic effects.

The C-QUAM decoder decomposes the composite intermediate frequency signal into the desired left (L) and right (R) audio outputs. The envelope (L+R) information is obtained from a synchronous detector. Two other synchronous detectors are used to obtain the quantities $(L-R)\cos\phi$ and $\cos\phi$. These outputs are fed to an analog divider which yields the difference signal information at its output. The envelope detector output (L+R) and the divider output (L-R) are applied to the audio matrix which yields the desired L and R outputs. A fourth detector derives the signal which controls the operation of the phase-locked loop (PLL) and the squelch circuitry.

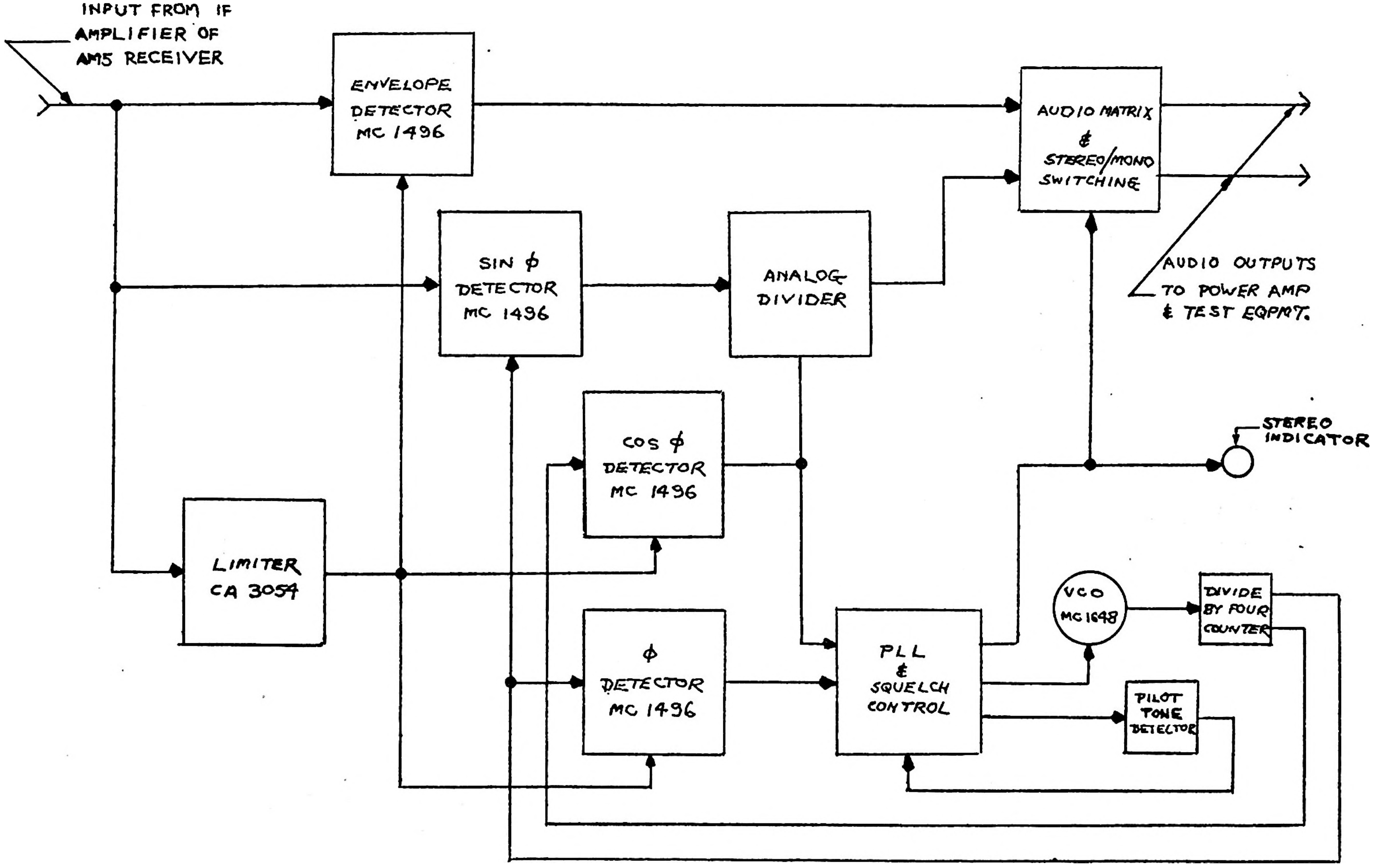
Block diagrams of the composite C-QUAM receiver and the C-QUAM decoder are shown on the following pages.

The C-QUAM decoder used at the NAMSRC Field Tests is not intended to be typical of a design approach for a high-volume production unit. The versatility of the C-QUAM system points to several methods of decoding and to opportunities for significant simplifications which are under investigation. These alternate decoder considerations will be examined in more detail in this proponent's individual filing and comments.

MOTOROLA C-QUAM
RECEIVER BLOCK DIAGRAM



MOTOROLA C-QUAM DECODER BLOCK DIAGRAM



A METHOD OF TRANSMITTING STEREOPHONIC INFORMATION IN THE AM BROADCAST BAND USING AN AM-FM MODULATION SYSTEM

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A METHOD OF TRANSMITTING STEREOPHONIC INFORMATION IN THE AM BROADCAST BAND USING AN AM-FM MODULATION SYSTEM

ABSTRACT

A system for transmitting stereophonic information in the AM broadcast band is described. Consideration is given to compatibility with existing monophonic receivers and minimum loss of station coverage range. Qualitative and quantitative analysis of the basic system concepts are explored and block diagrams of actual generation, monitoring, and reception equipment are presented. A discussion of the effects of nonideal system parameters is included.

INTRODUCTION

The widespread use of stereophonic recordings for home entertainment and for FM broadcasting has generated considerable interest in methods of transmitting "stereo" in the AM broadcast band. Traditionally, the additional program information required to produce stereo performance has been transmitted on an additional full bandwidth channel. In the case of recordings, this usually takes the form of a separate "track" on the record or tape, while in FM broadcasting a subcarrier, suitably spaced from the main carrier, is modulated with the required information.

Due to the bandwidth limitations imposed by present channel spacings, however, the AM broadcaster does not have the luxury of adding appreciably to his existing modulation spectrum. The problem is compounded by the fact that any transmission system which is to be seriously considered for broadcast use must be compatible with existing monophonic receivers; that is, the mono receiver must recover the sum total of the transmitted left and right information, and no objectionable distortion should be produced in the process. Additionally, the AM broadcaster would prefer to suffer no appreciable loss of station coverage range to either his mono or to his stereo audience.

These considerations have caused the gamut of possible AM stereo systems to be narrowed down to those systems which employ angle modulation of the RF carrier to convey the additional information. The system to be described in this paper is the "AM-FM" system proposed by Belar Electronics Laboratory, Inc., and tested by the National AM Stereophonic Radio Committee. This system is not without historical background, however, and was tested extensively (with minor parameter differences) by RCA as early as 1959. This paper will present the system as modified and tested by Belar.

BASIC SYSTEM CONCEPTS

The most general organization of a compatible AM stereo transmission system should amplitude modulate the carrier with a function $f_1(t)$ which is the linear sum of the left and right channel audio information, i.e. $f_1(t)=L(t)+R(t)$. Detection of this signal by the linear envelope demodulator of the monophonic receiver results in a "blend" of left and right channel audio. To facilitate the recovery of the stereophonic signals, however, additional information is required which relates what is different between the left and right channel signals. Moreover, the modulation of the difference information should be "transparent" to the envelope detector.

Various functions of L(t) and R(t) can be devised to describe the difference information, and several forms of angle modulation of the carrier have been proposed to satisfy the "transparency" requirement. The system described here employs the simple linear difference function, $f_2(t)=L(t)-R(t)$ to frequency modulate the carrier. The resultant RF signal then, appears as shown in FIG.1. It can be shown that, with proper IF filter and FM detector designs, the FM and AM components of the transmitted signal can be independently demodulated to yield (L+R) and (L-R). The linear addition and subtraction of these components will recover the original left and right audio channels.

BASIC TRANSMISSION & RECEPTION SYSTEMS

The simplest implementation of an AM stereo transmitter for the Belar AM-FM system is shown in FIG. 2. The left and right audio signals are applied to a matrix to generate (L+R) and (L-R) components. The (L-R) signal is pre-emphasized and frequency modulates the RF drive to the transmitter. The (L+R) signal then AM modulates the carrier in the normal fashion. The (L-R) modulation constants proposed for this system employ a peak low frequency deviation of ± 1.25 KHZ with a pre-emphasis time constant of 100 μsec. The stereo receiver must perform all the functions of a monophonic receiver in addition to providing a means of recovering stereophonic audio outputs. A typical implementation of a basic receiver for the Belar AM-FM stereo system is shown in FIG. 3. The RF and IF stages are typical of conventional AM receiver designs. The signal at the output of the IF amplifier is split into 2 separate detection paths. One path is applied to a conventional envelope detector where the AM information (corresponding to (L+R)) is extracted. The other IF output is applied to a limiting amplifier (which removes the AM modulation component) and is demodulated in a frequency discriminator. The resulting audio signal is de-emphasized to restore its original amplitude response and to enhance the signal to noise ratio of the (L-R) channel. The detected (L+R) and (L-R) components are applied to a simple audio matrix which performs the linear addition and subtraction required to recover the left and right audio information.

DETAILED TRANSMITTER DISCUSSION

A detailed block diagram of the AM-FM stereo exciter, as implemented by Belar (and tested by NAMSRC at WGMS, WTOP and WBT) is shown in FIG. 4. A frequency synthesizer, capable of operating on any 10 KHZ channel between 500 KHZ and 2000 KHZ is locked to a precision 3 MHZ frequency standard. The loop constants are chosen so that the voltage controlled oscillator (VCO) can be linearly frequency modulated without "loop following". The FM modulated output of the VCO is amplified to a level sufficient to drive the AM transmitter, and the RF is introduced in place of the usual crystal oscillator energy.

Left and right audio inputs to the stereo exciter are converted from balanced to unbalanced lines, and are individually level adjusted before being applied to the matrix. The audio matrix performs the linear addition and subtraction of L and R, resulting in the formation of (L+R) and (L-R) signals. The (L-R) component is pre-emphasized with a 100 μsec. time constant, and routed through a variable delay line to the FM modulator input. The variable delay line delays the (L-R) signal in selectable 2 μsec increments up to a maximum delay of 40 μsec. Delaying the (L-R) component in this fashion compensates for the delays imposed on the (L+R) component as it passes through the various stages of the transmitter modulator, and improves broadband stereo separation at the receiver or monitor. Initial delay matching is accomplished using the AM stereo station monitor as a detection standard.

The (L+R) component is level adjusted and is passed through a negative peak limiter circuit before being applied to the 600 Ω balanced input of the AM transmitter. The peak limiter is capable of holding negative modulation peaks to any preset value between 90 and 100%. For the NAMSRC tests, this circuit was adjusted on program material to limit negative modulation peaks to 95%. Positive peaks were allowed to modulate the transmitter well above 100%, insuring no loss in the station "loudness" in monophonic receivers.

DETAILED MONITOR DISCUSSION

A detailed block diagram of the AM-FM stereo station monitor, as implemented by Belar (and used in all NAMSRC tests of the Belar system) is shown in FIG. 5. A sample of the transmitter RF output, from a suitable monitoring point, is applied to the main RF input of the monitor. A carrier level independent AM demodulator recovers the (L+R) information from the envelope modulation. This detector supplies an audio output which is a function of the ratio of peak envelope voltage to average carrier voltage, and is independent of average carrier power changes or carrier shift. The RF input is also applied to an amplitude limiter, which removes the AM modulation, and then to a quadrature FM discriminator where the (L-R) information is recovered. The outputs of both detection channels can be disabled to facilitate the study of the loss of one or the other modulation channel, and to make totally independent modulation measurements at the audio output points. The (L+R) detector output is applied to metering amplifiers which allow independent measurement of positive and negative peak modulation, and is then fed to the audio matrix. The (L-R) detector output is also metered to allow measurement of the peak FM deviation, and is then applied through a 100 μsec. de-emphasis network, to the audio matrix. The left and right audio outputs of the matrix are individually metered to facilitate separation and response measurements, and are amplified to a level sufficient to drive headphones or speakers.

Measurements are made on two front panel meters. Meter A can be switched to measure positive AM modulation, negative modulation, or left channel audio output. Meter B can be switched to measure FM deviation or right channel audio output.

DETAILED TEST RECEIVER DISCUSSION

A detailed block diagram of the test receiver used for the NAMSRC field tests of the Belar AM-FM stereo system is shown in FIG. 6. Low level RF energy in the transmitter's far field induces a voltage in the remote shielded loop antenna. The signal is pre-amplified at the antenna and fed to the main RF section of the receiver. The AM stereo receiver is actually a developmental AM RF preselector designed for use with broadcast modulation monitors but its design is indicative of the impact which present day technology might have on future consumer AM receivers of quality design.

The receiver front end is broadband and passive, consisting of a 2 MHZ lowpass filter driving a doubly balanced diode mixer. The local oscillator drive for the first mixer is supplied from a low phase noise frequency synthesizer, and the output of this stage, at 10.7 MHZ is broadly filtered by a ceramic bandpass filter. Up-conversion to 10.7 MHZ eliminates image problems and the need for the attendant front-end preselection. The 10.7 MHZ output from the first IF is fed to an active mixer, with 10.44 MHZ local oscillator drive supplied by the frequency synthesizer. The 260 KHZ output from the second mixer is fed through a five pole L-C filter which sets the overall receiver selectivity, and is amplified in an AGC controlled IF amplifier.

The IF output of the preselector is routed to the stereo demodulator, which is identical to that employed in the stereo station monitor. Left and right audio outputs from the stereo demodulator are fed through a 10 KHZ whistle filter if necessary due to adjacent channel interference.

EFFECTS OF PARASITIC INFLUENCES ON SYSTEM PERFORMANCE

A number of parasitic influences in the transmission and reception equipment limit the overall distortion, separation, and noise performance obtainable. In the transmitter, any phase modulated noise or hum components, which might have been inaudible on monophonic AM receivers, will be demodulated by the stereo receiver's phase sensitive channel (L-R) to produce potentially objectionable noises at the left and right audio outputs. Similarly, the local oscillator employed in the stereo receiver must be designed to minimize extraneous FM modulations due to phase noise, hum or microphonics. Although the Belar AM-FM system has a distinct advantage over other phase modulated systems in these respects (owing to its much larger low frequency modulation index), optimum stereo performance will, nonetheless, require that proper attention be given to transmitter performance and receiver design.

Any source of AM to PM or PM to AM conversion will cause crosstalk which can degrade stereo separation and distortion. Typical sources of the former effect are incidental RF phase shifts caused as a result of the AM modulation process, and non-ideal limiters in the receiver circuit. A major source of PM to AM conversion is to be found in the receiver IF filter. The ideal IF filter for AM stereo should be nearly rectangularly shaped, and should display linear phase performance over a much of the passband as possible. The phase response of the station transmitting antenna can also limit overall stereo performance.

Systems which employ a matrix in the receiver to decode the stereo signal will need to maintain precise tracking of the (L+R) and (L-R) detector outputs over the full range of expected input signal strengths. Precision AGC is of some help but maximum effectiveness is obtained by the use of a carrier level independent AM demodulator as tested in this proposal, since any loss of tracking results in loss of separation.

CONCLUSIONS

The AM-FM method of transmitting AM stereo offers distinct advantages in simplicity, compatibility and ease of interfacing. Field tests have shown that with the normal amplitude distributions of program material, full bandwidth stereo transmissions can be accomodated in present channel allocations with negligable loss of station coverage or loudness.

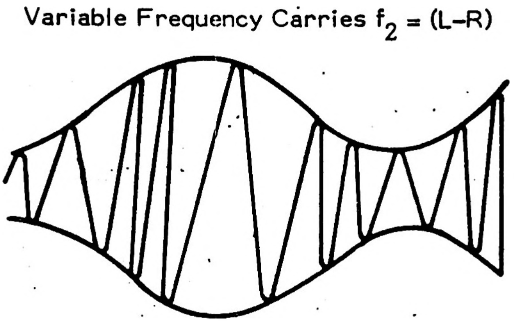


FIG. 1

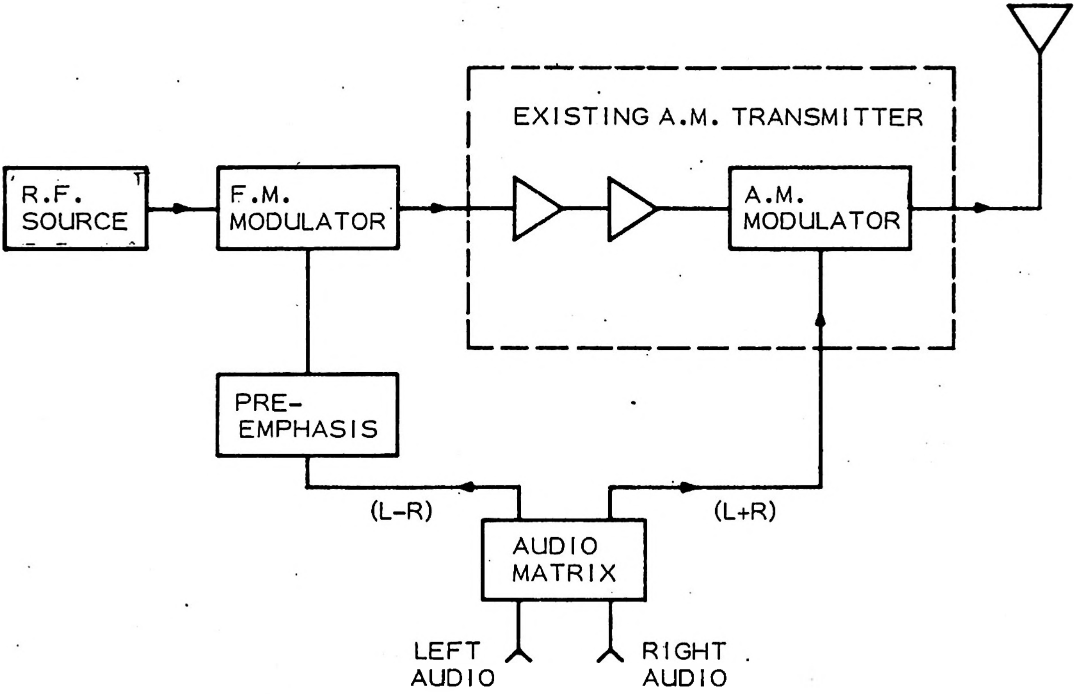


FIG. 2 THE R.F. INPUT TO A CONVENTIONAL TRANSMITTER IS FREQUENCY MODULATED

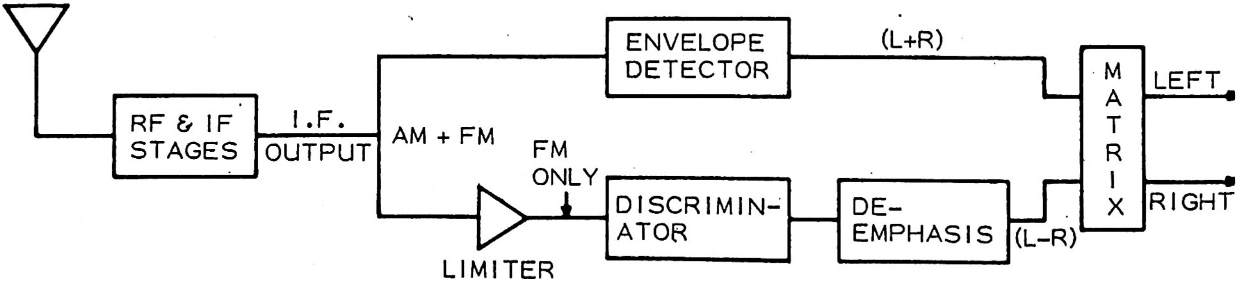


FIG. 3 BASIC RECEIVER FOR BELAR AM-FM STEREO SYSTEM

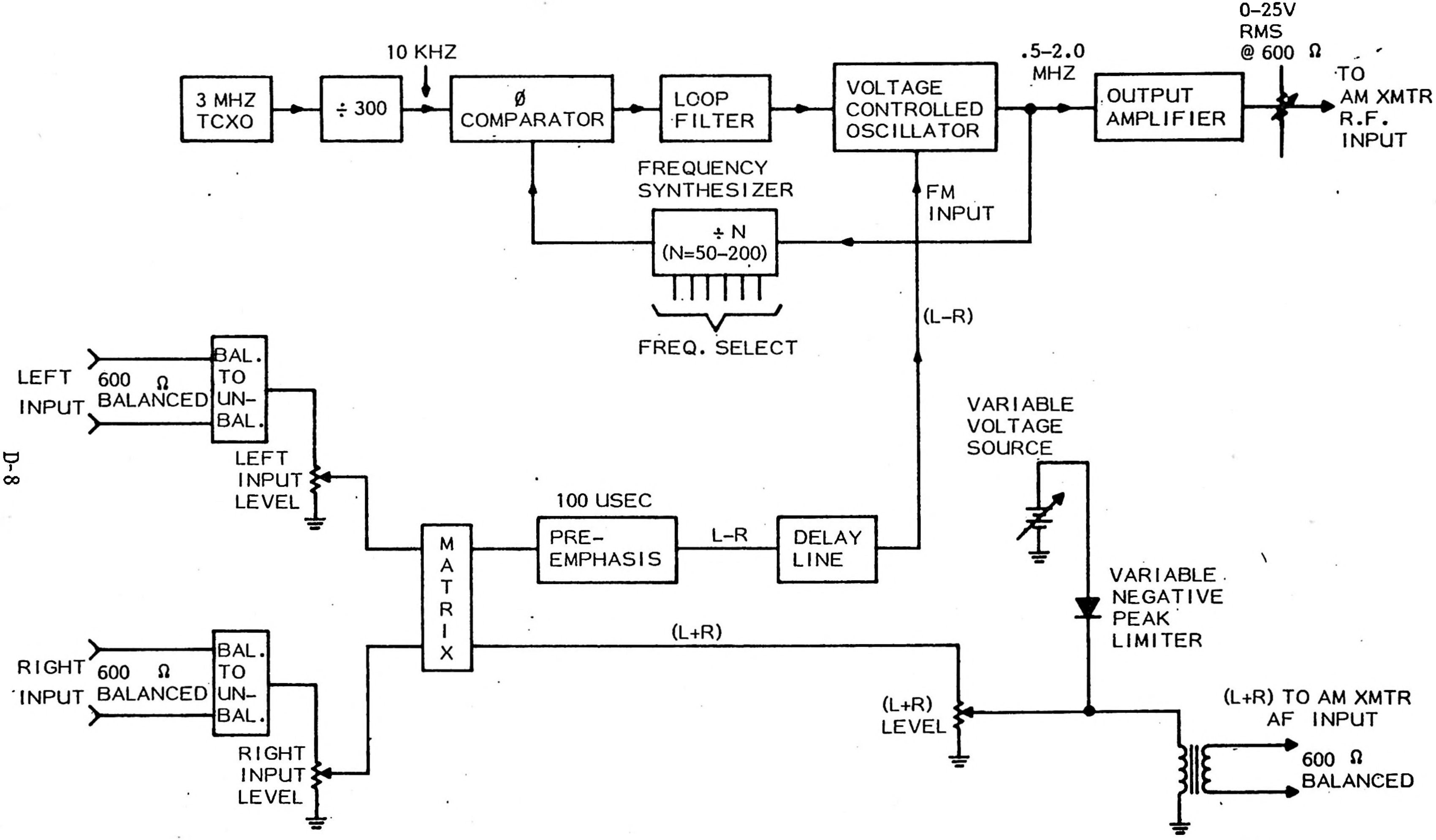


FIG. 4 DETAILED BLOCK DIAGRAM OF BELAR AM–FM STEREO EXCITER

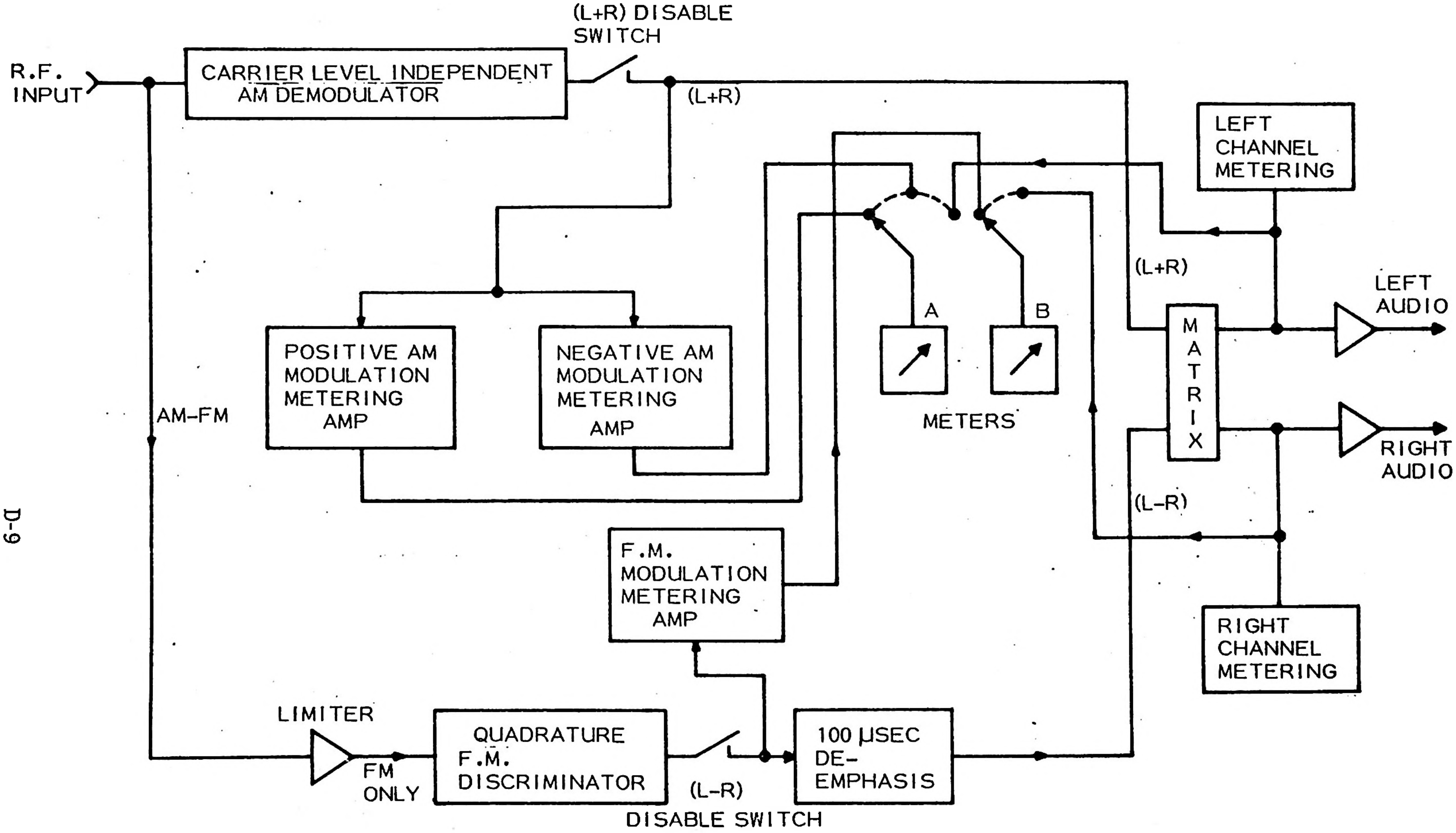
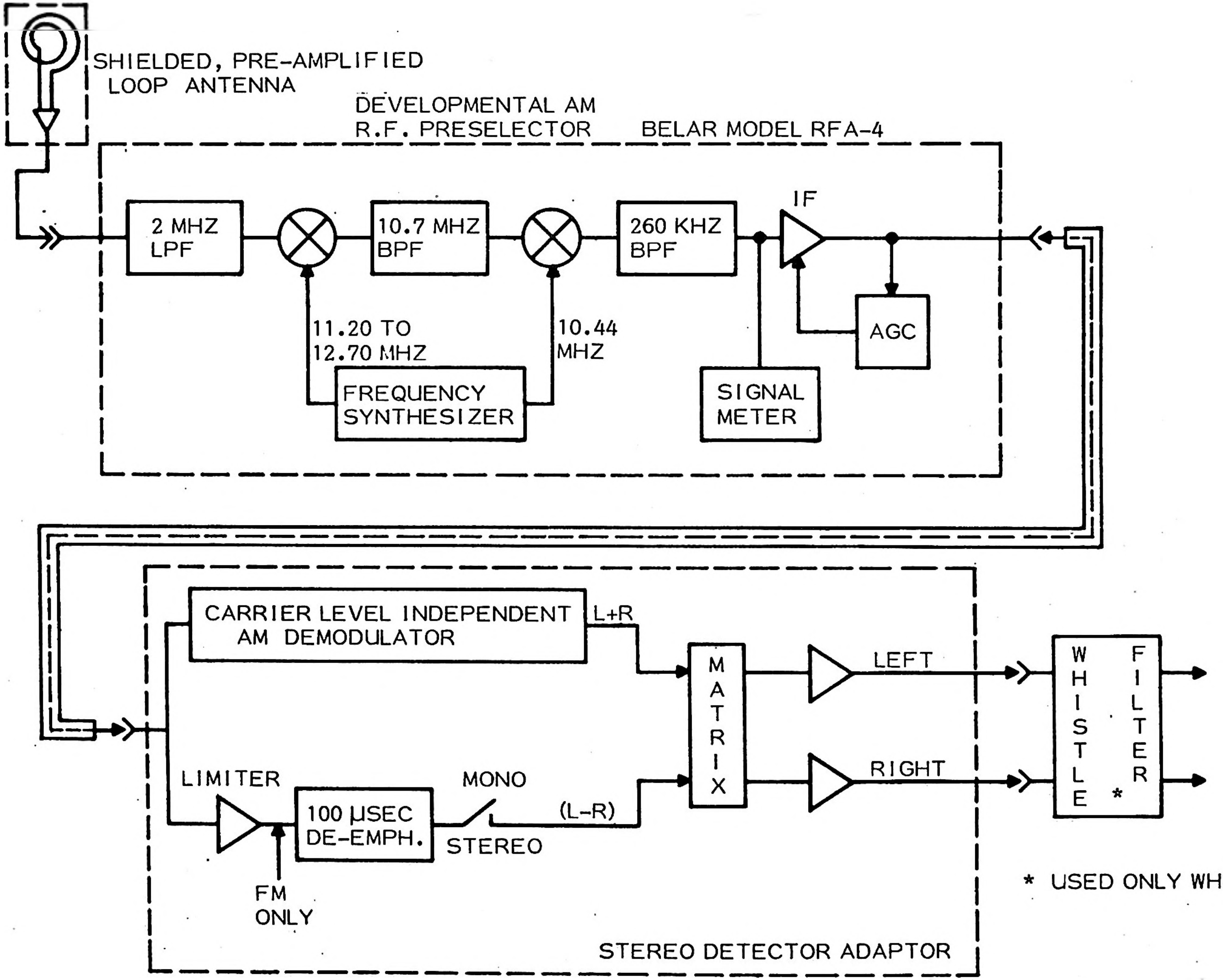


FIG. 5 DETAILED BLOCK DIAGRAM OF BELAR AM-FM STEREO STATION MONITOR



* USED ONLY WHEN NEEDED

FIG. 6 TEST RECEIVER USED FOR
BELAR AM-FM STEREO SYSTEM
FIELD TESTS

Panel I, Systems Specifications, began activity after the first organizational meeting of the NAMSRC with C. Eilers of Zenith Radio Corporation as Chairman and N. Parker of Motorola as Vice-Chairman. N. Parker was also appointed Chairman of a subcommittee charged with developing a System Analysis Chart and appropriate signal to noise ratio calculations for entry into the chart.

This report consists of the System Analysis Chart, Mathematical Expressions for the Radiated Signals and S/N Calculations.

THE SYSTEM ANALYSIS CHART

PANEL I

The System Analysis Chart is intended to provide a means of comparing the essential parameters of each system proposal using similar expressions to derive the value of each.

The chart covers the characteristics of the monophonic component or envelope of the signal, the biphonic component or the way the stereo information is used to vary the angular velocity of the carrier wave, and the composite signal which covers the range of signal parameters when all values of monophonic and stereophonic signal levels may be present.

The chart also gives the theoretical values for the signals at the left and right terminals separately, and finally the range of signal parameter compared to monophonic levels expected at the envelope detector of a compatible receiver.

Section 1.1 covers monophonic parameters.

Section 1.1.1 describes the information transmitted by the envelope and is the signal received by the existing monophonic receivers.

Section 1.1.2 gives the frequency response of the monophonic component measured at an appropriate monitoring point in the RF system for the systems proposed. The limitations will be governed by the characteristics of the transmitter plant and audio system, and restrictions imposed by the F.C.C. rules. Since these limitations apply to all systems of stereo transmission, no specific values will be specified for any system which does not have limitations preventing full band width transmission.

Section 1.1.3 gives the type of modulation used in modulating the monophonic signal component on the composite signal.

Section 1.1.3.1. indicates any downward limit on the modulation by the monophonic component due to stereo operation.

Section 1.1.3.2. indicates the limit placed on modulation peaks in the peak power direction. The existing rules allow peaks to reach 225% of carrier where the carrier is designated to be 100% when unmodulated. To achieve positive peak asymmetry it is required that the audio processor periodically reverse the phase of the audio signal to maintain the asymmetrical peaks in the positive direction. In stereo systems, it is necessary to reverse the phase of both channels simultaneously in order to maintain proper stereo sound fields. With the appropriate stereo processing techniques, there is no upper limit placed on the transmitter modulation which results from the transmission of stereo signals.

Section 1.2 covers the parameters governing the angular velocity modulation of the AM carrier by the biphonic or stereo signal.

Section 1.2.1. describes the type of information transmitted by the biphonic signal. This is intended to cover the signals which would be recovered from the channel which complements the monophonic signal to produce stereo signals.

Section 1.2.2. covers the bandwidth of the transmitted biphonic component. The bandwidth may vary from transmitter to transmitter depending on the response limitation of the RF power amplifiers. The response of the biphonic channel will not in general exceed the response of the monophonic signal. Since both these bandwidths are usually identical no numerical values will be given where no further system restriction is placed on the bandwidth of the biphonic signal.

Section 1.2.3. is a description of the type of modulation used to vary the instantaneous angular velocity of the radiated carrier.

Sections 1.2.3.1., 1.2.3.2. should be taken as the maximum and minimum values of the carrier level when the L(t) + R(t) signal is defined as zero. In order to be completely compatible the instantaneous amplitude of the carrier should be independent of the biphonic signal. This is true for modulating frequencies low enough for the carrier and sidebands to be received in the transmitted ratios at the envelope detector.

Section 1.2.3.3. is the maximum frequency or phase deviation applied to the unmodulated carrier by the biphonic signal.

In Section 1.3. the parameters for the composite signal are given in terms of the limits of modulation levels and phase or frequency deviation when both signals are present simultaneously.

Section 1.3.1. provides a description of the two signals transmitted by the composite signal and derived from the receiver decoder.

Section 1.3.2. is a description of the composite signal modulation.

Section 1.3.2.1. gives the lower boundary for instantaneous carrier level for any combination of L(t) and/or R(t) input signals.

Section 1.3.2.2. gives the upper boundary for instantaneous carrier level for any combination of L(t) and/or R(t) input signals.

Section 1.3.2.3. gives the maximum value of phase or frequency deviation for any combination of L(t) and/or R(t) and assumes the upper limits are symmetrical about carrier phase or frequency.

In Section 1.4. the resultant signals at the stereo output terminals are described. Since no bandwidth restrictions are assumed, the signals are those signals which would appear at the output terminals of an ideal wideband decoder.

In Section 1.4.1. the left signals are described.

Section 1.4.1.1. gives the signal content of the left output terminal. For full bandwidth systems the signal would be L(t).

Section 1.4.1.3. provides a measure of the noise level at either speaker terminal when the receiver is switched from monophonic to stereophonic operation.

Section 1.4.1.4. gives the maximum power at the left terminal in db where 0 db is equivalent to the signal at the left terminal in the stereophonic position with 100% modulation. The effect of a 5% residual carrier is neglected in estimating the power output with reference to 100% modulation of the monophonic signal since this limitation provides a minimal increase in negative peak clipping and should not effect the average program level.

Section 1.4.1.5. gives a value for the amount of crosstalk for any system which does not provide complete separation in the signal specification. When no system limitation on separation is present, no numerical value is given.

Section 1.4.2. same as Section 1.4.1, but for right channel signals.

Section 1.5 covers the received signal at the output terminals of an envelope detector with no bandwidth restrictions.

Sections 1.5.1 and 1.5.2 are subject to the same limitations as previously used for bandwidth restrictions (§ 1.1.2).

Section 1.5.3 the power levels are subject to the same interpretation used in 1.4.1.4.

Section 1.5.4 is the output obtained from an average detector instead of an envelope detector.

Section 1.6 covers all transmitted information with the exception of stereo information.

Section 1.6.1 covers stereo pilot signals.

Sections 1.6.1.1 and 1.6.1.2 cover the magnitude and type of modulation used for any pilot signal.

APPENDIX I

MATHEMATICAL EXPRESSIONS FOR THE RADIATED SIGNALS

The expression for the carrier voltage in an amplitude modulated system is:

(1) $E_c = A_c\ (1 + M\ F(t))\ \cos w_c t$

where A_c is the unmodulated carrier voltage

M is the modulation index (dimensionless)

F(t) is the modulating signal (normalized)

ω_c is the angular velocity of the carrier (radians/sec)

Now if stereo is transmitted it is essential for compatability that the envelope signal contain the monophonic information only. Since the monophonic component of the stereo signal is usually defined as:

(2) $E_m = F(t) = (L(t) + R(t))$

or the monophonic signal is the linear sum of the left and right components of the stereo signal.

The compatible signal must appear to have the following form when received on monophonic receivers.

(3) $E_c = A_c\ (1 + M_\Sigma\ (L(t) + R(t))\ \cos w_c t$

This form of signal provides a compatible sum signal but no provision for a second signal capable of converting the sum signal into separate left and right components.

The only way that this can be implemented within the boundaries of the existing channel allocations is to vary the carrier instantaneous angular velocity with the stereo signal so that:

$$E_c = A_c\ (1 + M_\Sigma\ (L(t)\ + R\ (t))\ \cos\ [w_c t + \phi_{ts}]$$

where ϕ_{ts} is the angular variation produced by the stereo signal.

All existing compatible stereo systems use this form of transmitted signal, the differences between the systems are all located in the ϕ_{ts} stereo term.

The basic assumption in all these systems (all that have been proposed both inside and outside the committee and including the Kahn proposal) is that if the rate at which ϕ_{ts} is varied (instantaneous frequency modulation) is low enough the phase modulation component will be ignored by existing receivers.

SYSTEM I MAGNAVOX PROPOSAL

The Magnavox Proposal uses phase modulation i.e. the phase deviation is independent of frequency but dependent on the modulating function.

$$\phi_{ts} = \phi_{max}\ [L(t)\ -\ R(t)]m_\Delta$$

where $\phi_{max} = 1$ radian

The radiated signal becomes:

$$E_c = A_c\ (1 + m_\Sigma\ (L(t)\ + R(t))\ \cos\ [w_c t + m_\Delta\ [L(t)\ -\ R(t)]]$$

The system operates so that in the case where L(t) = R(t) and $m_\Sigma = 1$ (100% modulation by the sum) that if the phase of L(t) or R(t) is reversed the deviation will be 1 radian; i.e. $m_\Sigma = m_\Delta = m$ so that

$$E_c = A_c \; (1 + m \; (L(t) + R(t)) \; \cos \; [\omega_c t + m \; L(t) - R(t))]$$

The composite signal also contains a stereo indicating pilot of $\pm$ 4 radians at 5 Hz so the composite signal is:

$$E_c = A_c \; (1 + m \; (L(t) + R(t)) \; \cos \; (\omega_c t + m \; (L(t) - R(t)) + 4 \sin 10\pi t)$$

A more general expression for the modulating signals is given when L(t) + R(t) is periodic over any arbitrary interval as:

$$L(t) + R(t) = \sum_{n=1}^{n=\infty} C_{sn} \cos \; (\omega_{snt} + \phi_{sn})$$

where C_{sn} is the magnitude of the n^{th} term of this sum signal and $= \sqrt{A_{sn}^2 + B_{sn}^2}$

A_{sn}, B_{sn} are the n^{th} order sine and cosine coefficients of the combined signal.

ω_{sn} = the n^{th} order angular velocity of the sum signal

ϕ_{sn} = angle at the n^{th} order term

$= \tan^{-1} (-\frac{B_{sn}}{A_{sn}}$

A_{sn} = cosine term

B_{sn} = sine term

and for L(t) - R(t)

$$L(t) - R(t) = \sum_{n=1}^{n=\infty} C_{dn} \cos \; (\omega_{dnt} + \phi_{dn})$$

where C_{dn} is the magnitude of the n^{th} order difference signal and $C_{dn} = \sqrt{A_{dn}^2 + B \; n^2}$

ω_{dn} = the nth order angular velocity term of the difference signal

$\emptyset_{dn}$ = angle of the nth order term

$= \tan^{-1}(- \frac{B_{dn}}{A_{dn}})$

A_{dn} = cosine term

B_{dn} = sine term

The generalized Magnavox Signal is:

$$E_c = A_c \, [1 + m \sum_{n=1}^{n=\infty} C_{sn} \cos (\omega_{snt} + \emptyset_{sn})] \cos \left[\omega_c t + m \sum_{n=1}^{n=\infty} C_{dn} \cos (\omega_{dnt} + \emptyset_{dn}) + 4 \sin 10 \pi t \right]$$

SYSTEM II BELAR

In this proposal $\emptyset_{ts}$ is composed of a frequency modulation term with a peak deviation of 1250 Hz together with a pre-emphasis network having a time constant of 100μs f_o = 1600 Hz

Since the modulating difference signal L(t) - R(t) increases at a rate of 6 db/octave above 1600 Hz the FM term becomes: (using the same generalized notation).

$$1250 \sum_{n=1}^{n=\infty} C_{dn} \sqrt{1 + (\frac{\omega_{dn}}{2\ 1600})^2} \cdot \frac{1}{\omega_{dn}} \left[\sin (\omega_{dn} + \emptyset_{dn} + \emptyset_{pe}) \right]$$

ΔF = 1250 Hz

f_o = 1600 Hz

where all terms are the same as used in Magnavox and

$\emptyset_{pe} = \tan^{-1}[\omega_{dn}/2\pi \ (1600)]$

The composite BELAR signal is:

$$E_c = A_c \left[1 + m\sum_{n=1}^{n=\infty} C_{sn} \cos\left(\omega_{snt} + \emptyset_{sn}\right)\right] \cos\left[\omega_c t + m\left(1250 \sum_{n=1}^{n=\infty} C_{dn} \sqrt{1 + \left(\frac{\omega_{dn}}{2\pi\, 1600}\right)^2} \cdot \frac{1}{\omega_{dn}} \sin\left[\omega_{dnt} + \emptyset_{dn} + \emptyset_{pe}\right]\right)\right]$$

SYSTEM III MOTOROLA

In this system compatible quadrature modulation is used for $\emptyset_{ts}$. In this case the angle is derived from the ratio of the L(t) - R(t) and the 1 + L(t) + R(t) signals, so that:

$$\emptyset_{ts} = \tan^{-1} \frac{L(t) - R(t)}{1 + L(t) + R(t)}$$

and in generalized form:

$$\emptyset_{ts} = \tan^{-1} \frac{m\sum_{n=1}^{n=\infty} C_{dn} \cos\left(\omega_{dnt} + \emptyset_{dn}\right)}{1 + m\sum_{n=1}^{n=\infty} C_{sn} \cos\left(\omega_{snt} + \emptyset_{sn}\right)}$$

The Motorola system also includes a variable level pilot carrier in which the amplitude of the pilot signal is made inversely proportional to the instantaneous carrier level.

The generalized composite signal with the pilot is:

$$E_c = A_c \left[1 + m\sum_{n=1}^{n=\infty} C_{sn} \cos\left(\omega_{snt} + \emptyset_{sn}\right)\right] \cos\left[\omega_c t + \tan^{-1} \frac{m\sum_{n=1}^{n=\infty} C_{dn} \cos\left(\omega_{dnt} + \emptyset_{dn}\right) + .05 \sin 50\pi t}{1 + m\sum_{n=1}^{n=\infty} C_{sn} \cos\left(\omega_{snt} + \emptyset_{sn}\right)}\right]$$

The signals in generalized form together with their single tone counterparts, useful for computation, are shown in Table I.

TABLE I

GENERALIZED EQUATIONS

SINGLE TONE EQUATIONS

WHERE $m_\Sigma(L_t+R_t)=m_\Sigma\cos 2\pi f t$

AND $m_\Delta(L_t-R_t)=m_\Delta\cos 2\pi f t$

NOTE: FOR $L=R$ $m_\Delta=0$ FOR $L=1$ $R=0$

FOR $L=-R$ $m_\Sigma=0$ $(m_\Delta=m_\Sigma)$

$$E_C=A_C\left(1+m\sum_{n=1}^{n=\infty}C_{sn}\cos(\omega_{sn}t+\phi_{sn})\right)\cos\left[\omega_c t+m\sum_{n=1}^{n=\infty}C_{Dn}\cos(\omega_{Dn}t+\phi_{Dn})+4\sin 10\pi t\right]$$

MAGNAVOX

$$E_C=A_C(1+m_\Sigma\cos 2\pi f t)\cos\left[\omega_C t+m_\Delta\cos 2\pi f t+4\sin 10\pi t\right]$$

$$E_C=A_C\left(1+m\sum_{n=1}^{n=\infty}C_{sn}\cos(\omega_{sn}t+\phi_{sn})\right)\cos\left[\omega_c t+m\left\{1250\sum_{n=1}^{n=\infty}C_{Dn}\sqrt{1+\left(\frac{\omega_{Dn}}{2\pi\cdot1600}\right)^2}\cdot\frac{1}{\omega_{Dn}}\sin(\omega_{Dn}t+\phi_{Dn}+\phi_{PE})\right\}\right]$$

BELAR

$$E_C=A_C(1+m_\Sigma\cos 2\pi f t)\cos\left[\omega_C t+\frac{1250}{f}\sqrt{1+\left(\frac{f}{f_0}\right)^2}\,m_\Delta\sin\left(2\pi f t+\tan^{-1}\left(\frac{f}{f_0}\right)\right)\right]$$

$$E_C=A_C\left(1+m\sum_{n=1}^{n=\infty}C_{sn}\cos(\omega_{sn}t+\phi_{sn})\right)\cos\left[\omega_c t+\tan^{-1}\frac{\left[m\sum_{n=1}^{n=\infty}C_{Dn}\cos(\omega_{Dn}t+\phi_{Dn})+.05\sin 50\pi t\right]}{\left[1+m\sum_{n=1}^{n=\infty}C_{sn}\cos(\omega_{sn}t+\phi_{sn})\right]}\right\}$$

MOTOROLA

$$E_C=A_C(1+m_\Sigma\cos 2\pi f t)\cos\left[\omega_C t+\tan^{-1}\frac{(m_\Delta\cos 2\pi f t+.05\sin 50\pi t)}{(1+m_\Sigma\cos 2\pi f t)}\right]$$

APPENDIX II S/N CALCULATIONS

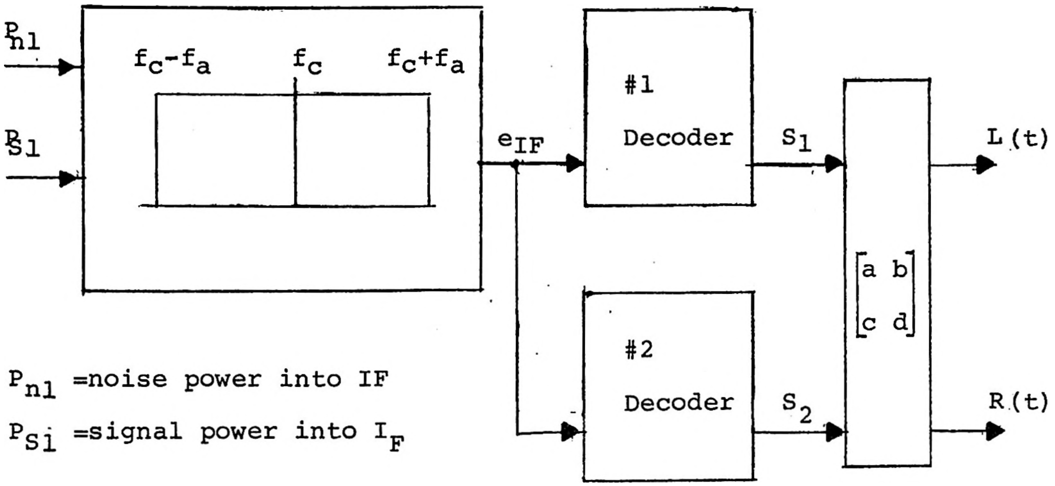
In order to provide comparable calculations of signal to noise ratio for each of the proposed systems a universal model that is applicable to all systems should be used. The goal of the model and the associated calculations is to compare the signal to noise ratio when receiving a monophonic signal to the signal to noise ratio when receiving a stereo signal. To more fully describe the signal to noise comparison ratio; assume that a stereophonic receiver is placed in the monophonic mode (the stereo channel and its associated noise is disconnected) but that both stereo speakers are active, each with identical sum signals derived from the monophonic signal (L+R). Now if the receiver is switched to the stereo mode the loudness should remain the same but additional noise will be introduced from the stereo channel (usually the difference channel (L-R). Since the receiver output is automatically "normalized" the ratio of signal to noise monophonic to signal to noise stereophonic is given as

$$1. \quad \frac{P_{n\Sigma}}{P_{n\Delta} + P_{n\Sigma}} = \frac{\text{Signal/noise Power ratio monophonic}}{\text{Signal/noise Power ratio stereophonic}}$$

$P_{n\Sigma}$ = noise power derived from sum channel (L+R)

$P_{n\Delta}$ = noise power derived from difference channel (L-R)

In order to establish uniform methods of calculating $P_{n\Sigma}$ and $P_{n\Delta}$ the model shown in Fig. 1 will be used.



P_{n1} =noise power into IF

P_{Si} =signal power into I_F

Fig. 1

The signal e_{IF} is the output of the IF amplifier which has a uniform constant amplitude and linear phase response and a bandwidth twice the maximum audio frequency f_a. The response outside the limits $f_c \pm f_a$ is defined as zero. This defines the noise bandwidth of the system to be equal to the maximum audio frequency with no noise components beyond f_a in the decoded signals.

The equation for the signal e_{IF} is:

(2) $A_c\ (1 + m_\Sigma\ f_1(t))\ \cos\ [\omega_c t + m_\Delta\ f_2(t)]$

where A_c = carrier amplitude

$f_1(t)$ = signal content appearing as amplitude modulation

m_Σ = amplitude modulation - index of modulation

ω_c = angular velocity of carrier phasor

$f_2(t)$ = signal content of the phase modulation

m_Δ = modulation index of phase modulation component

Now if $m_\Sigma = m_\Delta = o$, the signal E_{IF} is:

(3) $A_c \cos \omega_c t$ (carrier only)

and the normalized carrier power at the IF output is:

(4) $P_c = \frac{A_c^2}{2}$.

Now if the noise density of the noise power P is n watts/Hz (assuming Gaussian noise level distribution) then the noise power output of the IF amplifier is:

$$P_n = \int_{f_c-f_a}^{f_c+f_a} n\ df = 2f_a n \quad \text{watts}$$

n = noise density at IF input (IF gain unity)

The carrier to noise power ratio at the IF output is:

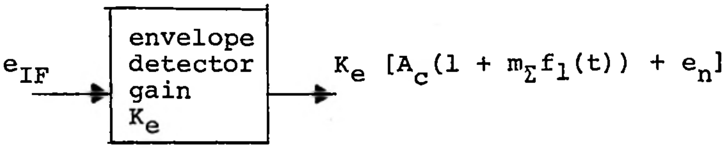
(5) $\boxed{\frac{P_c}{P_n} = \frac{A_c^2}{4f_a n} = \frac{P_c}{2f_a n}}$ IF carrier to noise

The model decoders may contain for each system different combinations of envelope detectors, synchronous detectors, frequency discriminators and phase detectors together with limiters and de-emphasis filters.

In each of these (with the exception of synchronous detectors) a carrier to noise level in excess of 12 db is required for coherent operation (noise peaks of frequent occurance are less than the carrier peak) where a 1 db increase in signal power produces a 1 db increase in S/N ratio for signals S_1 and S_2. Therefore the calculations are based on the assumption that the carrier to noise ratio exceeds 12 db.

The signal S_1 and S_2 decoders may use envelope detectors, synchronous detectors and/or discriminators, therefore the noise behavior for each type of detector will be reduced to standard equations and the noise performance of the system can be calculated by substituting for each block the appropriate functions.

I The envelope detector



$K_e e_n$ = detector noise voltage output

If the carrier is 100% modulated (i.e. $m_\Sigma f_1(t) = 1 \cos \beta t$) by a simple harmonic function and the detector output is:

$$K_e\ [A_c\ (1 + \cos\ \beta t)] + K_e\ e_n = e_s. \tag{6}$$

If the dc power in the detector is blocked the signal output power is:

$$\frac{(K_e A_c)^2}{2} = P_s.$$

Since the sideband noise has no correlation between upper and lower sidebands the output noise power instead of voltage is an additive between upper and lower sidebands.

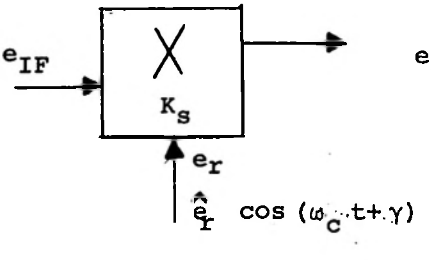
$$P_{n_{d_1}} = K_e^2\ P_n \tag{7}$$

P_n = IF noise

and the <u>maximum</u> signal to noise ratio at the envelope detector output is equal to the carrier to noise ratio in the IF amplifier.

$$\boxed{\frac{P_s}{P_{n_{de}}} = \frac{A_c^2}{4f_a n} = \frac{P_c}{2f_a n} \qquad \text{Envelope detector} \quad m_\Sigma^2 \equiv 1} \tag{8}$$

II Synchronous Detector



$$e_r \cdot e_{IF} = e_{ds}$$

$$e_{ds} = K_s\ [\hat{e}_r \cos\ (\omega_c t + \gamma)\ \times A_c\ (1 + m_\Sigma\ f_1(t))\ \cos\ [\omega_c t + m_\Delta\ f_2(t)] \quad (9)$$

$$= K_s \hat{e}_r A_c\ (1 + m_\Sigma\ f_1(t))\ \cos\ [m_\Delta\ f_2(t) - \gamma]$$

when all terms above ω_c are filtered at the output of the detector.

The envelope detector responds to carrier amplitude only, while the synchronous detector responds to both phase and amplitude.

Normalizing $K_s \cdot \hat{e}_r \equiv 1$ and remembering $\frac{{A_c}^2}{2} = P_c$

$$(10) \quad P_{s_s} = 2P_c \left\{[1 + m_\Sigma\ f_1(t)]\ \cos\ [m_\Delta\ f_2(t) - \gamma]\right\}^2$$

When the detected d.c. component due to carrier is dropped

$$(11) \quad \frac{P_{s_s}}{P_{n_{d_s}}} = \frac{\left\{m_\Sigma\ f_1(t)\ \cos\ [m_\Delta\ f_2(t) - \gamma]\right\}^2}{f_a} \cdot \frac{P_c}{n}$$

When there is no phase modulation ($m_\Delta \equiv o$) and when the reference is in phase with the carrier ($\gamma = o$) and the carrier is fully amplitude modulated by a simple harmonic function $m_\Sigma\ f_1(t) = \cos\ \beta t$,

$$(12) \quad \boxed{\begin{array}{ll} \dfrac{P_{s_s}}{P_{n_{d_s}}} = \dfrac{P_c}{2\ f_a n}\ . & \text{(identical to envelope detector)} \\ & \text{Synchronous Detector} \end{array}}$$

If $\gamma = \pi/2$ and $m_\Sigma f_1(t)$ is removed with a limiter the output can be used to detect phase modulation linearly for angles where $\sin \phi \simeq \phi$

(13) $e'_{d_s} = e_L \sin m_\Delta f_2(t)$

and for large S/N ratios the carrier to noise at the output of the limiter is the same as the input carrier to noise ratio.

If $m_\Delta f_2(t) = 1 \cos \beta t$ and the limiter gain is adjusted so that $e_r = A_c$ then

(14) $e'_{d_s} = A_c \sin (\cos \beta t)$ for angles near 1 radian there is significant distortion.

For small deviations of phase where $\sin \phi \approx \phi$

(15) $e'_{d_s} = A_c \cos \beta t$

and

(16) $$\frac{P'_{d_s}}{P_{n_{ds}}} = \frac{P_c}{2f_a n}.$$

Thus for small angle detection the synchronous detector gives again the same signal to noise ratio as the envelope detector (large carrier/noise).

III LINEAR PHASE DETECTOR

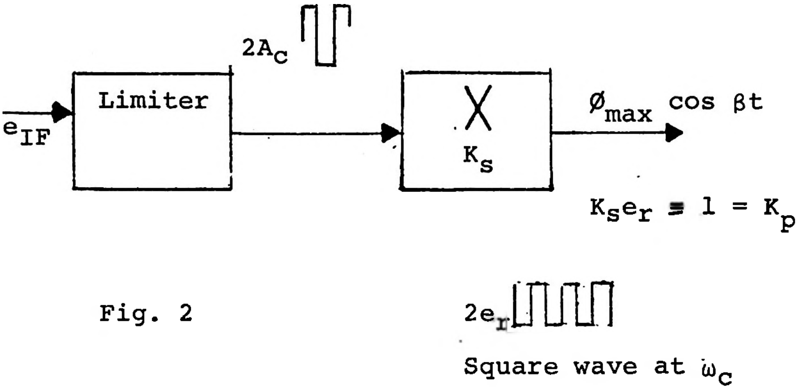


Fig. 2

When the limiter gain is adjusted so that the signal power output equals the signal power input, the noise power density at the phase detector output is:

$$\frac{K_p^2\, n}{A_c^2} \quad \text{watts/Hz} \tag{17}$$

and the noise power is

$$\frac{K_p^2\, n}{A_c^2}\int_{f_c-f_a}^{f_c+f_a} df = \frac{K_p^2\, 2f_a n}{A_c^2} = \frac{K_p^2\, f_a n}{P_c}. \tag{17a}$$

The signal output is:

$$e_{dp} = A_c\, \phi_{max} \cos \beta t. \tag{18}$$

The output signal to noise power ratio is:

(19) $$\boxed{\frac{P_{dp}}{P_{n_p}} = \frac{\emptyset_{max}^{2} \quad P_c}{2 \; f_a n}} .$$

This type of detector can be derived from a square wave driven multiplier or synchronous detector.

IV FM detector (Preceded by a limiter)

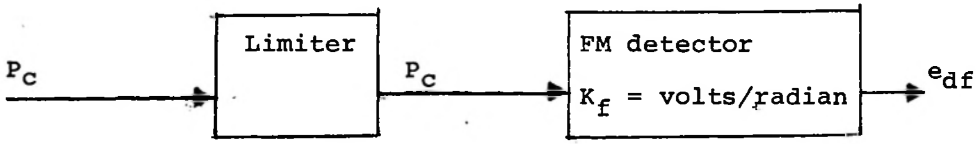


Fig. 3

The gain of the limiter is adjusted (for convenience) so that the power output equals the carrier power input.

The discriminator output is:

(20) $$e_{df} = K_F \, 2 \, \pi \, (f_c - f_{in}) = K_F \, 2\pi \quad \Delta F.$$

K_F = volts/radian and assumes a given level of limiter output (P_c).

The signal power output from the discriminator is:

(21) $$P_{s_F} = 4\pi^{2} \; K_F^{2} \; \frac{\Delta F^2}{2} .$$

The noise power output is:

(22) $$P_{nF} = \frac{(2\pi \; K_F)^2}{P_c} \; n \quad \int f^2 \, df = \frac{4 \; \pi^2}{3} \; f_a^3 \; K_F^2 \; \frac{n}{P_c}$$

The signal to noise ratio at the FM detector output is:

$$(23)\quad \boxed{\begin{array}{c} \dfrac{P_{SF}}{P_{nF}} + \dfrac{3}{2} \quad \dfrac{\Delta F^2}{f_a^{\,3}} \quad \dfrac{P_c}{n} \\ \\ \text{FM Detector} \end{array}}$$

If the discriminator is followed by a de-emphasis filter which reduces the high frequency noise by 6db per octave (a simple R-C filter) the signal power becomes

$$(24)\quad P_{S_{FD}} = 4\pi^2 K_F^2 \frac{\Delta F^2}{2} \cdot \left[\frac{1}{1 + \left[\frac{f^2}{f_o^{\,2}}\right]}\right]$$

where $f_d = \dfrac{1}{Ts^{2\pi}}$

T_s = R·C time constant of de-emphasis filter

If the transmitter has complementary pre-emphasis the signal power is independent of the modulating frequency but the noise becomes:

$$(25)\quad P_{n_{FD}} = \frac{4\,\pi^2\,K_F^{\,2}\,n}{P_c} \left[f_a f_d^{\,2} - f_d^{\,3} \tan^{-1}\left[\frac{f_a}{f_d}\right]\right]$$

and the FM signal to noise ratio with de-emphasis is:

TABLE I

E-25

DETECTOR TYPE	OUTPUT VOLTAGE $f(t)$	IF NOISE VOLTAGE $e_{nIF}=\sqrt{2 f_a n}$ NOISE VOLTS (RMS)	$f_1(t)=f_2(t)=\cos \beta t$ OUTPUT SIGNAL POWER (NO d.c.)
ENVELOPE	$K_e A_C m_\Sigma f_1(t)$	$K_e\sqrt{2 f_a n}$	$\frac{K_e^2 A_C^2 m_\Sigma^2}{2}$
SYNCHRONOUS	$K_S \hat{e}_r A_C(1+m_\Sigma f_1(t))\cos\left[m_\Delta f_2(t)-\gamma\right]$	$K_S \hat{e}_r\sqrt{2 f_a n}$	$m_\Delta = 0 \quad \gamma = 0$ $\frac{K_S^2 \hat{e}_r^2 A_C^2 m_\Sigma^2}{2}$
SYNCHRONOUS WITH LIMITER SIN Ø OR COS Ø	$K_S \hat{e}_r A_C \cos\left[m_\Delta f_2(t)-\gamma\right]$	$K_S \hat{e}_r\sqrt{2 f_a n}$	$m_\Delta \ll 1$ $\frac{K_S^2 \hat{e}_r^2 A_C^2 m_\Delta^2}{2}$
LINEAR PHASE	$K_P m_\Delta f_2(t)$	$\frac{K_P\sqrt{2 f_a n}}{A_C}$	$\frac{K_P^2 \phi_{MAX}^2}{2}$
FM WITH LIMITER	$K_F 2\pi \Delta F \cdot m_\Delta f_2(t)$	$\frac{K_F f_a \pi}{A_C}\sqrt{\frac{8n}{3}}$	$\frac{K_F^2 4\pi^2 \Delta F^2 m_\Delta^2}{2}$
FM WITH LIMITER AND DE-EMPHASIS	$K_F 2\pi \Delta F m_\Delta f_2(t)$	$\frac{K_F \pi}{A_C}\sqrt{8n\left[f_a f_o^2 - f_o^3 \tan^{-1}\left(\frac{f_a}{f_o}\right)\right]}$	$\frac{K_F^2 4\pi^2 \Delta F^2 m_\Delta^2}{2}\left[\frac{1}{1+\left(\frac{f}{f_d}\right)^2}\right]$

TABLE I (CONT'D)

DETECTOR TYPE	NOISE OUTPUT POWER WATTS	OUTPUT SIGNAL POWER TO NOISE POWER RATIO	$(P_C = \frac{A_C^2}{e})$
ENVELOPE	$K_e^2 \; 2 f_a n$	$m_\Sigma = 1$ $\frac{P_C}{2 f_a n}$	$m_\Sigma \cos \beta t = \cos \beta t = m_\Sigma f_1(t)$
SYNCHRONOUS	$K_S^2 \; \hat{e}_r^2 \; 2 f_a n$	$m_\Sigma = 1$ $\frac{P_C}{2 f_a n}$	$m_\Sigma \cos \beta t = \cos \beta t = m_\Sigma f_1(t)$
SYNCHRONOUS WITH LIMITER SIN Ø OR COS Ø	$K_S^2 \; \hat{e}_r^2 \; 2 f_a n$	$m_\Delta \ll 1$ $\frac{P_C \; m_\Delta^2}{2 f_a n}$	$m_\Delta \cos \beta t = m_\Delta f_2(t)$
LINEAR PHASE	$K_P^2 \frac{2 f_a n}{A_C^2}$	$\frac{Ø_{MAX}^2 \; P_C}{2 f_a n}$	$Ø_{MAX} \cos \beta t = m_\Delta f_2(t)$
FM WITH LIMITER	$\frac{K_F^2 f_a^2 \, 8 \pi^2 n}{3 A_C^2}$	$\frac{3}{2} \quad \frac{\Delta F_{MAX}^2}{f_a^3} \quad \frac{P_C}{n}$	$\Delta F_{MAX} \cos \beta t = m_\Delta f_2(t)$
FM WITH LIMITER AND DE-EMPHASIS	$\frac{K_F^2 \, 8 \pi^2 n}{A_C^2} \left[f_a f_d^2 - f_d^3 \tan^{-1} \left(\frac{f_a}{f_d} \right) \right]$	$\frac{\Delta F_{MAX}^2}{2 \left[f_a f_d^2 - f_d^3 \tan^{-1} \left(\frac{f_a}{f_d} \right) \right]} \; \frac{P_C}{n}$	$\Delta F_{MAX} \cos \beta t \sqrt{1 + \left(\frac{\beta}{2 \pi f_d} \right)^2}$ $= m_\Delta f_2(t)$

$$(26)\quad \boxed{\frac{P_{sFD}}{P_{nFD}} = \frac{\Delta F^2}{2\,[f_a f_d^2 - f_d^3 \tan^{-1}(f_a/f_d)]} \cdot \frac{P_c}{n}}$$

FM - S/N ratio with de-emphasis

GLOSSARY OF TERMS

K_e = envelope detector insertion loss (dimensionless)

K_s = synchronous detector insertion loss (dimensionless)

$\hat{e}_r$ = peak valve of the synchronous reference signal (volts)

K_p = phase detector sensitivity (volts/radian)

K_F = discriminator sensitivity (volts/radian)

m_Σ = modulation index for sum signal (1 max)

m_Δ = modulation index for angular modulation (difference)(1 max)

$f_1(t)$ = function representing AM signal modulation (dimensionless)

$f_2(t)$ = function representing angular modulation (dimensionless)

A_c = I_F peak carrier amplitude (volts)

P_c = I_F carrier power output (watts)

n = noise power density in IF output (watts/Hz)

f_a = maximum modulating frequency and upper frequency limit of reception (defined by IF bandwidth) (Hz)

f_c = carrier frequency

$f_d = \frac{1}{T_s 2\pi}$ where T_s is time constant of r-c de-emphasis filter (Hz)

ΔF_{max} = peak deviation used for FM

ϕ_{max} = peak angular deviation used for PM

SUMMARY OF ASSUMPTIONS

1) The IF noise has Gaussian distribution (white noise)

2) The audio response is unity to f_a and zero for all values $> f_a$

3) The carrier to noise ratio in the IF output exceeds 12db (required for 1db increase in signal to produce a 1db improvement in S/N ratio)

4) When a limiter is used the limited output has the same carrier power (in the filtered carrier term) as the input power to the limiter (arbitrary gain adjustment)

5) All power calculations assume $r=1$.

Calculating S/N for the Magnavox System

From appendix I the single tone equation for the radiated signal is: (neglecting pilot carrier)

$$E_c = A_c(1 + m_\Sigma \cos 2\pi\ ft) \cos [\omega_c t + m_\Delta \cos 2\pi ft]. \tag{27}$$

Now if a left signal is transmitted $m_\Sigma = m_\Delta = m$,

$$E_c = A_c\ (1 + m \cos 2\pi\ ft) \cos [\omega_c t + m \cos 2\pi\ ft]. \tag{28}$$

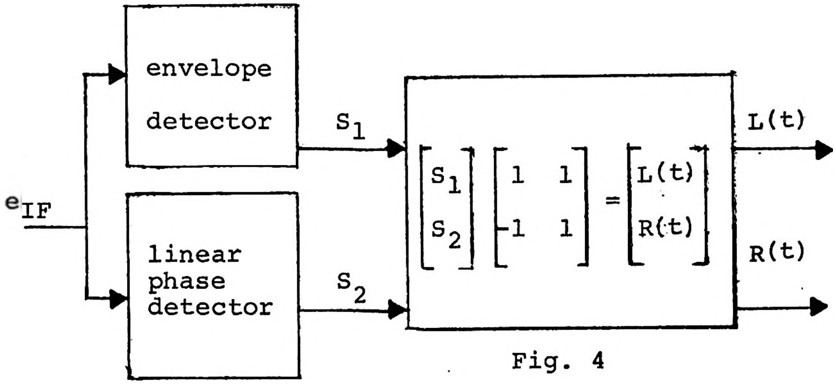


Fig. 4

Using Table I the signal S_1 derived from the envelope detector is:

$$(29)\quad S_1 = K_e\ A_c\ m_\Sigma\ f_1(t) \overset{\text{Table I}}{=} K_c\ A_c\ m \cos 2\pi\ ft$$

and

$$S_2 = K_p\ m_\Delta\ f_2(t) = K_p\ m \cos 2\pi\ ft$$

$$(30)\quad L(t) = S_1 + S_2 = (K_e\ A_c + K_p)\ m \cos 2\pi\ ft$$

$$R(t) = -S_1 + S_2 = (K_e\ A_c - K_p)\ m \cos 2\pi\ ft.$$

Since this is a left signal $R(t) = 0$

and $K_e\ A_c = K_p$ (Since A_c is proportional to carrier amplitude, either A_c must be held constant or K_p made to track carrier level variation.)

$$(31)\quad \text{Then } K_p = K_e\ A_c = Q \quad \text{and } K_e = \frac{Q}{A_c}$$

$$(32)\quad P_{n_\Sigma} + P_{n_\Delta} = \underset{\text{envelope detector}}{\frac{Q^2}{A_c^2}\ 2\ f_a n} + \underset{\text{phase detector}}{\frac{Q^2}{A_c^2}\ 2\ f_a n} = \frac{Q^2\ 4 f_a n}{A_c^2}$$

and the ratio of noise output in monophonic position to noise output in stereophonic mode is:

$$(33)\quad \frac{\text{Monophonic noise}}{\text{Stereophonic noise}} = \frac{\frac{Q^2}{A_c^2}\ 2 f_a n}{\frac{Q^2}{A_c^2}\ 2\ f_a n + \frac{Q^2}{A_c^2}\ 2\ f_a n} = \frac{1}{2}$$

Since this is a power ratio 3db,more noise when no modulation is present appears in each output terminal.

When a signal is present the signal to noise ratio becomes (left output channel with left signal)

$$(34)\quad [S/N]_{\text{left}} = \frac{[(K_e\ A_c + K_p)\ m \cos 2\pi \cdot ft]^2}{K_e^2\ 2\ f_a n + \dfrac{K_p^2\ 2\ f_a n}{A_c^2}} = \frac{m^2}{f_a} \cdot \frac{P_c}{n}$$

This formula does not account for dynamic variation in S/N ratio in the presence of changing carrier level due to amplitude modulation of the carrier by (L + R).

Calculating the S/N ratio for the Belar System

From appendix I the formula for the radiated signal is

$$(35)\quad E_c = A_c\ (1 + m_\Sigma \cos 2\ \pi ft) \cos \left[\omega_c t + \frac{1250}{f} \sqrt{1 + [f/f_o]^2} \right.$$

$$\left. m_\Delta \sin (2\pi\ ft + \tan^{-1}[f/f_o]) \right]$$

A receiver for decoding this signal may use an envelope detector for L(t) + R(t) and a freqency discriminator followed by a de-emphasis network with a 100μs time constant, as shown in Fig. 5.

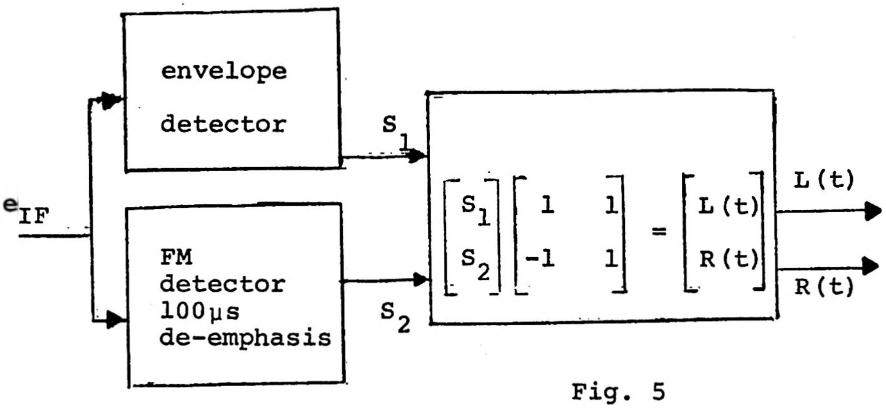


Fig. 5

Again for a left signal $m_\Sigma = m_\Delta = m$.

Using Table I the signals S_1 and S_2 are:

$S_1 = K_e A_c m \cos 2\pi ft.$

In table I of appendix II the output of the FM discriminator is given in terms of frequency modulation whereas the modulating signal in equation (35) is in terms of instantaneous phase modulation To convert the phase modulation term to equivalent frequency modulation.

$$(36) \qquad \Delta F(t) = \frac{1}{2\pi} \frac{d\phi}{dt} = d \frac{\dfrac{1250 \text{ m} \sin\left[2\pi ft + \tan^{-1}\left(\frac{f}{f_d}\right)\right]}{f} \sqrt{1 + \left(\frac{f}{f_d}\right)^2}}{dt}$$

$$(37) \qquad \Delta F(t) = 1250 \text{ m} \cos\left[2\pi ft + \tan^{-1}\left(\frac{f}{f_d}\right)\right] \sqrt{1 + \left(\frac{f}{f_d}\right)^2}$$

After de-emphasis

(38) $\Delta f(t) = 1250 \text{ m} \cos 2\pi ft$

S_2 becomes:

(39) $S_2 = K_F \, 2 \pi \, 1250 \text{ m} \cos 2\pi \, ft$

and

(40) $L(t) = (K_e A_c + K_F \, 2500\pi) \text{ m} \cos 2\pi \, ft$

$R(t) = (K_e A_c - K_F \, 2500\pi) \text{ m} \cos 2\pi \, ft$

for $R(t) \equiv 0$ for a left signal

(41) $K_e A_c = K_F \, 2500 \, \pi$

and the noise from sum and difference channels is:

using $\Delta F = 1250\text{Hz}$

(42) $$\frac{P_\Sigma}{P_\Sigma + P_\Delta} = \frac{1}{1 + \frac{f_o^2}{\Delta F^2} \frac{\left[f_a - f_d \tan^{-1}\left(\frac{f}{f_d}\right)\right]}{f_a}}$$

$$-3.74\text{db} = \frac{1}{1 + \left[\frac{1600}{1250}\right]^2 \frac{\left[15000 - 1600 \tan^{-1} \left(\frac{15000}{1600}\right)\right]}{15000}}$$

When the system is switched from mono to stereo the background noise increases by 3.74db.

Since $K_e \ A_c = K_F \ \ 2\pi \ \Delta F$ the carrier amplitude must be accurately regulated by an appropriate a.g.c. system or K_F must track changes in A_c.

When a signal is present the S/N ratio becomes (left output channel with left only signal)

$$(43) \qquad [\frac{S}{N}]_{\text{left}} = \frac{(K_e \ A_c + K_F \ \ \Delta F 2\pi)^2}{2 \left[\frac{2K_F^2 \ (2\pi)^2 \ \Delta F^2 \ f_a h}{A_c} + \frac{K_F^2 \ 8\pi^2 \ n \ f_d}{A_c^2} \left(f_a - f_d \tan^{-1} \frac{fa}{fd} \right) \right]}$$

$$= \frac{2m^2}{f_a + (\frac{f_d}{\Delta F})^2 \left(f_a - f_d \tan^{-1} \frac{f_a}{f_d} \right)} \qquad \frac{P_c}{n}$$

This formula does not account for dynamic variation in S/N ratio in the presence of changing carrier level due to amplitude modulation of the carrier by (L(t) + R(t)).

Calculating the S/N ratio for the Motorola System

From Appendix I the single tone equation for the radiated signal is: (neglecting pilot carrier)

(44) $$E_c = A_c (1 + m_\Sigma \cos 2\pi ft) \cos\left[\omega_c t + \tan^{-1}\frac{m_\Delta \cos 2\pi ft}{(1 + m_\Sigma \cos 2\pi ft)}\right]$$

Although several systems can decode this signal, for large S/N ratios the results are similar. An example here is the envelope detector for L(t) - R(t) shown in Fig. 6

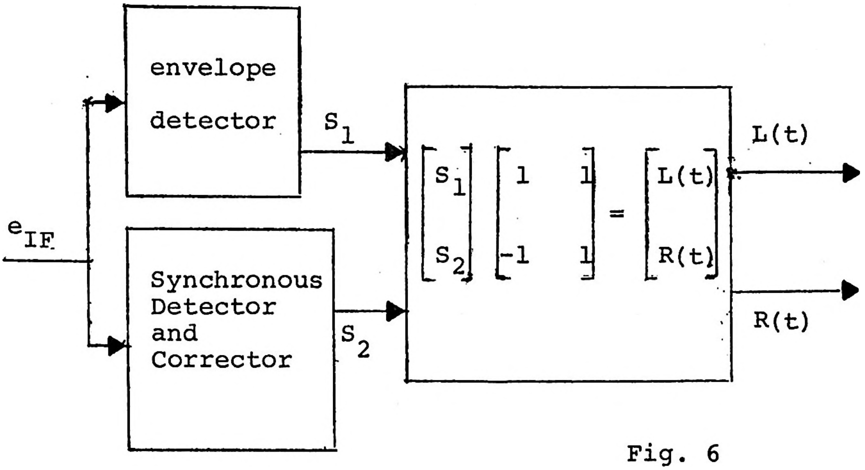


Fig. 6

(45) $S_1 = K_e A_c m \cos 2\pi ft$ $m = m_\Sigma = m_\Delta$ left signal

(46) $S_2 = K_s \hat{e}_r A_c (1 + m \cos 2\pi ft) \cos [m_\Delta f_2(t) - \gamma], \gamma = \pi/2$

$S_2 = K_s \hat{e}_r A_c (1 + m \cos 2\pi ft) \sin [m_\Delta f_s(t)]$

(47) $m_\Delta f_2(t) = \tan^{-1} \frac{m \cos 2\pi ft}{1 + m \cos 2\pi ft}$

using $\Sigma = 1 + m \cos 2\pi ft$

$\Delta = m \cos 2\pi ft$

(48) $S_2 = K_s \hat{e}_r A_c \Sigma \sin \tan^{-1} \frac{\Delta}{\Sigma}$

(49) $\theta = \tan^{-1}(\frac{\Delta}{\Sigma})$

(50) $S_2 = K_s \hat{e}_r A_c \Sigma \sin \theta$

$$\frac{S_2}{\cos \theta} = K_s \hat{e}_r A_c \Sigma \tan \theta = K_s \hat{e}_r A_c \Delta$$

$$\frac{S_2}{\cos \theta} = K_s \hat{e}_r A_c m \cos 2\pi ft$$

The output of the synchronous detector (with corrector) is given in (50) and

(51) $L(t) = (K_e A_c + K_s \hat{e}_r A_c) m \cos 2\pi ft$

$R(t) = (K_e A_c - K_s \hat{e}_r A_c) m \cos 2\pi ft$

and since $R(t) \equiv 0$

$$K_e = K_s \hat{e}_r$$

The effect of the corrector is ignored since the corrector alters the noise level by less than one tenth of a db at the synchronous detector output when the coherent conditions are maintained.

$$\frac{\text{Monophonic noise}}{\text{Stereophonic noise}} = \frac{2\ f_a n}{2\ f_a n + 2\ f_a n} = \frac{1}{2} \tag{52}$$

The background noise increases 3 db when switching to stereo.

When a signal is present in the left channel the S/N ratio becomes

$$\frac{A_c^2\ [(K_e + K_s\ \hat{e}_r)\ m \cos 2\pi\, ft]^2}{K_e^2(2f_a n) + K_s^2\ e_r^2(2f_a n)} = \frac{m^2}{f_a} \cdot \frac{P_c}{n} \tag{53}$$

SYSTEM ANALYSIS CHART	BELAR	MAGNAVOX	MOTOROLA
1. Radiated Signal Parameters			
1.1 Signal L (Monophonic Component)			
1.1.1 Information Transmitted	L(t)+R(t)	L(t)+R(t)	L(t)+R(t)
1.1.2 Bandwidth of Modulating Signal (kHz)	Ⓐ	Ⓐ	Ⓐ
1.1.2.1 Lowest Freq. (Hz) and Level (dB ref 400 Hz)	Ⓐ	Ⓐ	Ⓐ
1.1.2.2 Highest Freq. (kHz) and Level (dB ref 400 Hz)	Ⓐ	Ⓐ	Ⓐ
1.1.3 Type Modulation	DSB AM	DSB AM	DSB AM
1.1.3.1 Percent of Unmodulated Carrier at Max. Negative Peak Modulation (%)	∽5%	∽5%	∽5%
1.1.3.2 Percent of Unmodulated Carrier at Max. Positive Peak Modulation (%)	Ⓔ	Ⓔ	Ⓔ
1.2 Signal 2 (Biphonic Direction Signal)			
1.2.1 Information Transmitted	L(t)−R(t)	L(t)−R(t)	L(t)−R(t)
1.2.2 Bandwidth of Modulating Signal (kHz) (Approx.)	Ⓐ	Ⓐ	Ⓐ
1.2.2.1 Lowest Freq. (Hz) and Level (dB ref 400 Hz)	Ⓐ	Ⓐ	Ⓐ
1.2.2.2 Highest Freq. (kHz) and Level (dB ref 400 Hz)	Ⓐ	Ⓐ	Ⓐ

SYSTEM ANALYSIS CHART	BELAR	MAGNAVOX	MOTOROLA
1.2.3 Type Modulation	FM	PM	COMPATIBLE QUADRATURE
1.2.3.1 Percent of Unmodulated Carrier at Max. Negative Peak Modulation (%)	100% Ⓑ	100%	100%
1.2.3.2 Percent of Unmodulated Carrier at Max. Positive Peak Modulation (%)	100% Ⓑ	100%	100%
1.2.3.3 Maximum Frequency or Phase Deviation	±1250 hz	±1 RADIAN	±π/4 RADIANS
1.3 Signal 3 (Composite Signal)			
1.3.1 Information Transmitted	L(t),R(t)	L(t),R(t)	L(t),R(t)
1.3.2 Type Modulation	AM FM	AM PM	COMPATIBLE QUADRATURE
1.3.2.1 Percent of Unmodulated Carrier at Max. Negative Peak Modulation (%)	∽5%	∽5%	∽5%
1.3.2.2 Percent of Unmodulated Carrier at Max. Positive Peak Modulation (%)	Ⓔ	Ⓔ	Ⓔ
1.3.2.3 Maximum Frequency or Phase Deviation	±1250 hz	±1 RADIAN	±1.5 RADIANS
1.4 Description of Resultant Signals at Stereo Receiver Output Terminals			
1.4.1 Left Output			
1.4.1.1 Signal Content	L(t)	L(t)	L(t)
1.4.1.2 Audio Bandwidth (kHz) (Approx.)	Ⓐ	Ⓐ	Ⓐ
1.4.1.2.1 Lowest Freq. (Hz) and Level (dB ref 400 Hz)	Ⓐ	Ⓐ	Ⓐ

SYSTEM ANALYSIS CHART	BELAR	MAGNAVOX	MOTOROLA
1.4.1.2.2 Highest Freq. (kHz) and Level (dB ref 400 Hz)	Ⓐ	Ⓐ	Ⓐ
1.4.1.3 Noise Power with No Modulation on L or R Channels (dB ref noise power in monophonic mode)	Ⓓ $\frac{2.96}{3.74}$	3	3
1.4.1.4 Maximum Signal Power (dB)			
1.4.1.4.1 $L_{(t)} = R_{(t)}$	0	0	0
1.4.1.4.2 $L_{(t)}$Max; $R_{(t)} = 0$	+6	+6	+6
1.4.1.5 Maximum Theoretical Crosstalk .dB $L_{(t)} = 0$; $R_{(t)}$Max.			
1.4.2 Right Output			
1.4.2.1 Signal Content	$R(t)$	$R(t)$	$R(t)$
1.4.2.2 Audio Bandwidth (kHz) (Approx.)	Ⓐ	Ⓐ	Ⓐ
1.4.2.2.1 Lowest Freq. (Hz) and Level (dB ref 400 Hz)	Ⓐ	Ⓐ	Ⓐ
1.4.2.2.2 Highest Freq. (kHz) and Level (dB ref 400 Hz)	Ⓐ	Ⓐ	Ⓐ
1.4.2.3 Noise Power with No Modulation on L or R Channels (dB ref noise power in monophonic mode)	Ⓓ $\frac{3.74}{2.96}$	3	3
1.4.2.4 Maximum Signal Power (dB)			
1.4.2.4.1 $L_{(t)} = R_{(t)}$	0	0	0

SYSTEM ANALYSIS CHART	BELAR	MAGNAVOX	MOTOROLA
1.4.2.4.2 $R_{(t)} = 0$; $R_{(t)}$ Max.	+6	+6	+6
1.5 Description of Resultant Signals at the Output Terminals of a Monophonic Receiver			
1.5.1 Envelope Information	L(t)+R(t)	L(t)+R(t)	L(t)+R(t)
1.5.2 Audio Bandwidth (kHz) (Approx.)	Ⓐ	Ⓐ	Ⓐ
1.5.2.1 Lowest Freq. (Hz) and Level (dB ref 400 Hz)	Ⓐ	Ⓐ	Ⓐ
1.5.2.2 Highest Freq. (kHz) and Level (dB ref 400 Hz)	Ⓐ	Ⓐ	Ⓐ
1.5.3 Maximum Output (Stereo Transmission) Comp. with 100% Envelope Modulation (dB)			
1.5.3.1 $L_{(t)} = R_{(t)}$	0	0	0
1.5.3.2 $L_{(t)} = R_{(t)}$	NO OUTPUT	NO OUTPUT	NO OUTPUT
1.5.3.3 $R_{(t)}$ Max; $L_{(t)} = 0$	0	0	0
1.5.3.4 $L_{(t)}$ Max; $R_{(t)} = 0$	0	0	0
1.5.4 Average Detector Output $L_{(t)} = R_{(t)}$	−4 dB	−4 dB	−4 dB
1.6 Ancillary Signals			
1.6.1 Stereo Pilot			
1.6.1.1 Type of Modulation		PM	COMPATIBLE QUADRATURE
1.6.1.2 Pilot Frequency		5 hz	25 hz

SYSTEM ANALYSIS CHART	BELAR	MAGNAVOX	MOTOROLA
1.6.1.3 Phase or Freq. Deviation		4 RADIANS	±.03 RADIANS Ⓒ
1.6.1.4 Amplitude Modulation		0	0

A. Transmission bandwidth limited only by restrictions on existing transmitting equipment.

B. Carrier frequency level is a function of the modulation index, but the total signal amplitude, as seen by a wideband envelope detector, is essentially independent of biphonic signal modulation.

C. The value of pilot carrier level is inversely proportional to the instantaneous carrier level due to $L_{(t)} + R_{(t)}$ modulation.

D. In the FM system the unmodulated carrier to noise ratio depends on the receiver bandwidth, whereas in the other two systems it does not.

The S/N ratio with 15,000 Hz assumed audio bandwidth is 3.74 db.

The S/N ratio with 5,000 Hz assumed audio bandwidth is 2.96 db.

E. Peak modulation is limited by transmitter limitations or broadcast rule limits only.

Report of Panel II, Transmission Systems

Compatibility of Stereo Systems with Existing Transmitting Systems

As noted elsewhere in the Committee's report, field tests were performed, by transmitting from three stations, and at each station three different stereo systems were tested. At each station, a different model transmitter was employed, yet no change was made in the three stereo exciters to go from one transmitter type to another except for operating a built-in adjustment to match the time delays at mid-audio frequencies, of the L + R (AM) and L - R (FM or PM) channels. An interface provided between the stereo exciters and the existing transmitters amounted to little more than: the addition of an RF jack on the transmitter to provide a connection to a new carrier source; a switch to choose between the normal crystal oscillator and the stereo exciter as a carrier signal source; and a few small components. The cost of this interface and the transmitter modification was negligible. The cost of stereo exciters has not been formally estimated, but a preliminary judgment of the probable cost range of exciters is $3500.

Not all basic transmitter types in normal broadcast service today are represented by the field test transmitters and these other types need to be considered. Parametric performance data was provided to the Committee by manufacturers of other transmitter types which indicate that there is an excellent chance of successful stereo operation of these transmitters with any of the three stereo systems. The most important parametric data

data provided was incidental phase modulation which is, in effect, L + R (AM) to L - R (FM or PM) crosstalk. This parameter affects both separation and L or R distortion in stereo operation. Data was provided on the Doherty system by Continental Electronics Mfg. Company, on the Ampliphase system by RCA Corp., on the high-level modulation system by McMartin Industries, and on the PDM system by Harris Corp. Data supplied to the Committee indicated that satisfactory stereo performance should be readily achieved with any of these AM modulation systems. No complicated or expensive interface or transmitter modification requirements were foreseen by any of these transmitter manufacturers.

The transmitter types actually tested during the Committee's stereo field tests were RCA 10 KW and 50 KW high-level plate modulated transmitters of rather old design and a modern 5 KW Harris Corp. PDM transmitter.

Although each of the stereo systems appears to be basically compatible with any existing transmitter type tested or otherwise considered, some detail problems came to light in attempts to operate certain individual transmitters in stereo. These problems will require additional retrofit circuit development and some transmitter modifications beyond the simple ones already described. These range from additional small circuit changes to changes that have not yet been fully explored. However, no problem arose that is expected to make any existing transmitter, no matter how old, unsuited to stereo broadcasting after reasonable modifications have been made. Specifically, some problems uncovered in adapting individual transmitters to stereo performance were:

1. A problem of L - R (PM) hum in one transmitter which might require additional power supply filtering.

2. A problem in one transmitter in coupling between an exciter at DC ground potential and on RF chain above ground which might require an additional carrier signal coupling transformer and amplifier.
3. A problem occurred in one older transmitter with unexplained stereo distortion and poor separation at high audio frequencies. This problem might yield to minor component changes in the transmitter or, in the extreme, require retrofiting with a more modern exciter and associated RF amplifier changes.
4. Other models of transmitters, not yet tested in stereo operation could contain problems of a similar nature that might require correction. If so, the required changes probably would fall within the bounds of difficulty of the problems described in 1-3 above.

In contrast to the minor problems encountered in the use of existing AM transmitters for stereo, some pleasant surprises were noted. Although the carrier amplifier chain (CW circuits) of existing transmitters were not originally designed to amplify frequency or phase modulated signals, in several tests the L-R (FM or PM) channel performed better than the L + R (normal AM) channel. That is, the L - R channel had lower distortion at all modulating frequencies and lower noise, when L + R modulation was not present.

In addition to the transmitter/stereo-exciter interface developed during the field test and specific problems encountered or solved, some possible technical refinements for future AM stereo transmitters were recognized. This subject is covered under the next heading.

Transmitter Characteristics: Modification Requirements for AM Stereo

All of the stereo systems under consideration include some form of frequency or phase modulation of the carrier frequency signal source together with normal amplitude modulation of the processed carrier. The interface between the frequency or phase modulated carrier, normally generated in a stereo exciter, and the main transmitter has been described. The two modulation processes must be adjusted for time coincidence at the transmitter output.

Envelope Delay vs. Modulating Frequency Equalization was not employed in the field test systems but should be included in future transmitters or, preferably, in stereo exciters associated with these transmitters. In the field tests, an adjustable audio delay line matched the timing of the L - R and L + R channels for best separation at mid-audio frequencies. The separation at low and at high audio frequencies was much better in the closed circuit tests employing signal generators than in the field tests employing full scale transmitters. This suggests that transmitter stereo performance will be improved if the L - R and L + R channel timing are matched at all audio frequencies by the addition of all-pass circuits to accomplish envelope delay equalization, or some other technique for matching L - R and L + R timing at all audio frequencies.

Linear-Phase Carrier-Frequency Amplifier design should be considered in any new transmitter designed for AM stereo. This will amount to not much more than ensuring a reasonable bandwidth in all RF stages prior to the point in a transmitter where AM modulation occurs. Experience has shown that this requirement was fortuitously met fairly well by existing transmitter designs but improvements most likely can be made in future designs.

Careful Neutralization of all AM modulated or linear amplifier stages in an AM stereo transmitter must be attained by circuit design and neutralization instructions in order to minimize incidental phase modulation resulting from amplitude modulation. The consequence of incidental phase modulation resulting from amplitude modulation. The consequence of incidental phase modulation is loss of stereo separation and an increase in distortion in the stereo mode.

Other Sources of Incidental Phase Modulation must be avoided by circuit design and transmitter tuning instructions. Some potential sources of incidental phase modulation are: unsymmetrical sideband response of RF circuits after the point of AM modulation including the effects of antenna bandwidth and antenna loading of the PA; non-linear impedance of high power tubes as a function of AM level which produce reactance modulation (tuning effects) on their associated input and output RF circuits. As noted in connection with comments on phase linearity, existing transmitters fortuitously were well bbhaved but improvements in future designs should be possible.

AM Modulation Produced by Intentional FM or PM should be avoided by design. This is the inverse of incidental phase modulation. It is incidental amplitude modulation resulting in L - R to L + R crosstalk. No significant level of this adverse characteristic was observed in any existing transmitter tested by the Committee.

Built-in Stereo Modulation Capability may be an intrinsic part of some future transmitter designs. These may include functions that were a part of the add-on stereo generators employed in the Committee's field tests. If so, this will decrease the cost, womewhat, of ancillary equipment required to convert an AM transmitter form monaural to stereo broadcasting. One new 5 KW AM transmitter displayed at the 1977 NAB Convention included both L - R and L + R audio input terminals. The L - R terminals provided for internal phase modulation of the carrier frequency signal.

Standards and Interim Standards for AM Stereo-Broadcasting

In setting standards for stereo broadcasting, the Commission should bear in mind that most AM broadcasters will want to convert their existing transmitters for stereo operation. It has been demonstrated that this can be done with very good-sounding stereo performance. However, such a conversion might not attain the high technical standards of stereo performance that could be achieved by a future transmitter, designed specifically for stereo. Therefore, the Commission should consider either a loose standard initially or an interim standard that will permit stereo broadcasting with less stringent requirements for frequency response, stereo separation, noise and distortion than those imposed on FM broadcasting.

For applicable parameters, in no case should the interim stereo requirements be more severe than the values presently imposed for AM monaural broadcasting.

AM STEREO MONITORING REQUIREMENTS

Present FCC rules on envelope monitoring should still apply. It may be desirable to have the additional requirement that both the positive peak and negative peaks be measured simultaneously to insure that the limits of peak modulation are not exceeded on those stereo receivers which may be disturbed by zero carrier or near zero carrier conditions. The devices to measure peaks can simply be fixed, pre-set peak lights that are already available on modern AM monitors.

It is anticipated that the AM stereo monitor could be used in conjunction with a present modern envelope monitor. It need not duplicate the envelope monitor functions. The stereo monitor may have the L + R detector built in, if necessary. Additional functions for measuring and monitoring AM stereo are desirable, such as left channel, right channel, L - R, and L + R. These functions could be accomplished with a single meter with a function switch to switch to the appropriate circuitry for measurement. The metering could have a range switch to permit detailed measurements of the left and right separation and crosstalk into the L - R and L + R channels.

The AM stereo demodulator should represent the highest level of performance currently obtainable in order to accurately measure the performance of the transmitted stereophonic signal. Those systems that do not require an L - R detector, as such, for stereo demodulation still require the L - R to be measured. This function is probably the most important function to measure, since most present transmitters have AM - PM conversion. The L - R measurement function will permit the broadcaster to improve the stereo performance of his transmitter. This function must have a sufficiently high level of performance so as not to introduce any AM - PM conversion in the measurement itself. Special attention will have to be paid to the design of the limiters so that high levels of negative modulation may be used for testing of AM - PM conversion of broadcast transmitters.

A delay standard between the envelope modulation and angle modulation will have to be set and the stereo monitor will have to incorporate this standard. Phase coincidence between the envelope modulation and angle modulation may not necessarily be the best choice from the standpoint of economical receiver design.

The AM stereo monitor's function will primarily be that of a measurement tool. Angle deviations may not have to be actually "monitored", since the deviations are constrained by all of the stereo transmission systems. The test functions are mandatory for the proper setup of a broadcast transmitter.

SIGNAL PROCESSING FOR AM STEREO BROADCASTING

Introduction

Current studies of the National AM Stereophonic Radio Committee have identified the need to examine more carefully various audio signal processing techniques as they apply to the emerging AM stereo technology. Although there are available today a large number of commercial processing devices such as automatic level controls, compressors, limiters, etc., these devices as presently configured do not fully meet the requirements for AM stereo broadcasting. In FM stereo broadcasting the components of the composite signal may be viewed as either an alternate transmission of left and right signals at a 38 kHz rate, or a composite of sum and difference channels. In either case the resultant broadcast is by frequency modulation, and all components of the signal may be treated in a similar manner. In contrast, AM stereo broadcast systems may require conventional processing for the compatible AM (sum) signal and different processing for the angle modulation (difference) signal. Some of the ways in which these conflicting requirements may be managed will be examined in this paper.

Automatic Gain Control Systems

Figure 1 illustrates the basic circuit for most automatic gain control devices currently in popular use. Audio program is passed through an amplifier which has the capability of adjusting gain in response to the application of an external DC control signal. At the output of the variable gain amplifier a portion of the signal is sampled and fed back to a control circuit, usually a detector which produces a DC signal varying in level with changes in audio program level. The loop is completed by connecting this DC signal to control the gain of the variable gain stage. When a peak limiting function is desired, the equipment designer provides a high loop gain and rapid time constants of detection. Increasing the time constants for slower response produces an automatic gain control function, and reducing the loop gain produces a compressor with a less tightly controlled output signal level.

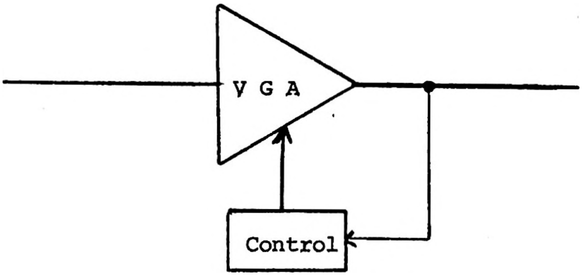


Figure 1.

A number of variations on the above circuit may be employed for stereo signal processing. In general, when left and right signals are independently fed to different signal processing amplifiers, it is desirable to insure dynamic tracking of the two amplifiers. If the gain of left and right channels is allowed to vary independently, an instability of center phantom images will result. Similarly, as will be shown later, if independent processing is employed on the sum and difference signals, an instability of separation may result, also creating an instability of phantom images. Figure 2 illustrates one method by which both gain control devices can be operated in unison.

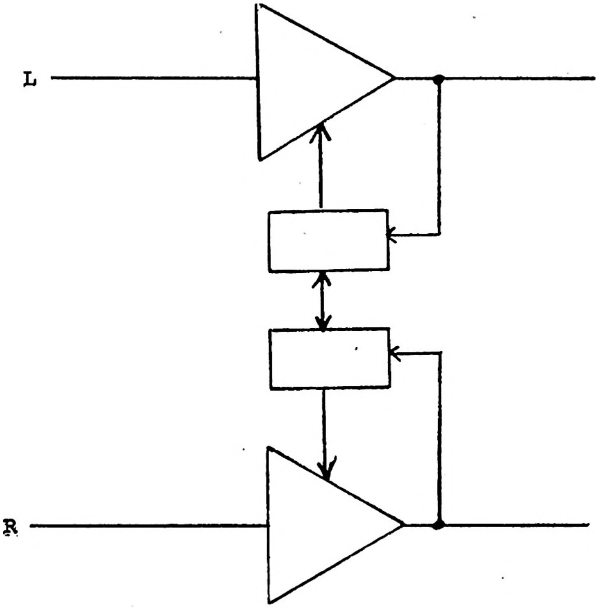


Figure 2.

The two control circuits are connected in such a way that either section may control the gain of both. In general, such a configuration usually means that the channel with highest program level will cause gain reduction to occur in both channels. This configuration may be satisfactory for compression or automatic level control, but it is unsatisfactory for peak limiting, as it cannot accurately anticipate the ultimate waveforms of the resultant sum and difference signals.

Figure 3 shows a more preferred method of connecting the two channels for automatic level control purposes. By deriving a control signal which is based on the sum of left plus right, a more constant compatible signal is obtained.

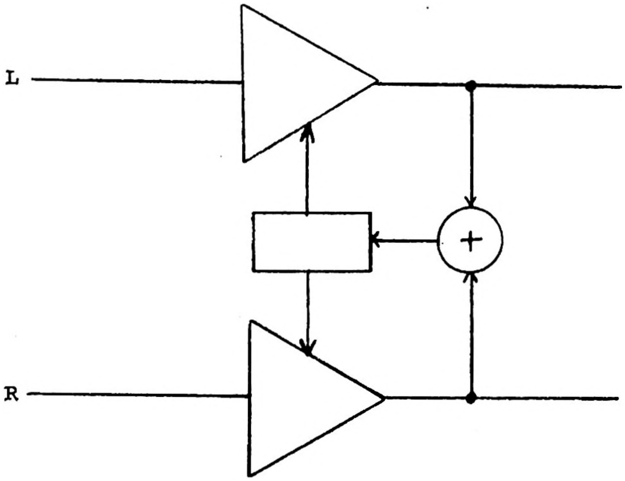


Figure 3.

A more complete prediction of sum and difference levels is achieved by the configuration of Figure 4. Here separate control signals are derived for both the sum and difference signals. A more complex control circuit establishes a protocol by which audio gain may be adjusted in response to these two functions. The configuration of Figure 4 is probably

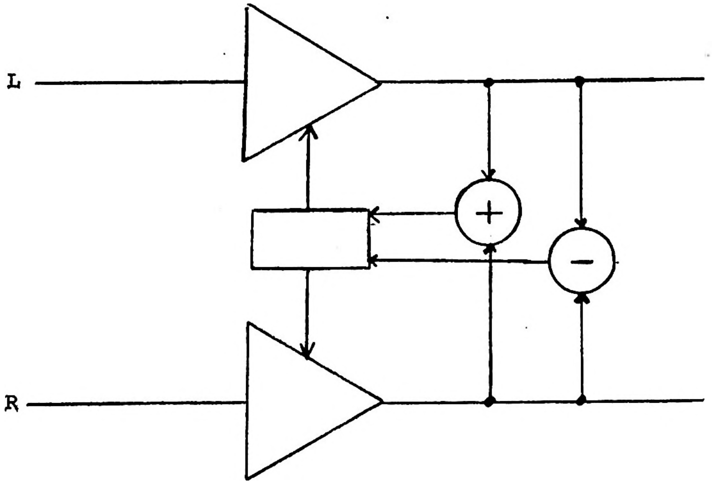


Figure 4.

not very good for either gain control or limiting purposes. As a level control, it is unnecessarily complex. As a peak limiter it has the same disadvantages as the configuration of Figure 3, i.e., it is not possible to predict with absolute accuracy what the ultimate waveforms of the sum and difference signals will be. There is too much potential for gain and phase changes in stereo encoding circuitry which follows such a processor.

Sum and Difference Peak Limiting

Although separate gain riding of left and right signals is usually desirable for automatic level control, it is more appropriate to process signals in a sum and difference configuration for peak limiting. Figure 5 illustrates a basic arrangement for such a function.

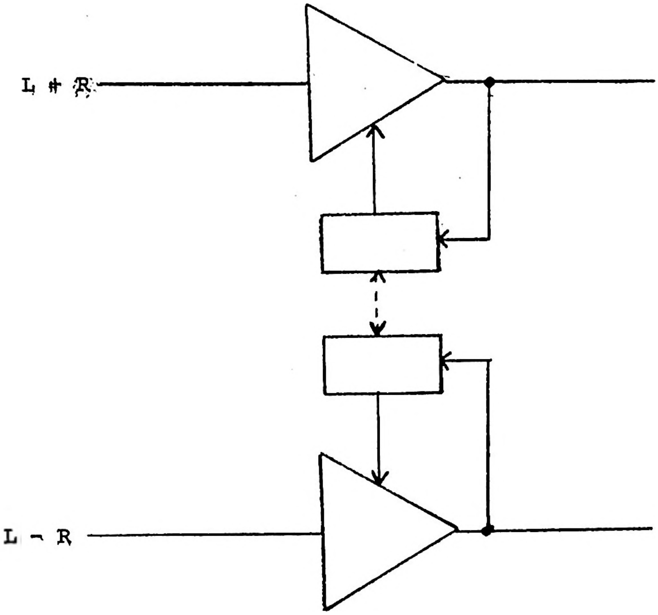


Figure 5.

Note that the tethering of the two control circuits is only tentative in the above schematic. As previously mentioned, if these circuits are untethered, a modulation of left and right separation may result. In a slowly changing automatic level control such an effect would be clearly objectionable. With a rapidly acting peak limiter, the problem may not be as severe. On the other hand, if the two control circuits are connected in a bi-directional manner as shown in previous figures, another unfortunate result may be obtained. AM broadcasters are competitively sensitive to the high modulation levels of their stations. It is readily apparent that if tethering is employed in the configuration of Figure 5, a loss of sum signal modulation may occur when difference signal levels are high. This may be unacceptable to some broadcasters.

Another configuration is suggested (probably for the first time) in Figure 6. Here, tethering is accomplished in a unidirectional manner only. High level sum signals will cause gain reduction of both channels, thus preventing image modulation. However, difference signals are prohibited from affecting the desirable high level modulation of the main channel. Some image modulation may occur, but this approach in Figure 6 appears to offer a satisfactory compromise to the problem.

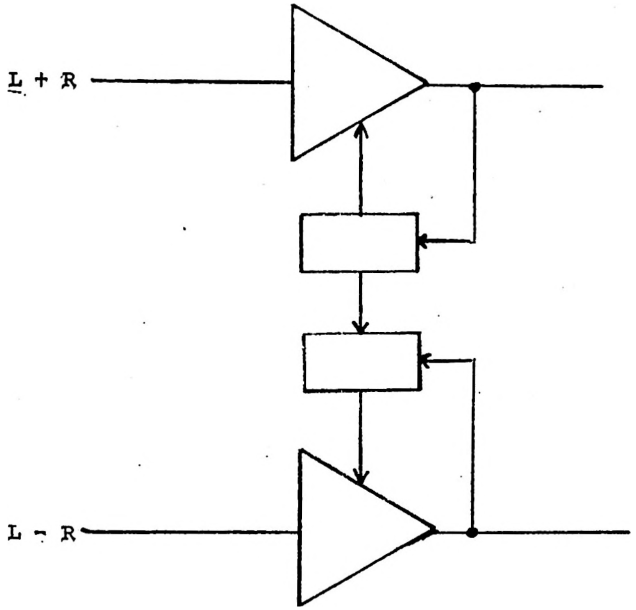


Figure 6.

Clippers

Some manufacturers of peak limiters utilize "safety" clippers at the output of their devices. Whether such control is accomplished by conventional diode clipping or by more complex rapid gain control techniques, the effect is the same -- occasional rapid reduction of peaks with near instantaneous recovery to original gain. Since clippers are normally not tethered for FM stereo operation, it may be assumed that similar operation will be satisfactory for AM stereo broadcasting.

Automatic Polarity Control

Another technique commonly used by AM broadcasters recognizes that waveform assymetry and the peak-to-average ratio of live speech is often significantly greater than that of music or pre-recorded commercial announcements. Ordinary limiters would adjust the gain downward in the presence of signals with such high peak factor, thus resulting in an undesirable loudness imbalance in the program. Current FCC regulations allow for 2 dB higher maximum modulation (125%) of such positive going peaks. Since program signals, especially those of male announcers, are often asymmetrical, many broadcasters employ automatic devices which insure that the polarity of highest peak level is used for positive modulation. Assuming that the use of such devices will continue to be desirable for the AM component of a stereo signal, it should be specified that any devices which automatically switch the polarity of an audio signal must operate in unison on both the sum and difference channels.

Phase Shift Networks

Finally, consideration must be given to the operation of all-pass networks which are used to reduce the peak factor of program signals. This is accomplished by a circuit which has continuously increasing phase shift (with frequency). High peak factors of live signals are produced when all signal harmonics add at the same point in time to produce a signal of maximum peak level. By intentionally introducing phase shift into the audio channel, the harmonic-time function is modified and a lower peak factor will result. Although it is possible to show how such a circuit could increase the peak factor of certain signals, it is generally agreed that, statistically, an improvement is made. With signals reduced to a lower peak factor, broadcasters are able to increase the average modulation level of their stations -- a condition which has already been shown to be desirable. Such all-pass networks may continue to be used in AM stereo systems provided that they are installed ahead of final peak limiting, and also provided that phase tracking within a few degrees is achieved between channels.

PROGRAM DISTRIBUTION FROM STUDIO TO TRANSMITTER

General

The specification of audio channels for AM stereophonic broadcasting may be correctly assumed to follow closely the practices which are currently observed in FM stereo. Such parameters as frequency response, signal-to-noise, crosstalk, distortion, and phase and amplitude tracking contribute to the perceived fidelity and stereophonic effect without regard to the radio frequency modulation technique which is used. Only one parameter -- audio bandwidth -- may need to be significantly degraded in order to appropriately limit sideband radiation in AM broadcasting.

Various sources may be used to determine what the current practice for stereophonic transmission is. These include the FCC Rules and Regulations, telephone company practices, and the recommendations of such organizations as the CCIR and the NQRC. The specifications thus studied follow.

Frequency Response

Telco equalized transmission lines are normally available in three grades of service:

5 kHz = 100 to 5,000 Hz

8 kHz = 100 to 8,000 Hz

15 kHz = 50 to 15,000 Hz

For each, the amplitude vs. frequency response of individual channels is maintained within plus or minus 1 dB of the 1,000 Hz amplitude. This is compatible with FCC broadcast requirements which permit a total deviation of plus or minus 2 dB for the entire broadcast chain, including various amplification and limiting devices, as well as the transmission lines.

Amplitude tracking between stereo cable pairs, on the other hand, is not presently regulated. Telco standards call for gain differences between channels to be held within plus or minus 1/2 dB, and in actual practice, even better response is usually achieved. However, the use of dynamic gain adjusting devices such as compressors and limiters will degrade this performance by 1 to 2 dB. Although a 2 dB amplitude difference between left and right stereo channels will cause a center image shift of approximately 5 degrees, this error is not normally noticed by listeners and there appear to be state-of-the-art limitations to further improvement at this time.

Signal to Noise Ratio

Telco standards permit feeding program line levels as high as +8 VU. Maintenance of such levels is encouraged in order to maximize signal to noise ratios, as the attenuation of equalized lines may be as great as 40 dB. Assuming an 8 dBm input signal, the following minimum performance is expected:

Grade of Line	S/N
5 kHz	62 dB
8 kHz	62 dB
15 kHz	65 dB

Phase Response

This characteristic of audio channels is presently unspecified both for Telco lines and FCC broadcast standards.* There are two modes of

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* The FCC does, however, specify the maximum allowable phase error between the main and subchannels of an FM stereo generator, as this parameter will ultimately affect left-right audio separation.

phase response -- phase delay vs. frequency on a single line, and interchannel phase tracking. The former is considered an unimportant factor as such delay is inaudible and a normal characteristic of equalized lines. The latter is more important as it can affect the quality of stereo images and compatibility of monophonic reception. Figure 1 summarizes the recommendations for maximum allowable phase difference by three organizations -- NQRC[1], CCIR[2], and OIRT[3]. All illustrated in this Figure, the NQRC recommends a maximum differential of 38.6 degrees, for monophonic compatibility of 1 dB. (The NQRC recommendation is directed to discrete quadraphony, but the same standard can be applied to stereo.) The CCIR report suggests a lower possible error of 20 degrees at mid frequencies, and the OIRT, which specifies response at only three frequencies, drops to a low figure of 10 degrees.

Separation

FCC Rules and Regulations infer a minimum left-right separation requirement of approximately 30 dB. Such performance is readily achieved in audio transmission circuits, but not necessarily in program sources such as disc and tape recordings. Although separation as low as 20 dB is considered adequate for proper psychoacoustic stereo effect, there appears to be no need to deviate from the 30 dB figure for AM stereo transmission.

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1. "Report of the National Quadraphonic Radio Committee", Nov. 1975.
2. "Audio-Frequency Parameters for the Stereophonic Transmission and Reproduction of Sound", CCIR Report 293-3, (1963-1966-1970-1974).
3. "Parameters of the Sound Transmission Channel at the Input of the International Transmission Channel", CCIR Doc. 10/44, (1974-1978)

Signal Processing

As applied to commercial broadcasting, the term "signal processing" refers primarily to the use of audio automatic level controls, or AGC amplifiers, and peak limiters, or clippers.

Automatic gain control amplifiers are relatively slow-acting devices which are used to maintain a nearly-constant average program level. For stereo, two such devices are employed -- in the left and right program channels, respectively. The two units are connected in such a way as to ensure equal and simultaneous response in both channels, thus avoiding any instability in the apparent localization of phantom images. The automatic level control requirements for AM stereo are similar to those for FM stereo, and existing equipment may be used without modification.

For peak limiting, the requirements of AM stereo are more complex. In FM stereo broadcasting, the components of the composite signal may be viewed as either an alternate transmission of left and right signals at a 38 kHz rate, or a composite of sum and difference channels. In either case the resultant broadcast is by frequency modulation, and all components of the signal may be treated in a similar manner. In contrast, AM stereo broadcast systems may require conventional processing for the compatible AM (sum) signal and special processing for the angle modulation (difference) signal. The particular requirements for AM stereo peak limiting stem from several considerations -- the desire to maintain high modulation of the compatible standard AM broadcast signal (including positive peak modulation up to 125% where applicable), and the need to accurately control the peak level of the difference signal modulation, especially if audio pre-emphasis is employed. This latter requirement may lead to perturbations of interchannel separation as a function of frequency and modulation level, if sum and difference limiting is employed, or to reduced overall modulation level if left and right channel limiting is employed. For a more complete discussion of this topic, see TORICK, "Signal Processing For AM Stereo Broadcasting", appended to this Report.

Studio-Transmitter Radio Link

Currently, FM stereo broadcasters utilize STLs in either of 2 modes -- separate left and right audio transmission on the same RF channel but with a 100 kHz offset between the two signals, or direct transmission of the composite signal.

In AM stereo, similarly, two methods may be used -- transmission of left and right, or sum and difference signals. In either case, use of the frequency offset technique is indicated, in order to maintain optimum separation or crosstalk. No modification of existing links or equipment is required, however, since the audio specifications for AM and FM stereo may be considered to be similar.

One last consideration concerns STL bandwidth. Under existing FCC Rules, 500 kHz is available per STL channel. Given the fact that neither AM nor FM stereo operation requires such bandwidth, and the possibility that authorization of AM stereo broadcasting may create an unprecedented demand for such channels, it appears that consideration may be given to reduction of the STL bandwidth. However, it should be emphasized that no specific study of the impact of such a modification of the Rules has yet been made.

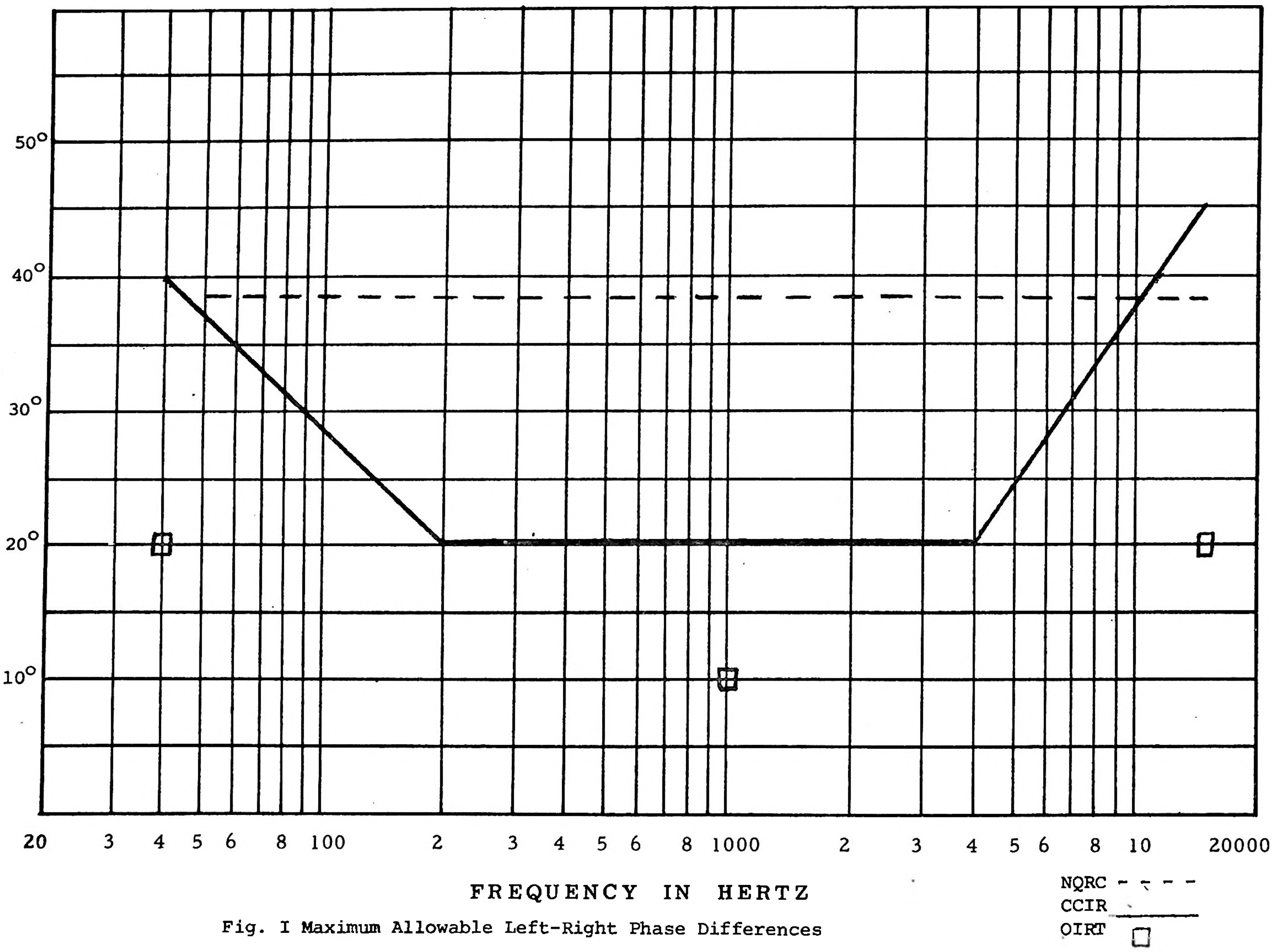

Fig. I Maximum Allowable Left-Right Phase Differences

RADIO STL CONSIDERATIONS

FOR

AM STEREO BROADCASTING

INTRODUCTION

For AM stereo broadcasting, the radio STL will provide an attractive method to convey the program signals between the studio and remote transmitter site. Many consider the STL to be technically superior, more cost effective, and more reliable than standard wire line circuits. This paper will consider some of the various ways in which a radio STL may be used.

Before considering these, a review of the radio STL techniques used for FM stereo seems appropriate. Two basic configurations are employed in FM broadcast service. One system uses two separate STL systems operating in one 500 kHz channel to convey the left and right audio channels. This is commonly referred to as the dual STL configuration. The second, and more commonly used technique, is to use one wideband STL to convey the encoded stereophonic signal to the transmitter where it is applied to the wideband input of a direct FM exciter. This systems can convey remote control and SCA subcarriers, and both can be configured in a hot standby mode for increased reliability.

In AM stereo, a composite STL (in the FM sense) cannot be used because of the different input ports for the sum and difference signals to the transmitter. Thus, the STL system must deliver either the left and right signals or the sum and difference signals to the transmitter. It is in this sense that the term composite AM STL can be used.

Because of the expected heavy demand on STL assignments, the occupied bandwidth of the STL is of prime importance. The technical performance of the STL can, accordingly, be somewhat less than the current practice provides for FM broadcast service. In general, an STL system for AM stereo should deliver a signal with a distortion of 1% or less, a signal-to-noise ration in excess of 55 dB, separation of at least 30 dB, and a frequency response from 30 Hz to 15 kHz. Some rolloff at the upper frequency can be tolerated in many cases. It is most desirable that the two audio channels (L and R or L+R and L-R) be treated the same by the STL configuration.

GENERAL COMMENT

With the above in mind, there are several ways in which a radio STL can be used to convey programs from the studio to the transmitter. These are briefly outlined below with pertinent comments.

1. A single radio link using the "main channel" (30 Hz to 15 kHz) for one audio (or sum) channel, and a subchannel for the other audio (or difference) channel can be used. However, there will be a measurable difference in the performance of the subchannel versus the "main channel". This difference between channels becomes less at the expense of occupied bandwidth. Appropriate modulator-demodulator units are required for the subchannel regardless of whether it is AM or FM.

2. A single radio link can be used with a digital, i.e., PCM, encoder-decoder for conveying the two audio channels to the remote site. In this system, both audio channels are treated identically, but the bandwidth required for PCM schemes, even those with compression techniques, is surprisingly high. The spectrum utilization is, there-

fore, poor. It does offer a potential advantage in a multi-hop repeater STL system.

3. A single radio link with a pair of signals occupying a single subchannel can also be used. The signals can be of the double-sideband suppressed carrier (DSSC) type with the suppressed subcarriers in phase quadrature. Both audio channels are treated in the same manner, but the noise will be higher than the "main channel" spectrum. Again, special modulator-demodulator units are required.

4. A single radio link using a conventional FM stereo generator can be used to convey the two audio channels to the remote site. Because of the requirements of AM stereo, the FM composite signal must be decoded to obtain the separate audio channels. This equipment adds to the cost of a system and, unless a significant reduction in the upper audio frequency is allowed as well as some degradation in the signal-to-noise ration, the system will require the same bandwidth as that for FM broadcast service.

5. A pair of radio links may be used in a dual configuration to convey the left and right channels individually to the remote site.

DISCUSSION

Each of the above systems can be varied to transmit the sum (compatible) and difference signals if more convenient to the modulators employed in the AM transmitter. Also, different RF bandwidths can be assigned to accommodate different audio bandwidths. For example, if the upper audio frequency of interest is reduced from 15 kHz to 8 or 10 kHz, the occupied RF spectrum can be reduced. Also, lower deviations than those presently used by FM radio STL's can be used (with a corresponding reduction in the system SNR). Distortion will be determined in large part by the selectivity and phase characteristics of the STL receiver.

Using two separate radio links appears to be the most attractive method at the present time. In a dual configuration, both audio channels are treated identically, no special multiplexing equipment is required, and the signal-to-noise ratio and channel separation are maximized. In any single link (composite) system, cross talk and separation are both potential problems. Given the fact that 500 kHz has been shown to be required to provide a satisfactorily transparent FM composite STL to comply with current FCC specifications, it is obvious that narrowing the bandwidth of such a system can be accomplished only by lowering the audio frequency modulating rate. When the deviation is reduced to accommodate a lower bandwidth, the SNR will immediately suffer while the bandwidth does not drop proportionately.

Present demands for aural STL's are already overloading the spectrum currently available for this service. Therefore, in consideration of an STL system for AM stereo, occupied bandwidth will be an extremely important characteristic. This, in turn, will dictate the performance characteristics of the individual audio channels. A separate link providing audio responses from 30 Hz to 15 kHz, distortion products of less than 1%, and signal-to-noise ratios in excess of 55 dB can be achieved in an occupied bandwidth of 50 to 100 kHz. It must be remembered, however, that some STL receivers will be collocated with an STL transmitter, so receiver overload or channel adjacency problems may be expected in some instances if narrowband channels are allocated for AM stereo service. It seems reasonable that the present 250 kHz channel assignment for one of the links of a dual FM system can accommodate a dual AM stereo link without difficulty. With proper receiver design,and care in the channelization allocations in a specific geographic area, this occupancy can possibly be doubled again. However, this places a large engineering and administrative load on the Federal Communications Commission in the assignment of licenses. In all the systems designated above, transmitter remote control signals can be accommodated without difficulty. In any event, the Commission recognizes that the current 947-952 MHz spectrum for STL service may be inadequate to accommodate both FM and AM STL requirements. Consideration should be given toward enlarging the spectrum.

Panel III, Receiving Systems, was activated on April 12, 1976, with T. A. Prewitt of Delco Electronics as Chairman and A. L. Kelsch of Magnavox as Vice-Chairman. Subsequent meetings were held in Washington, D.C., on May 10, 1976, September 16, 1976, and October 20, 1976. A special working meeting was called at Kokomo, Indiana, on March 15, 1977.

Panel III tasks included the following:

1. Classification of AM receivers into generic groups based on their performance attributes and selection of five representative categories for use in compatibility testing.

2. Characterization of five monophonic compatibility receivers for use by the Field Tests panel.

3. Conducting and evaluating an industry survey to determine the bandpass characteristics of contemporary monophonic AM receivers. Results were provided to the Systems Panel for their use in system compatibility calculations.

RECEIVER PANEL TASKS

Classification of AM Receivers for Compatibility Testing

One important requirement for an AM Stereo system is that it be fully compatible with the hundreds of millions of existing monophonic receivers already in the hands of the public. In selecting compatibility test receivers to be used by the field test panel, the receiver panel noted the exceedingly wide spreads in cost, sensitivity, and selectivity to be found within this group of receivers and chose five types which it believed would fairly represent the monophonic performance of the entire group. These receivers were as follows:

- Inexpensive pocket portable, typical of those sold in huge quantities by mass merchandisers at prices as low as $3.00. In addition to exemplifying the bottom of the line in terms of cost, these receivers also represent the minimum sensitivity and audio fidelity acceptable to users and also comprise the largest group in terms of sheer numbers.

- Multi-band portable, typical of many models retailing in the $30-80 price class. These receivers have more amplifying stages and tuned circuits than the inexpensive pocket portable and also have larger speaker systems and, consequently, better audio fidelity.

- Console receiver, representative of those packaged together with a record changer and/or tape player in a furniture-style cabinet. Receivers of this type ordinarily reproduce a relatively wide audio frequency spectrum because their cabinets are large enough to provide effective low-frequency baffling.

- Component hi-fi receiver or tuner. Although this category includes only a small percentage of the total number of AM receivers, it is important since it represents the top of the line in terms of wide bandwidth, extended fidelity and low distortion. The design of tuners or receivers of this kind is commonly optimized for best performance in metropolitan and suburban areas where signals from the desired stations are strong and wide system bandwidths can be used to achieve the best possible high frequency response.

- Auto radio receiver, which by virtue of its mobile operating environment, experiences a wide range of signal strengths and ambient conditions. Since on a single trip an auto radio may pass by a transmitter site and continue on to a remote area, it is commonly designed to operate over an extremely wide range of signal strengths. Wide bandwidth capability is usually traded off in favor of good adjacent channel selectivity and reduce susceptibility to power line and ignition noise.

AM COMPATIBILITY RECEIVER DATA

Five monophonic AM receivers were measured at Delco Electronics Division, Kokomo, Indiana, on March 15, 1977. These are labeled and identified as follows:

Designation	
T-101	AM Pushbutton Auto Radio. Service Model 70BP1., S/N 1024788. Delco Electronics Div., GM Corp., Kokomo, Ind. 46901
T-102	Hi-Fi Component AM Tuner. Model AM-5, S/N AM500632. McKay-Dymec Co., 675 No. Park Ave., Pomona, CA, 91766.
T-103	AM/FM/Stereo Consolette Receiver. Model R-34303-BB, S/N 638528. Magnavox Co., Ft. Wayne, IN.
T-104	Low-Cost AM Pocket Portable. Model 31-16, No S/N.
T-105	AM/FM/PSB Portable. Model RF-1080, No S/N. Panasonic, Matsushita Electric Corp. of America, 1 Panasonic Way, Secaucus, New Jersey 07094.

ACKNOWLEDGEMENT

Panel III of the National AM Stereo Radio Committee is grateful to:

Delco Electronics Division, General Motors Corporation

McKay-Dymec Company

The Magnavox Company

Matsushita Electric Corporation of America

which provided receivers and to Delco Electronics Division, which also provided facilities and manpower for the measurements.

TAPrewitt

T. A. Prewitt
Chairman, Panel III

Sensitivity for reference output of 1 watt into 10 ohm load - 30% AM @ 1 kHz. 70 pfd split dummy antenna (23 pfd series, 47 pfd shunt), 14 VDC supply.

kHz	uV
570	1.9
1030	2.7
1500	3.1

20 dB (S+N)/N - Test signal as above.

kHz	uV
570	9.0
1030	7.0
1500	7.5

% Distortion Versus % Modulation. 1 watt output, 1000 Hz modulation, volume control set at tone tap position (identify by slight plateau in volume versus % rotation curve of control).

	% MODULATION									
kHz	10	20	30	40	50	60	70	80	90	100
570	4.3	2.0	1.6	1.5	1.4	1.4	1.7	2.3	3.2	4.9
1030	4.5	2.0	1.5	1.7	1.7	1.9	2.1	2.5	3.2	4.6
1500	4.0	1.9	1.6	1.5	1.4	1.5	1.7	2.4	3.4	5.0

Frequency Response at 30% AM, volume control at tap, 5K uV signal, tuned for minimum output at 5 kHz modulation. Tone control at mid-range detent.

	Frequency, Hz					
kHz	100	400	1000	2500	5K	10K
570	+6.2 dB	+3.2	0	-5.2	-18	-38
1030	+6.2	+3.2	0	-4.8	-17	-39
1500	+6.0	+3.2	0	-4.7	-16	-38

AGC Figure of Merit at 1000 kHz, Volume control set for 1 watt output at 5K uV signal, 30% modulated @ 1000 Hz.

uV	Audio Output, dB
1	-27
3	-11
10	- 5
30	- 3
100	- 2
300	- 1
1K	0.5
3K	0
10K	+ 0.5
30K	+ 1.4
100K	+ 5.6
300K	+ 6.8

T-101 CONTINUED

Apparent Bandwidth.

- 6 dB	7.3 kHz
-60 dB	31.3 kHz

Shape factor = 4.3

All data measured with DISTANT and WIDE buttons depressed unless otherwise stated. Signals applied to 50-ohm antenna terminals (no loop antenna used).

Sensitivity for 20 dB (S+N)/N ratio, 30% AM at 1 kHz.

kHz	uV
570	22
1030	10
1500	9.5

% Distortion Versus Modulation, 1K uV, 30% AM at 1 kHz.

	% Modulation									
kHz	10	20	30	40	50	60	70	80	90	100
570	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	1.5
1030	0.5	0.5	0.5	0.2	0.2	0.3	0.4	0.5	1.3	2.2
1500	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	1.8

Frequency Response, output control at maximum, 5K uV at 30% AM.

	Frequency, Hz					
kHz	100	400	1000	2.5K	5K	10K
570	0 dB	0	0	0	-4	-8
1030	0	0	0	0	-4	-9
1500	0	0	0	0	-1	-8

AGC Figure of Merit, 1 MHz at 30% AM.

uV	Audio Output, dB
1	---
3	-25
10	-10
30	- 6
100	- 2.8
300	- 1.2
1K	- 0.8
3K	0
10K	0
30K	0
100K	+ 1
300K	+ 2

AGC Versus Signal Level, 1 MHz, 30% AM at 1 kHz, tuned for minimum output at 5 kHz, 10 uV, narrow bandwidth.

	AGC Volts	
uV/M	Wide	Narrow
3	-0.234	-0.482
10	-0.953	-1.430
30	-1.853	-2.155
100	-2.397	-2.576
300	-2.736	-2.868
1K	-2.992	-3.099
3K	-3.201	-3.290
10K	-3.374	-3.446
30K	-3.514	-3.572
100K	-3.632	-3.677

True Bandwidth with AGC clamped at -3.26V (approximately equivalent to 3K uV/M signal). 30% AM at 100 Hz, 3K uV input.

kHz	dB, Wide	dB, Narrow
1017	-40	---
1018	-32	---
1019	-15	---
1020	- 6	---
1021	- 4	---
1022	- 2	---
1023	- 0.9	---
1024	0	-50.0
1025	0	-12.0
1026	0	- 2.8
1027	- 0.4	- 1.5
1028	- 0.6	- 1.0
1029	- 0.8	- 0.5
1030	- 0.9	- 0.2
1031	- 0.9	- 0.2
1032	- 1.0	- 0.5
1033	- 1.0	- 0.5
1034	- 1.0	0
1035	- 1.0	0
1036	- 0.9	- 0.5
1037	- 1.0	- 0.8
1038	- 1.5	- 2.0
1039	- 1.8	- 7.0
1040	- 3.1	-50.0
1041	- 6.0	---
1042	-10.0	---
1043	-14.0	---
1044	-23.0	---
1045	-34.0	---
1046	-45.0	---

T-103

Tone controls at mid-range, loudness off for all measurements.

Sensitivity for 20 dB SINAD. 30% AM at 1000 Hz

kHz	uV/M
570	320
1030	220
1500	160

AGC Figure of Merit at 1030 kHz, 30% AM at 1000 Hz.

uV/M	dB
30	-28
100	-18
300	-10
1K	- 5
3K	- 1.3
10K	- 0.8
30K	0
100K	+ 0.5

% Distortion Versus Modulation at 10K uV/M, 30% AM at 1000 Hz.

	% Modulation									
kHz	10	20	30	40	50	60	70	80	90	100
570	2.0	1.3	1.0	1.1	1.3	1.5	1.7	1.6	1.6	1.9
1030	1.5	1.1	1.3	1.7	2.0	2.5	2.8	3.0	3.2	3.2
1500	3.0	1.5	1.1	0.8	0.7	0.8	0.9	1.0	1.2	1.8

Frequency Response at 1030 kHz, 5K uV/M, 30% AM.

Hz	dB
100	
400	
1K	**Not Available**
2.5K	
5K	
10K	

True Bandwidth at 2K uV/M, AGC line grounded (equivalent to AGC voltage at 2K uV/M), 30% AM at 100 Hz. Reference 0 dB = 0.5W into 10 ohms.

kHz	dB
1024	-41
1025	-35
1026	-29
1027	-27
1028	-24
1029	-20
1030	-17
1031	-14
1032	-10
1033	- 6
1034	- 3
1035	- 1.3
1036	- 0.1
1037	0
1038	- 1
1039	- 2
1040	- 3.8
1041	- 6
1042	- 9
1043	-12
1044	-17
1045	-23
1046	-31
1047	-40
1048	-45

T-104

Measured with fresh internal battery.

Sensitivity, 20 dB SINAD.

kHz	uV/M
570	2K
1030	600
1500	560

Frequency Response at 1030 kHz, 30% AM at 1 kHz.

Hz	dB
100	-34
400	-10
1K	0
2.5K	- 8
5K	-25
10K	-35

% Distortion Versus Modulation at 3K uV/M.

% Modulation	% Distortion
10	2.4
20	1.8
30	2.1
40	2.4
50	2.7
60	2.8
70	3.0
80	3.4
90	3.6
100	3.2

True Bandwidth at 30% AM, 1 kHz, 3000 uV/M, 1 volt out. AGC line clamped at -1 volts.

kHz	dB
1025	-40
1026	-24
1027	-10
1028	- 3
1029	- 1
1030	0
1031	- 0.2
1032	- 1.8
1033	- 4.8
1034	- 9
1035	-14
1036	-26
1037	-40

T-105

Measured on AM band, using fresh internal batteries.

Sensitivity for 20 dB SINAD.

kHz	uV/M
570	190
1030	150
1500	110

Frequency Response at 1030 kHz, 30% AM.

Hz	dB
100	+ 1
400	+ 5
1K	0
2.5	- 8
5K	-12
10K	-23

% Distortion Versus Modulation at 1030 kHz, 1 kHz AM.

% Modulation	% Distortion
10	1.6
20	1.0
30	1.2
40	0.9
50	1.0
60	1.2
70	1.8
80	2.3
90	2.4
100	2.0

Apparent Bandwidth at 20 dB SINAD (AGC line not found), 5000 uV/M, 1030 kHz, 1 kHz AM 30%.

dB	BW
6	20
20	36

DISTORTION vs MODULATION PERCENTAGE
1030 kH2 1K mV/m

Distortion-Percent

Modulation Percentage	T101A Delco	T102 Dymec	T103 Magnavox Compat.	T104 K-Mart	T105 Panasonic	Magnavox		Motorola thru decoder (L channel)	Belar
						narrow	wide		
10%	2.3%	1.3%	2.8%	19%	7.5%	2.2%	1.3%	2.3%	2.8%
20	1.2	.65	1.4	11.	3.6	1.1	.67	1.2	1.4
30	.9	.42	1.2	9.2	2.6	.75	.55	1.0	.9
40	.9	.34	1.4	10.5	2.0	.65	.58	1.4	.7
50	1.1	.34	1.6	12.5	1.9	.63	.66	1.5	.6
60	1.4	.36	1.9	14.5	2.1	.65	.79	1.2	.5
70	1.5	.45	2.1	16.	2.4	.72	.90	0.9	.5
80	1.5	.75	2.4	17.7	2.5	.84	.98	.75	.65
90	1.6	1.4	2.9	18.5	3.5	.90	1.05	1.3	.9
100	1.8	2.5	3.6	19.5	4.1	.91	1.2	2.4	1.1

RETEST OF COMPATIBILITY RECEIVERS, AND MONAURAL CHARACTERIZATION OF PROPONENT'S STEREO RECEIVERS

Audio Output vs R.F. Input Level

AGC	T101	T102	T103	T104	T105	Magnavox		Motorola	Belar
					@ 10mW	wide	narrow		
1 uV	-33dB	-54dB			-	-	-	-	-
3	-17	-40			-	-	-23 dB	-	+5.8
10	-6.4	-15.5			-23	-16.8 dB	-17.5	-32.	+1.2
30	-3.	- 3.4	-21 dB		-12.3	-10.9	- 9.5	-23.4	0
100	-1.5	- 1.4	-13.5		- 6.4	- 3.7	- 2.4	- 7.4	0
300	-0.6	- 0.6	- 5.6		- 2.	- .6	- 0.5	- 2.0	0
1K	0	0	0		0	0	0	0	0
3K	+ .5	+ .4	+ 2.8		+ .9	+ .40	+ .4	+ 1.0	0
10K	1.0	+ .7	4.0		1.3	.63	+ .6	+ 1.7	-0.2
30K	1.8	1.0	4.6		2.0	.70	+ .7	+ 2.4	-0.8
100K	3.2	2.0	5.2		5.0	.93	+ .85	+ 2.7	-2.4
300K	7.4	6.2						+ 3.0	-6.0

SENSITIVITY vs FREQUENCY
20 dB 5+n/n

Frequency	T101-A D-E	T102 Dymek	T103 Magnavox Compat.	T104 K-Mart	T105 Panasonic	Magnavox		Motorola thru decoder (L channel)	Belar
						wide	narrow		
570 kH2	14	21	810uV/m	2K uV/m	250 uV/m	310 uV/m	125 uV/m	63	40
1030 kH2	13	12	460	800	210	280	150	39	40
1500 kH2	12	9	320	540	180	300	170	23	40

AUDIO FREQUENCY RESPONSE
1030 kH2 5K uV/m

Audio Frequency	Response - dB								
100	+4	+ .3	+ 1.5 dB	- 29 dB	+ .5 dB	- 0.8 dB	- 0.7 dB	0	0
400	+2	.2	0.6	- 8.2 dB	+ 6.0	+ .3	+ 0.6	+ .2	+ .2
1K	0	0	0	0	0	0	0	0	0
2.5K	-4.5	0	- 2.6	- 8.2	- 8.5	- 1.2	- 2.4	- 1	- .6
5K	-19	- 0.9	- 9.9	- 23	- 12.5	- 4.8	- 7.2	- 3.5	-1.3
10K	-43	- 9.6	- 23.4	- 29	- 25.	- 8.1	-27.4	- 7.0	-3.4

NATIONAL AM STEREOPHONIC RADIO COMMITTEE

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August 26, 1976

Carl Eilers
Chairman, Panel I (System Specification)
National AM Stereophonic Radio Committee
Zenith Radio Corporation

Dear Carl,

Panel III (Receiving Systems) has completed its survey of IF bandpass characteristics of AM radios currently being manufactured and/or sold in the U.S. As committee designee I have reduced, compiled, interpreted and summarized the information returned as a result of the Panel III inquiry. The following is a summary.

Four categories of receiver products have been distinguished as representative of the spectrum of radios currently being manufactured and/or sold. These are A) Component or Hi-FI; B) Automotive; C) Console, Compact, and Modular; D) AM Pocket Portable. The mean and limits for each of these is as follows:

A. Component	Mean 6dB Bandwidth	7.2KC
	Extremes	5 to 10.5KC
	Mean 20dB Bandwidth	14.5KC
	Extremes	13 to 16KC
	IF Frequency	455KC
B. Automotive	Mean 6dB Bandwidth	7.3KC
	Extremes	6 to 8.7KC
	Mean 20dB Bandwidth	13.5KC
	Extremes	12.3 to 16KC
	Mean 60dB Bandwidth	33.6KC
	Extremes	30.6 to 36.5KC
	IF Frequency	262.5KC
C. Console, Compact, Modular	Mean 6dB Bandwidth	8.5KC
	Extremes	5.5 to 11KC

	Mean 20dB Bandwidth	20.8KC
	Extremes	11.5 to 28KC
	IF Frequency	455KC

Note: The results in this category tended to be polarized near the extremes, such that the mean represents neither of the groupings evident in the reported data. One group of receivers had 6dB IF bandwidths of 6 or 7KC and 20dB bandwidths of 13 to 15KC. The other grouping of receivers had 6dB bandwidths of 10KC and 20dB bandwidths of 26 to 28KC. However, the average shown is the mean of the data returned on all receivers.

D.

AM Pocket Portable	Mean 6dB Bandwidth	6.8KC
	Extremes	4 to 11KC
	Mean 20dB Bandwidth	14.3KC
	Extremes	10 to 20KC
	IF Frequency	455KC

The following qualifications apply to this survey:

1) The limits (extremes) shown are the limits of the means reported from the several respondents in each category. Individual units, on occasion fell outside the listed extremes. In addition to that, some small percentage of units falling outside the reported limits are certainly in existence, but are undocumented by this survey.

2) The results shown refer to current production and do not apply to the general cross-section of all receivers in the field, past and present. However, it is my judgment that this data is a valid representation of existing product and in future years will become more and more representative of all outstanding product.

3) The composite data shown is an average of several methods of compilation and signal levels, with the preponderance of method being a constant AGC one, and of level being a "listenable signal" reference.

4) A very high percentage of all receivers in the field, with the possible exception of category A, are not designed for smoothness of response (low ripple), symmetry, or specific phase characteristics. Indeed, as a practical manufacturing matter, the IF would normally be peak aligned without concern for shape or symmetry. There is nothing to indicate from the survey or from experience, that there is production control on any parameter except peak response. Consequently, the survey relates to specific attenuation points on the skirts, but says nothing about response in between these points.

5) In my judgment the "AM Personal Portable" category is under-represented in terms of population sample size. Survey returns in this category were insufficient to give a very high confidence level that the sample population truly represents the total population. Inputs from off-shore sources was minimal.

Thirty-seven letters of inquiry were sent out and 18 replies were received. Three of these had no information to convey. In category A) 5 replies were received; B) 3 replies; C) 8 replies; D) 4 replies. Several respondents had entries in more than one category.

The responding letters will be put on file at EIA and will be available for documentation or further study. However, this is company-supplied information and is intended only for NAMSRC use as determined by E. M. Tingley.

A copy of the inquiring letter is included for your information.

For Panel III, I am

Sincerely yours,

Albert L. Kelsch

A. L. Kelsch
Vice Chairman
Panel III, Receiving Systems
National AM Stereophonic
Radio Committee

cc: H. Kassens
Norm Parker (Motorola)
Thomas Prewitt (Delco)
E. M. Tingley (10) for Panel Members

dkb

RECEIVER CONSIDERATIONS FOR AM STEREO RECEPTION

Bandwidth

As is also the case in monophonic reception, the audio response of an AM stereo receiver will be a function of the receiver bandwidth, which in turn depends on the intended application. While it is true that receivers or tuners having a very wide bandwidth (e.g., 20 kHz) can provide essentially flat, noise-free audio response up to at least 10 kHz on strong signals form local AM broadcast stations, their wide bandwidth makes them more susceptible to adjacent channel interference and noise if the user desires to listen to a weak, distant station. Although this conflict may be resolved by the use of a variable-selectivity intermediate frequency amplifier, such an approach is more costly. For this reason it may be that many models of AM stereo receivers will be designed with a compromise selectivity characteristic, exactly as is now done with AM monophonic receivers.

A further point to keep in mind in assessing the fidelity capability of an AM stereo receiver is that the front-end selectivity with present technology tends to vary by as much as three to one across the AM broadcast band, being narrowest at the low-frequency end of the band, where its effect is great enough to significantly reduce the overall bandwidth of the receiver.

Passband Ripple

With the exception of a few wide-band tuners, monophonic AM receivers typically are aligned for maximum response at the center of the passband, resulting in a peaked, rather than flat-topped passband response. Phase linearity across the passband is ordinarily not a controlled parameter. The need for either a minimum passband ripple or a maximum limit on phase shift in a particular design of AM stereo receivers may result in some increase in manufacturing cost.

Tuning Accuracy

Monophonic AM receivers are ordinarily rather tolerant of mistuning up to ±2 or 3 kHz, and tuning indicators or AFC circuits are rarely used in modern designs. Factors which affect the accuracy of electro mechanical tuning include the user's ability to aurally determine the proper tuning point, backlash in the tuning mechanism, and frequency drift with temperature change. In addition to these factors, the tuning accuracy of automobile radios is also affected by vibration, large variations in supply voltage, and resettability errors in mechanical pushbutton tuners. Electronic tuners employing frequency systhesis are beginning to appear in new receiver designs, specifically in automobile radios. These are crystal-controlled and typically tuned by 10 kHz channel-width increments; consequently, they exhibit maximum tuning errors on the order of 60 Hz or less. The same tuning accuracy is achieved in either the automatic, preset, or manual tuning modes.

An AM stereo system which requires precise receiver tuning for proper operation would increase the cost of a conventionally-tuned receiver due to the tighter manufacturing tolerances needed in the tuner mechanism. The cost of an electronic-tuned receiver would not be affected by a requirement for high-tuning accuracy, since this capability already exists.

SYSTEM FEATURES OF IMPORTANCE TO THE RECEIVER DESIGNER

Stereo Identification

Since the public is accustomed to the stereo indicator found on nearly all FM stereo receivers, it would appear desirable to offer the same feature in an AM stereo broadcasting system. An additional factor favoring the inclusion of stereo identification is that modern electronic-tuned FM receivers now have an automatic stereo search mode in which the tuner is programmed to stop only on stations having a stereo pilot carrier. The same capability can easily be added to an electronic-tuned AM stereo receiver if identification is possible of the AM stereo composite signal. For this purpose, stereo identification should be made within a fast sampling time.

Stereo Demodulators

As discussed in section I of this report, a choice of stereo detection is probably more related to the designers perference than the system. Each detector has its own characteristics. For instance, a phase locked loop (PLL) usually requires a certain amount of lockup time before proper decoding can take place. This in turn has an effect on the "feel" of continuous tuning receivers. The station wouldn't gradually become clearer as is the case in AM, but the receiver could remain muted until lockup occurs and then the sound would be heard. The PLL is used only in the L-R detector, so another possibility is that the receiver could be held in mono while tuning, and when the PLL locked up, then the stereo function would begin.

It could be anticipated that the early AM stereo receivers will use the commonly understood and presently available technology. However, as was the case with color television, and FM stereo, improvements will probably be made.

Report of Panel IV

Field Tests

Introduction

One major objective of the committee was to develop test procedures and perform the tests on the systems submitted to NAMSRC. A series of meetings and committee work produced a Field Test Plan which described laboratory measurements and tests over existing radio stations. The basic concept was to determine the feasibility of the AM stereo systems in terms of spectrum occupancy, compatibility with the existing receiving and transmitting equipment, compliance with FCC allocations criteria, and other factors such as coverage and audio fidelity. The tests would be conducted so that identical test equipment and procedures would be used for each proponent so that direct comparisons could be made. The purpose of the NAMSRC activity was to produce a report of comprehensive test results. The NAMSRC does not recommend a system to the FCC.

The test plan that developed from the meetings was modified during the actual field tests. Generally this was due to the particular instrumentation available or working with the actual stereo equipment suggested better methods to achieve the test objective.

In this section each test is generally described, followed by a test procedure and a test arrangement block diagram. A copy of the actual field data taken is then provided. For those tests that involved the use of the automatic frequency response and distortion analyzer, the charts are included at the end of the field test report. An index to the charts immediately preceeds the charts. The charts are organized according to those tests which had an equivalent among all three proponents, with a chart for each proponent appearing on the same page. The placement was consistent with Magnavox on top, Motorola in the center, and Belar on the bottom. Tests of the Magnavox narrow band position of their receiver are inserted immediately after the group of equivalent wide band tests.

There were many tests made which did not have a precise equivalent such as Magnavox narrow band receiver, and Motorola with the pilot tone off. All tests which did not have an equivalent, are grouped by proponent at the end of the chart section.

In addition to the techincal measurements, tests of each system were made with musical selections specially prepared for NAMSRC. These tapes will be made available to the Federal Communications Commission.

FIELD TESTS OF AM STEREO

Summary

Test Name	Notes
A. Closed Circuit Tests	
A1. System Performance-Monitor	Audio Tests-Transmitter Stereo Encoder and RF Generator into wideband "Ideal Detector".
A2. System Performance - Receiver	Audio Tests-Transmitter Stereo Encoder and RF Generator into Receiver .
A.3 Mono Compatibility	Audio measurements. Transmitter Stereo Encoder and RF Generator into compatibility receivers.
A.4 Envelope modulation limit test	To determine limitations in amplitude modulation of stereo transmissions.
A.5 Stereo Receiver Noise Performance	Receiver sensitivity at L+R and L, R, only at 18, 24, and 30 dB S+N+D/N+D.
A.6 Occupied Bandwidth	RF spectrum analysis- Transmitter Stereo Encoder into RF Generator, modulate with 4 tones, AM L+R, L-R, L, R.
A.7 Protection Ratio	Measure noise in compatibility receiver from stereo and mono transmissions on 1st, 2nd, and 3rd adjacent channels.

B. Over the Air Tests

B.1	WGMS Groundwave Tests on 570 kHz	Monaural audio tests, stereo audio tests, vehicular observations of null distortion
B.2	WTOP Groundwave Tests on 1500 kHz	Monaural audio tests, stereo audio tests
B.3	WBT Skywave Tests on 1110 kHz	Recordings of stereo transmissions from both monaural and stereo receivers

SUGGESTED PROPONENT EQUIPMENT

1) Transmitter Stereo Encoder	RF out: 570, 1110 and 1500 kHz, 0-25 volts RMS into 500 ohms Audio out: 0 - + 10 dBm, 600 ohms transformer balanced Note: Design for sufficient RFI immunity-Field intensities may exceed 25 volts/meter. Input audio levels: Nominal + 8 VU program level, capable of linearly passing a +18 dbm tone (600 ohms) Inputs should be transformer balanced.
2) RF Generator	Provide composite stereo carrier output with above encoder on above frequencies. Sufficient output level to drive Wideband Detector and to drive General Radio loop to required field intensities. 0 to .5 volt RMS at 50 ohms is required. Output should be attenuatable to less than 10 microvolts.
3) Wideband (Ideal) Detector	Best stereo detector not bandwidth limited. Input RF levels 500 millivolts to 20 volts RMS into 50 ohms. Audio outputs: left, right, at +10 dbm for 85% AM modulation at 600 ohms unbalanced. Operable for noise measurements in RF fields of 25 volts/meter.
4) Stereo Receiver	Tunable to AM band. IF bandwidth and performance not specified. Audio measurements made at essentially flat output provided for left and right at 1 volt RMS at 1000 ohms at 85% AM modulation. Outputs taken prior to any substantial equalization.

5) Modulation Monitoring Equipment (Optional)	May be incorporated with wideband detector to indicate appropriate modulation of RF Generator or broadcast transmitter to assist in proper setup, adjustment or trouble shooting.

Test A.1

SYSTEM PERFORMANCE - MONITOR

Objective: To provide data on the best possible performance from an embodiment of a proponent's system. The stereo encoder, RF generator, and "ideal detector" will be employed as a system with no bandwidth limitations.

Conditions:

1. Audio processing not employed
2. Frequency of operation: 570 kHz
3. Modulation levels: Reference is 200 Hz, at 85% AM
4. Response and distortion measured with flat audio input, and through a 100 microsecond deemphasis
5. Intermodulation measurements made employing 200, and 2500 Hz, 4:1 amplitude ratio respectively
6. Filters may be employed to attenuate hum on the low frequencies and noise above the high frequency limit of the system.

The test will be made for the following input and output conditions:

Input Signal	Output Signal	Test
L = R	L	Amplitude response, THD,[1] noise, IMD[2]
L + R	R	Amplitude response, THD, noise, IMD
L = -R	L	Amplitude response, THD, noise, IMD
L = -R	R	Amplitude response, THD, noise, IMD
L Only	L, R	Amplitude response, THD, noise, IMD, separation
R Only	R, L	Amplitude response, THD, noise, IMD, separation
L -45°, R +45°	L, R	1000 Hz level and THD

[1] Total Harmonic Distortion

[2] Intermodulation Distortion

The tests of audio performance were also made through a 100 microsecond deemphasis network. This was chosen to approximate the audio spectrum of typical programming. Because of the current interest placed upon audio performance resulting from AM transmitters feeding antennas whose impedance varies significatly over the audio bandwidth it was felt appropriate to make a similar test on the AM stereo systems. A test device was made which provided a dummy load impedance with "Q's" of 0, 5, 10, 20, and 30. The dummy load was made to operate at 570 kHz. The load consisted of a series R-L-C circuit tuned to resonance at 570 kHz. "Q" of the antenna load as used above is defined as the ratio of inductance reactance to resistance at 570 kHz. The output to feed the test receivers was tapped across 5 ohms of the 50 ohm resistive load. Variable delay networks were placed between the input terminals and the dummy load. The networks were all "Pie" sections.

The delays available were 0, 45, 60, 75, 90, 105, 120, and 135°. These variable delays permitted the rotation of the load impedance through all possible combinations. The combined dummy load network permitted testing of the various systems into a wide range of variation of load impedance Q and through variable delay networks to provide a full range of load impedance characteristics for tests in the transmission system.

The System Performance - Monitor test initially is not bandwidth limited. In order to determine the effects of the bandwidth limitations of a transmitting antenna system, each of the systems was retested by passing the AM stereo signal through a filter having a Q of 30 and a delay of 60 degrees. The results are shown in both Appendix I and in tabulated form following this discussion.

The measurements of frequency response, total harmonic distortion and separation were performed with a London Company BKF-10 automatic distortion analyzer and the companion REC-66 chart recorder. The charts produced by this equipment are contained in Appendix I. The remaining data regarding noise levels, intermodulation distortion follow this discussion. Also a description of the test is contained in this section.

SYSTEM PERFORMANCE - MONITOR

Test Procedure

Refer to Fig. I-1

A. Monophonic L=R

The left and right inputs to the proponent's stereo encoder are connected to the two outputs of the 600 ohm divider. The input to the divider is connected, through a BA-43 program amplifier, to the swept audio output from the BKF-10 distortion analyzer. The RF output from the proponent's RF source is split into two paths, one of which is routed directly to the proponent's AM stereo monitor. The other RF output from the divider is applied to the spectrum analyzer, the oscilloscope, and the TFT monitor.

The left output from the proponent's stereo monitor is applied to the input of the BKF-10 distortion analyzer, and the BA-43 is adjusted to produce 85% L+R (AM) modulation, as indicated by the TFT monitor's peak flasher. Sweeps of the left channel response and left channel distortion are recorded. The output frequency of the BKF-10 is next set to 400 HZ, and the residual noise is measured using the built in noise measurement function. The above measurements are repeated on the right channel output from the proponent's monitor.

B, C, D, E. Left and Right Performance

The L+R (AM) level is set to 85% modulation, as was done above. The right input to the proponent's stereo encoder is then disconnected from the 600 ohm divider and the right divider output is terminated with a 600 ohm resistor. The left output of the proponent's monitor is connected to the BKF-10 input, and sweeps are made of response and distortion, and a spot check of residual noise is made at 400 HZ. The right out-put from the stereo monitor is then connected to the BKF-10 input, and a swept recording of right channel separation is made on the same chart. The left and right channel inputs and outputs are reversed, and the above tests are repeated for the right channel.

F. L-R

The equipment is arranged as in (A) above, and the BA-43 is adjusted to produce 85% L+R(AM) modulation. The phasing of one of the balanced inputs to the stereo encoder is then reversed, and the BKF-10 is connected to the left monitor output. Swept recordings are made of left channel response and distortion, and a spot check of residual noise is made at 400 HZ.

The above measurements are repeated on the right channel output from the proponent's monitor.

G. +45°

The left and right inputs to the proponent's stereo encoder are connected, respectively, to the -45 and +45 outputs of the phase splitter, through a pair of BA-43 program amplifiers. The gain/phase meter is

G. +45° (cont'd)

connected across the left and right inputs to the stereo encoder, and the phase splitter is driven from a 1000 HZ sine wave oscillator.

The output from the proponent's RF source is split into two (2) 50 ohm signal paths, one of which drives the proponent's stereo monitor directly. The other RF signal path drives the spectrum analyzer, the oscilloscope, and the TFT monitor.

The right output of the proponent's stereo monitor is connected to the BKF-10 distortion analyzer, and the amplified right output of the phase splitter is connected to the right input to the proponent's stereo encoder. The amplified left channel output from the phase splitter is terminated with a 600 resistor, and the right channel BA-43 amplifier is adjusted to produce 42.5% AM modulation, as indicated by the peak flasher on the TFT monitor. The termination is next moved to the right channel BA-43 output, and the left channel BA-43 amplifier is adjusted to produce 42.5% AM modulation. The 600 ohm termination is removed and the left and right outputs from the BA-43 amplifiers are connected to the corresponding inputs on the proponent's stereo encoder. The composite AM modulation, as indicated by the TFT monitor, should be approximately 60% under this condition, and the differential gain and phase, as indicated by the gain/phase meter, is recorded. A distortion measurement is made of the left and right channel outputs of the proponent's stereo monitor, and the results are recorded.

The gain/phase meter is connected to the left and right outputs from the proponent's stereo monitor, and the differential gain and phase are recorded. Lastly, a photograph of the spectral display from the spectrum analyzer is made.

II. 100 SEC DE-EMPHASIS

A) Tests (A) through (F) are repeated with a 100 m sec de-emphasis network inserted in the swept audio output path from the BKF-10.

III. BANDPASS FILTER TEST

The equipment is connected as in I above, except that the step attenuator, Bandpass filter and RF amplifier are connected between the output of the 50 divider and the RF input to the proponent's stereo monitor. (Note that a 600 ohm to 50 ohm matching transformer is used at the output of the Belar RF source for this test).

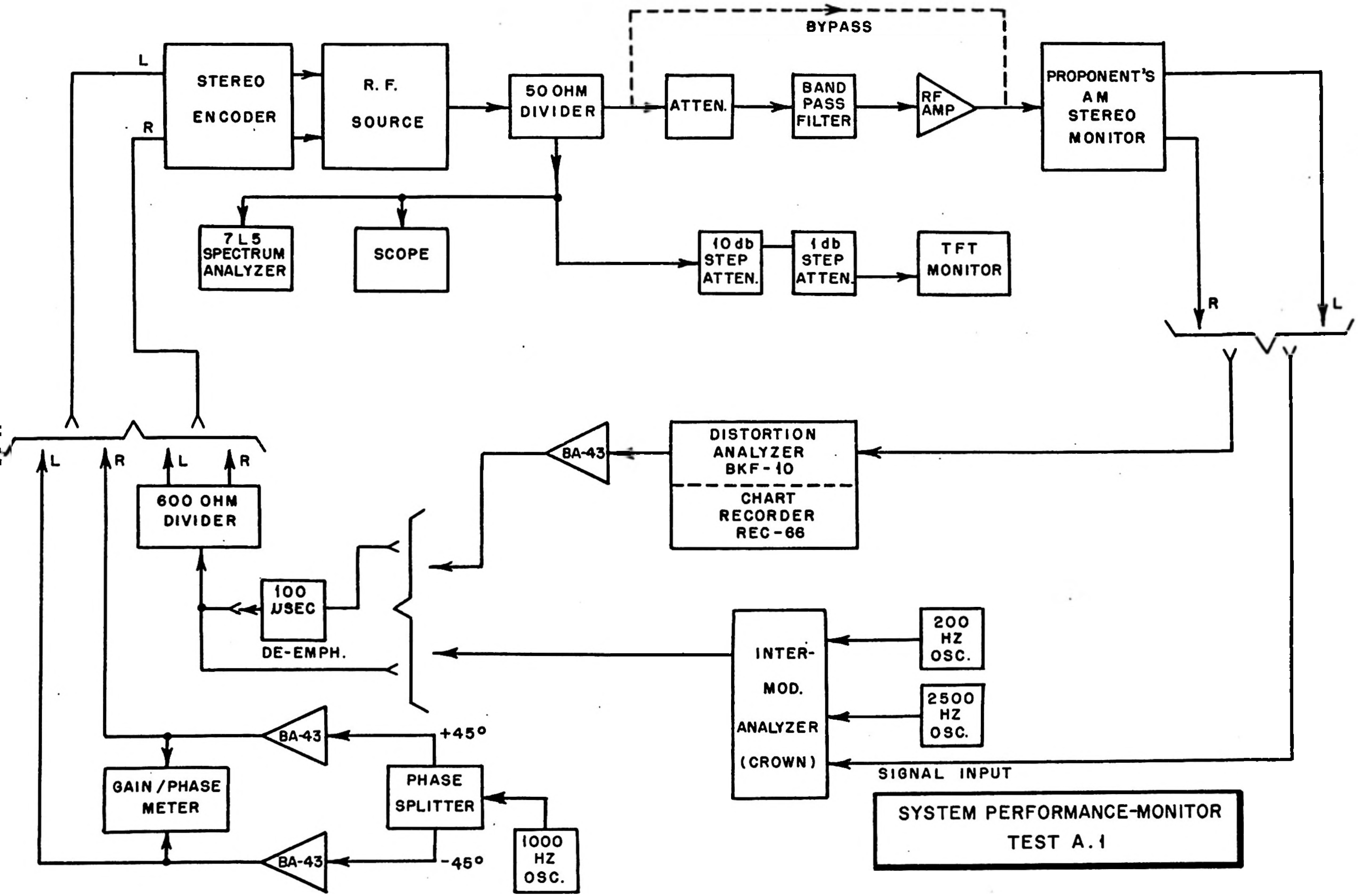
The attenuator is adjusted to produce 3 volts RMS output from the RF amplifier, and the bandpass filter is adjusted to produce a Q of 30 and a delay of 60^{o}. Tests I (A,B,C,D,E) above and IV below are repeated for this test condition.

IV. INTERMODULATION DISTORTION

The external tone inputs to the Crown intermodulation analyzer are driven from 2 sine wave oscillators operating at 400 HZ and 2500 HZ. The relative outputs of the oscillators are adjusted so that the level of the 400 HZ signal is exactly 4 times the level of the 2500 HZ signal.

The two tone output from the IMD analyzer is applied through the 600 resistive divider, to the left and right inputs to the proponent's stereo encoder. The output from the proponent's RF source is applied, through the 50 ohm divider, to the proponent's stereo monitor, and to the TFT monitor. The master output control on the IMD analyzer is adjusted to produce 85% L+R (AM) modulation, as indicated by the peak flasher on the TFT monitor.

The intermodulation distortion is measured and recorded at the left and right audio outputs from the proponent's stereo monitor under this condition (L+R). The phase of one of the balanced audio inputs to the stereo encoder is reversed, and the intermodulation distortion at the left and right audio outputs from the stereo monitor is measured and recorded for this (L-R) case. Finally, the left and right inputs are driven individually, as in I (B,C,D,E) above and the intermodulation distortion is measured and recorded at the corresponding stereo monitor outputs.



SYSTEM PERFORMANCE-MONITOR
TEST A.1

Test A.1

Magnavox

No Bandwidth Filter

SYSTEM PERFORMANCE - MONITOR

CPP 6/17

SMT 6/17

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R	L	007	+21 dB	-25.7 dB	007	2.25 %
		R	008	+21	-27.0	008	0.63

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100 uSec. Deemphasis not used on tests below

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.2	Mono, L=R	L					
		R					
a.3	Stereo, L=-R	L	013	+21	-25.8	013	0.75
		R	014	+21	-28.1	014	1.18
a.4a	Left Only	L	015	+21	-25.9	015	1.11
a.4b	Left Separation L Modulated	R	015				
a.5a	Right Only	R	017	+21	-27.2	017	0.21
a.5b	Right Separation R Modulated	L	017				

			Signal Level	Harmonic Distor.
a.6	L /-45, R /+45	L	dB	%
		R		

aHC

EDS

17 June 77

Magnavox

No Bandwidth Filter

Test A.1

SYSTEM PERFORMANCE - MONITOR

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R	L		dB	dB		%
		R					
	100 uSec. Deemphasis used on tests below						
a.2	Mono, L=R	L	009	+21	-25.8	009	
		R	010	+21	-27.2	010	
a.3	Stereo, L=-R	L	011	+21	aHC -25.9 ~~[illegible]~~	011	
		R	012	+21	-28.2	012	
a.4a	Left Only	L	016	+21	-25.8	016	
a.4b	Left Separation L Modulated	R	016				
a.5a	Right Only	R	018	+21	-27.2	018	
a.5b	Right Separation R Modulated	L	018				

			Signal Level	Harmonic Distor.
a.6	L /-45, R /+45	L	dB	%
		R		

aHC

mO

RDS

Bandwidth Filter
Q=30

Test A.1

SYSTEM PERFORMANCE - MONITOR

Proponent Magnavox

Date 6/22/77

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	(no deemphasis) Intermod. Distor.
a.1	Mono, L=R	L	057	21.6 dB	-28.5 dB	057	3.58 %
		R	058	22	-29.	058	0.40

100 uSec. Deemphasis used on tests below

		Output Channel	Response Chart #	Reference Level	Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.2	Mono, L=R	L	060	21.7	-29.2	060	[redacted] aHC
		R	059	22	-28.8	059	[redacted] aHC
a.3	Stereo, L=-R	L	061	21.9	-29.1	061	3.18
		R	062	21.8	-31.	062	2.02
a.4a	Left Only	L	064	21.8	-29.	064	0.30
a.4b	Left Separation L Modulated	R	064				
a.5a	Right Only	R	063	21.9	-30.9	063	1.05
a.5b	Right Separation R Modulated	L	063				

			Modulation	Harmonic Distor.	Gain	Phase
					Transmitter	
a.6	L /-45, R /+45	L+R	58 %	L 1.25 %	-0.25 aHC [redacted] dB	-90.1 ° aHC
					Monitor	
		L-R	58 %	R 0.50	-0.25 dB	-89.6 °

(as measured on proponents meter)

aHC

RDS

SYSTEM PERFORMANCE - MONITOR

Proponent Magnavox

Date 6/21/77

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R	L		dB	dB		%
		R					

100 uSec. Deemphasis used on tests below

		Output Channel	Response Chart #	Reference Level	Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.2	Mono, L=R	L					
		R					
a.3	Stereo, L=-R	L					
		R					
a.4a	Left Only	L					
a.4b	Left Separation L Modulated	R					
a.5a	Right Only	R					
a.5b	Right Separation R Modulated	L					

			Modulation	Harmonic Distor.	Gain	Phase
					Transmitter	
a.6	L /-45, R /+45		L+R 59 %	(L) .72 %	-0.35 dB	-90.1 °
					~~Receiver~~ Monitor	
			L-R 58.5 %	(R) .85 %	-0.30 dB	-89.65 °

(MEASURED BY PROPONENT MONITOR)

DDS

Page 3

Test A.1

SYSTEM PERFORMANCE - MONITOR

Proponent Motorola

Date 6/28/77

No Pilot Tone

		Output Channel	Response Chart #	Noise Measurement		Harmonic Distor. Chart #	Intermod. Distor.
				Reference Level	Residual Noise		
a.1	Mono, L=R	L	078	21.3 dB	-40 dB	078	1.92 %
		R	077	21.5	-40	077	.645

100 uSec. Deemphasis not used on tests below

		Output Channel	Response Chart #	Reference Level	Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.2	Mono, L=R	L					
		R					
a.3	Stereo, L=-R	L	079	21.3	-41.5	079	1.325
		R	080	21.5	-40	080	1.395
a.4a	Left Only	L	081	21.2	-41	081	~~[illegible]~~ 2.18 aHC
a.4b	Left Separation L Modulated	R	081				
a.5a	Right Only	R	082	21.6	-41	082	1.15
a.5b	Right Separation R Modulated	L	082				

			~~Signal Level~~ Modulation	Harmonic Distor.	Gain	Phase
					Transmitter	
a.6	L /-45, R /+45	L+R	58 %L	1.3 %	-.05 dB	-90.15°
					Monitor	
		L- R	%R	1.1	-.25 dB	-90.15°

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a.J.R.

Page 4

Test A.1

SYSTEM PERFORMANCE - MONITOR

Proponent Motorola

Date 6/28/77

No Pilot Tone

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R	L		dB	dB		%
		R					
	100 uSec. Deemphasis used on tests below						
a.2	Mono, L=R	L	084	21.4	-43	084	
		R	083	21.5	-42	083	
a.3	Stereo, L=-R	L	085	21.3	-43	085	
		R	086	21.6	-42	086	
a.4a	Left Only	L	087	21.2	-42	087	
a.4b	Left Separation L Modulated	R	087				
a.5a	Right Only	R	088	21.6	-41	088	
a.5b	Right Separation R Modulated	L	088				

			Signal Level	Harmonic Distor.
a.6	L /-45, R /+45	L	dB	%
		R		

JAH

AHC

a.L.K.

Page 5

Test A.1

SYSTEM PERFORMANCE - MONITOR

Proponent Motorola

Date 6/28/77

Pilot Tone On

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R	L	093	21.2 dB	-36 dB	093	1.58 %
		R	094	21.3	-36.1	094	.805

100 uSec. Deemphasis not used on tests below

		Output Channel	Response Chart #	Reference Level	Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.2	Mono, L=R	L					
		R					
a.3	Stereo, L=-R	L	096	21.2	-35	096	1.64
		R	095	21.4	-36.1	095	1.46
a.4a	Left Only	L	097	21.2	-35.2	097	2.507
a.4b	Left Separation L Modulated	R	097				
a.5a	Right Only	R	098	21.5	-36.1	098	1.09
a.5b	Right Separation R Modulated	L	098				

			Modulation ~~Signal Level~~	Harmonic Distor.	Gain	Phase
					Transmitter	
a.6	L /-45, R /+45	L+R	58	~~dB~~ % L 1.05 %	+.05 dB	-90.15°
					Monitor	
		L-R		R .85	-.25 dB	-90.15°

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a.f.k.

Page 6

Test A.1

SYSTEM PERFORMANCE - MONITOR

Proponent Motorola

Date 6/28/78

Pilot Tone On

		Output Channel	Response Chart #	Noise Measurement Reference Level	 Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R	L		dB	dB		%
		R					
	100 uSec. Deemphasis used on tests below						
a.2	Mono, L=R	L	100	21.5	-35.6	100	
		R	099	21.6	-36.5	099	
a.3	Stereo, L=-R	L	101	21.4	-35.4	101	
		R	102	21.6	-36.5	102	
a.4a	Left Only	L	103	21.3	-36.6	103	
a.4b	Left Separation L Modulated	R	103				
a.5a	Right Only	R	104	21.7	-36.5	104	
a.5b	Right Separation R Modulated	L	104				

			Signal Level	Harmonic Distor.
a.6	L /-45, R /+45	L	dB	%
		R		

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Doug A.L.K.

Bandpass Filter
Q = 30, 60°

Page 7 Test A.1

SYSTEM PERFORMANCE - MONITOR

Proponent Motorola

Date 6/29/77

No Pilot Tone

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R	L	105	21.3 dB	-42.5 dB	105	2.8 %
		R	106	21.6	-42.7	106	1.01

100 uSec. Deemphasis not used on tests below

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.2	Mono, L=R	L					
		R					
a.3	Stereo, L=-R	L	108	21.2	-42.3	108	2.31
		R	107	21.8	-42.7	107	2.06
a.4a	Left Only	L	109	21.2	-42.7	109	2.51
a.4b	Left Separation L Modulated	R	109				
a.5a	Right Only	R	110	21.8	-43.	110	1.92
a.5b	Right Separation R Modulated	L	110				

			Modulation ~~Signal Level~~	Harmonic Distor.	Gain	Phase
					Transmitter	
a.6	L /-45, R /+45	L+R	59 %	L 1.75 %	+0.25 dB	-90.1 °
					Monitor	
		L-R		R 1.58	-0.2 dB	-89.7 °

Bandpass Filter Page 9 Test A.1
Q=30, 60°

SYSTEM PERFORMANCE - MONITOR

Proponent Motorola

Date 6/29/77

Pilot Tone On

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R	L	118	21.4 dB	-36.2 dB	118	2.41 %
		R	117	21.6	-36.1	117	1.2

100 uSec. Deemphasis not used on tests below

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.2	Mono, L=R	L					
		R					
a.3	Stereo, L=-R	L	119	21.2	-35.8	119	2.72
		R	120	21.8	-36.2	120	2.11
a.4a	Left Only	L	121	21.2	-36.2	121	2.94
a.4b	Left Separation L Modulated	R	121				
a.5a	Right Only	R	122	21.7	-36.1	122	1.72
a.5b	Right Separation R Modulated	L	122				

			Modulation ~~Signal Level~~	Harmonic Distor.	Gain	Phase
					Transmitter	
a.6	L /-45, R /+45	L+R	59 %~~dB~~	L 1.78 %	+0.25 dB	-90.1°
					Monitor	
		L-R		R 1.6	+0.15 dB	-89.7°

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Bandpass Filter Page 10 Test A.1

Q = 30, 60°

SYSTEM PERFORMANCE - MONITOR

Proponent Motorola

Date 6/29/77

Pilot Tone On

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R	L		dB	dB		%
		R					

100 uSec. Deemphasis used on tests below

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.2	Mono, L=R	L	124	21.4	-36.2	124	
		R	123	21.5	-36.5	123	
a.3	Stereo, L=-R	L	125	21.2	-35.8	125	
		R	126	21.7	-36.6	126	
a.4a	Left Only	L	127	21.2	-36.1	127	
a.4b	Left Separation L Modulated	R	127				
a.5a	Right Only	R	128	21.9	-36.5	128	
a.5b	Right Separation R Modulated	L	128				

			Signal Level	Harmonic Distor.
a.6	L /-45, R /+45	L	dB	%
		R		

AHC

Bandpass Filter Page 8
Q = 30, 60°

Test A.1

SYSTEM PERFORMANCE - MONITOR

Proponent Motorola

Date 6/29/77

No Pilot Tone

		Output Channel	Response Chart #	Noise Measurement		Harmonic Distor. Chart #	Intermod. Distor.
				Reference Level	Residual Noise		
a.1	Mono, L=R	L		dB	dB		%
		R					
	100 uSec. Deemphasis used on tests below						
a.2	Mono, L=R	L	112	21.4	-44	112	
		R	111	21.5	-44	111	
a.3	Stereo, L=-R	L	113	21.1	-44.3	113	
		R	114	21.7	-44	114	
a.4a	Left Only	L	115	21.1	-44	115	
a.4b	Left Separation L Modulated	R	115				
a.5a	Right Only	R	116	21.9	-44.5	116	
a.5b	Right Separation R Modulated	L	116				

			Signal Level	Harmonic Distor.
a.6	L /-45, R /+45	L	dB	%
		R		

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JHA A.J.K.

PAGE 1

SYSTEM PERFORMANCE - MONITOR

Proponent BelAR

Date 14 July 1977

15 July 77

L-R detector IN except for a.2 below

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R	L	141	+12.5 dB	-32.0 dB	141	1.6 %
		R	142	+13.5	-31.5	142	1.35
	100 uSec. Deemphasis NOT used on tests below						
a.2	Mono, L=R (L-R detector out)	L	147	+12.5	-45.2	147	1.49
		R	148.	+13.2	-44.2	148	1.45
a.3	Stereo, L=-R	L	144.	+12.0	-31.5	144	.63
		R	143	+13.0	-31.0	143	.64
a.4a	Left Only	L	145	+12.25	-31.75	145	.65
a.4b	Left Separation L Modulated	R	145				
a.5a	Right Only	R	146	+13.2	30.1	146	.74
a.5b	Right Separation R Modulated	L	146				

			MODULATION ~~Signal~~ ~~Level~~	Harmonic Distor.
a.6	L /-45, R /+45	L+R	59% %	L .9 %
		L-R	59% %	R .7 %

GAIN PHASE

XMITTER

R/L .55 db +90.15°

MONITOR

R/L .85 db -91.7°

JK

Y. Sakai

JK J.L.K.

Y. Sakai

PAGE 2

SYSTEM PE[illegible] - MO[illegible]

Proponent BeLAR

Date 14 July 77

L-R. detector <u>in</u> except for a.1 below

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R	L	151	7.1 dB	-47.2 dB	151	%
	(L-R detector out with 100uS deemphasis)	R	152	+8.0	-45.8	152	

100 uSec. Deemphasis used on tests below

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.2	Mono, L=R	L	150	+7.0	-32.0	150	
		R	149	+8.0	-31.0	149	
a.3	Stereo, L=-R	L	154	+6.5	-32.0	154	
		R	153	+7.4	-31.0	153	
a.4a	Left Only	L	155	+7.0	-32.0	155	
a.4b	Left Separation L Modulated	R	155				
a.5a	Right Only	R	156	+7.8	-31.0	156	
a.5b	Right Separation R Modulated	L	156				

			Signal Level	Harmonic Distor.
a.6	L /-45, R /+45	L	dB	%
		R		

Y. Sakai

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SYSTEM PERFORMANCE - MONITOR

Proponent BeLAR

Date 14 July 1977

BAND PASS NETWORK 60° DeLAY Q=30

IM TAKEN ON 15 July 77

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R (L-R DeTecTor out)	L	160	+12.6 dB	-42.0 dB	160	.58 %
		R	159	13.2	-44.1	159	.58
	100 uSec. Deemphasis ~~is~~ NoT used on tests below (L-R DeTecTor IN ON TesTS Below)						
a.2	Mono, L=R	L	157	+12.5	-31.5	157	1.5
		R	158	+13.3	-31.0	158	1.25
a.3	Stereo, L=-R	L	161	+12.1	-32.0	161	.64
		R	162	+13.1	-30.5	162	.70
a.4a	Left Only	L	164	+12.5	-31.8	164	.85
a.4b	Left Separation L Modulated	R	164				
a.5a	Right Only	R	163	+13.2	-31.0	163	.74
a.5b	Right Separation R Modulated	L	163				

			ModuLATion ~~Signal Level~~	Harmonic Distor.	GAIN	Phase
					TRANSMITTER	
a.6	L ∠-45, R ∠+45 TAKEN 15 July 77	L+R	59 %	L .7 %	R/L .55 db	+90.15°
					MONITOR	
		L-R	59	R 1.1	R/L .65 db	-91.35°

JR

Y. Sakai

JR

Y. Sakai

PAGE 4

SYSTEM PERFORMANCE - MONITOR

Proponent Belar

Date 14 July 77

Band pass network 60° delay Q=30

				Noise Measurement			
		Output Channel	Response Chart #	Reference Level	Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R (L-R detector out 100uS deemphasis)	L	167	+7.0 dB	-44.7 dB	167	%
		R	168	+7.9	-46.0	168	

100 uSec. Deemphasis used on tests below (L-R detector in on tests below

a.2	Mono, L=R	L	166	+7.0	-32.0	166	
		R	165	+8.0	-30.2	165	
a.3	Stereo, L=-R	L	170	+6.8	-32.2	170	
		R	169	+7.8	-31.0	169	
a.4a	Left Only	L	171	+7.0	-32.0	171	
a.4b	Left Separation L Modulated	R	171				
a.5a	Right Only	R	172	+8.0	-31.0	172	
a.5b	Right Separation R Modulated	L	172				

			Signal Level	Harmonic Distor.
a.6	L /-45, R /+45	L	dB	%
		R		

JR

Y Sakai

Test A.2

SYSTEM PERFORMANCE - RECEIVER

Objective: To provide data on a bandwidth limited stereo receiver. The generating system employed in test A.1 is expected to be of high enough performance so that any degradation is essentially due to the receiver.

Test Conditions: Stereo receiver performance is measured with the unit exposed to an RF field intensity of 25 mV/m or at an input level specified by the system proponent as being proper for his receiver, in the case of external antenna receivers. The test carrier frequency is 570 kHz. Modulation conditions are the same as in test A.1. Intermodulation measurement conditions were also the same. The stereo receiver was tuned initially and the same tuning was maintained for all tests. In the case of a dual bandwidth unit, receiver performance was completely characterized for both conditions. The receiver was considered to be a separate unit for each bandwidth, and all tests, both closed circuit and over the air, were repeated for both conditions.

A test of separation tracking vs. RF signal level was also performed. This tests the receiver's ability to maintain separation over wide variations in rf input levels.

The following transmission conditions were used:

1. Monophonic L=R, 85% envelope
2. Left only, 42 1/2% envelope
3. Right only, 42 1/2% envelope
4. Stereophonic L= -R, 85% stereo information
5. Audio phasing L /-45°, R /+45°, 60% envelope
6. Stereo tracking L, only
7. Stereo tracking R, only

1. In the monophonic test, a 20 to 20 kHz Radiometer BKF-10 was used, and the receiver output was recorded on a Radiometer REC 61. The parameters measured for the sweep condition were: R output - response, distortion, L output - response, distortion.

Also measured as a single point measurement was S/N ratio of the L and R outputs with 1000 cps. Finally, intermodulation distortion at the L and R outputs was measured using the Crown unit with external tones of 200 Hz and 2500 Hz.

This entire block of tests was performed with and without 100 usec de-emphasis at the transmitter.

2. Left only. 20 to 20 kHz tone sweeps were generated with the BKF 10 and response charts of L and R outputs were made. Separation on these charts is the dB difference in L and R response. Distortion and S/N ratio at 400 Hz in the L channel was recorded on the REC 61. Intermodulation distortion in the L channel was measured using the Crown unit, and tones of 200 Hz and 2500 Hz. These tests were performed with and without 100 usec de-emphasis.

3. Right only. 20 to 20 kHz tone sweeps were generated with the BKF 10 and L and R response charts were made with the REC 61. Separation is the dB difference between L and R outputs. Distortion and S/N ratio at 400 Hz, in the R channel was also recorded. Intermodulation distortion in the R channel using the Crown unit was also measured with tones of 200 and 2500 kHz. These tests were performed with and without 100 usec de-emphasis.

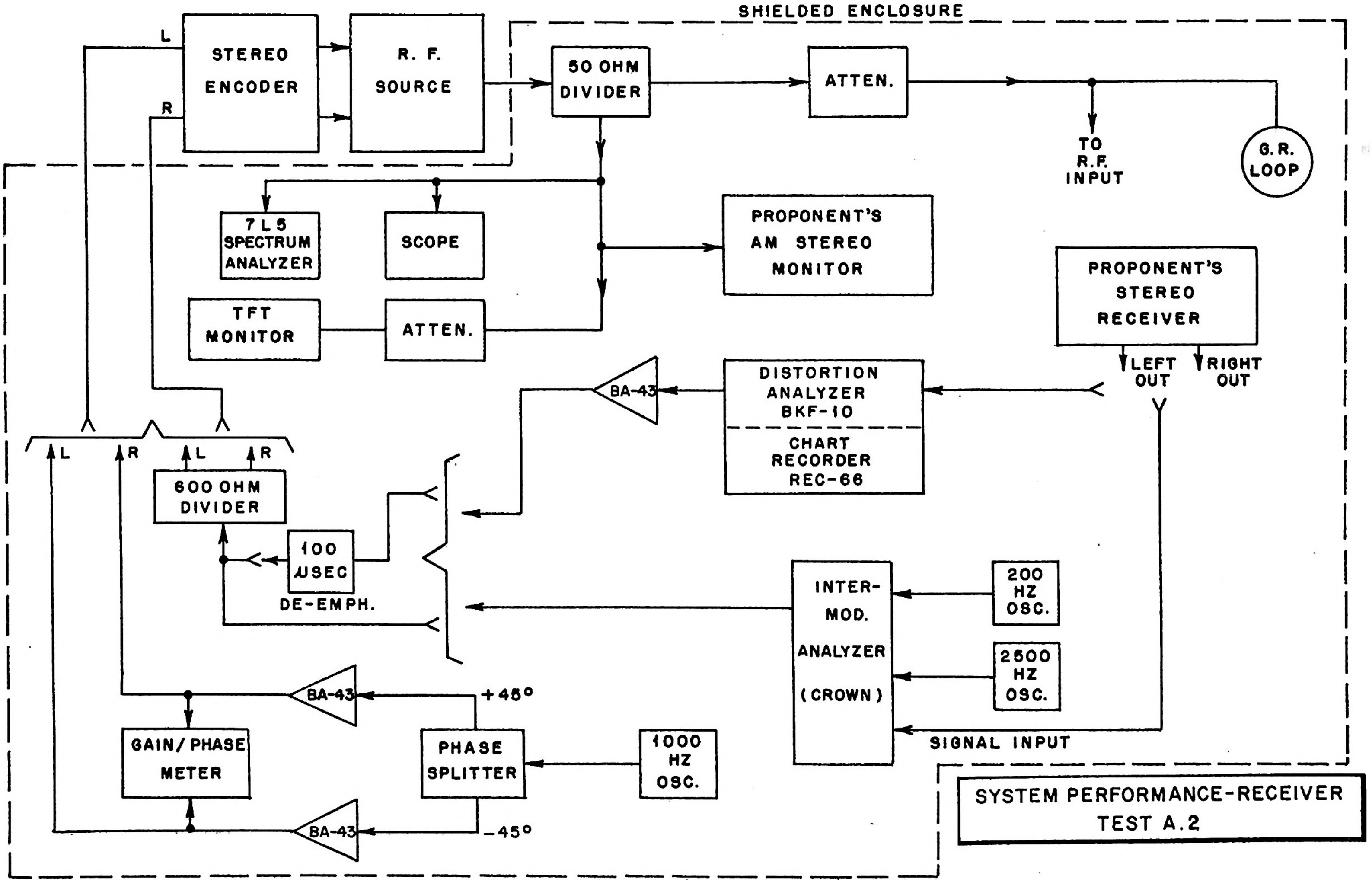
4. Stereophonic L = -R. 20 to 20 kHz tone sweeps were generated with the BKF 10 and L and R response charts were made with the REC 61. Also recorded was L and R distortion. A single point measurement of S/N ratio with 1000 Hz was made for L and R output. Intermodulation distortion using the Crown unit with tones of 200 Hz and 2500 Hz were measured for L and R output.

5. Audio Phasing L /-45°, R /+45°. The condition was set-up at the stereo exciter using 42 1/2% L envelope and no right input; next 42 1/2% R envelope was setup using no L input. The two were then combined, and the 90° phase between L and R was verified with the HP3575A gain phase meter. A spectrum photograph was recorded of the transmitted signal.

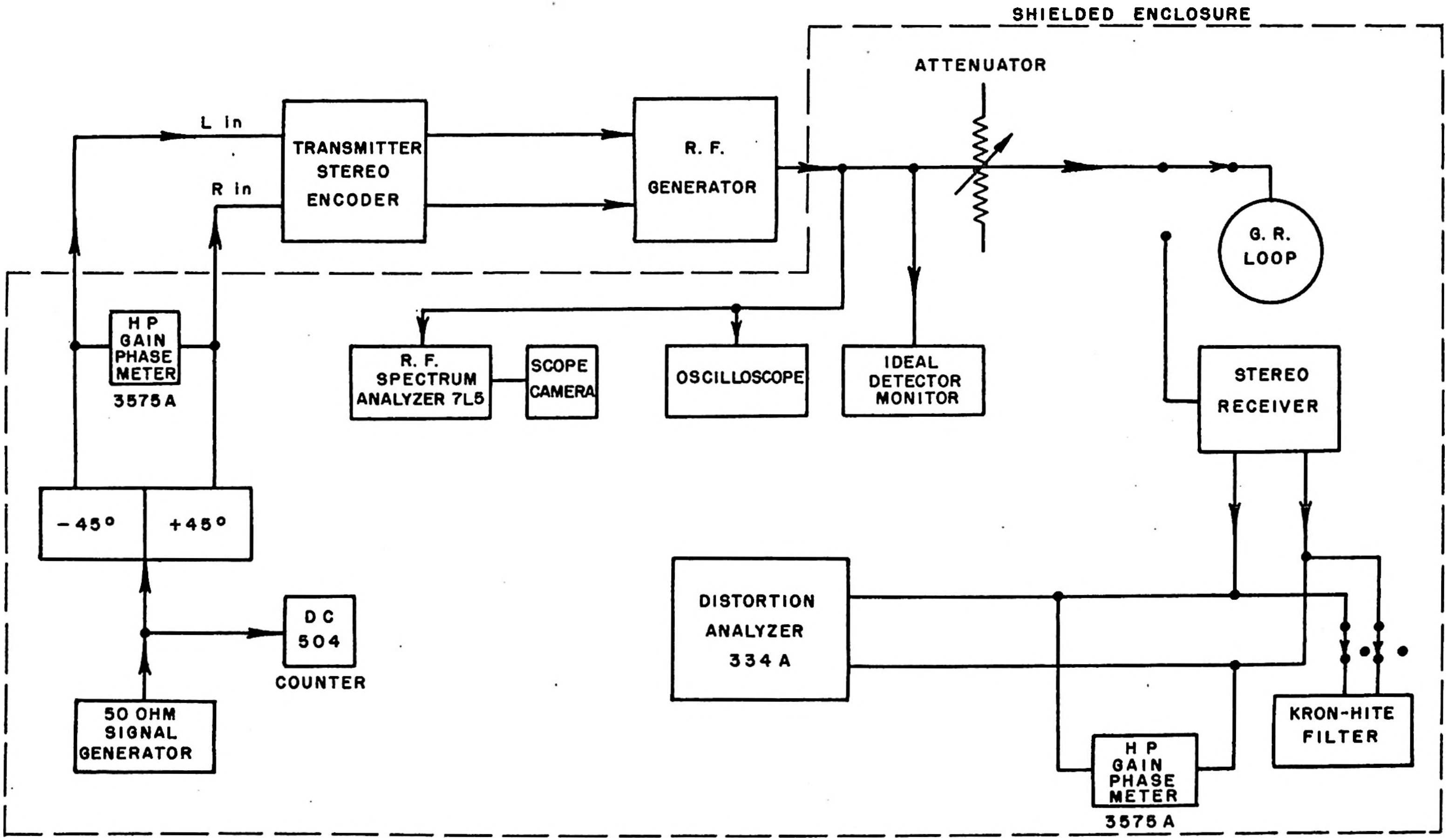
The receiver outputs were then measured for distortion (THD) and phasing using the HP 3575A gain phase meter.

6. Stereo Tracking L only. An 85% L+R signal is set with 1000 Hz. The R channel is then disconnected and terminated. The receiver is illuminated with a 25 mV/m field in the case of a radiated signal, or with an input specified by the proponent in the case of a direct input receiver. Separation at the receiver output is then measured by comparing the L output (wanted) to the R output (unwanted). The rf field intensity is then decreased in 5 dB increments until a reduction of 35 dB is attained. This is 440 uV/m for the radiated case. Separation is recorded for each level.

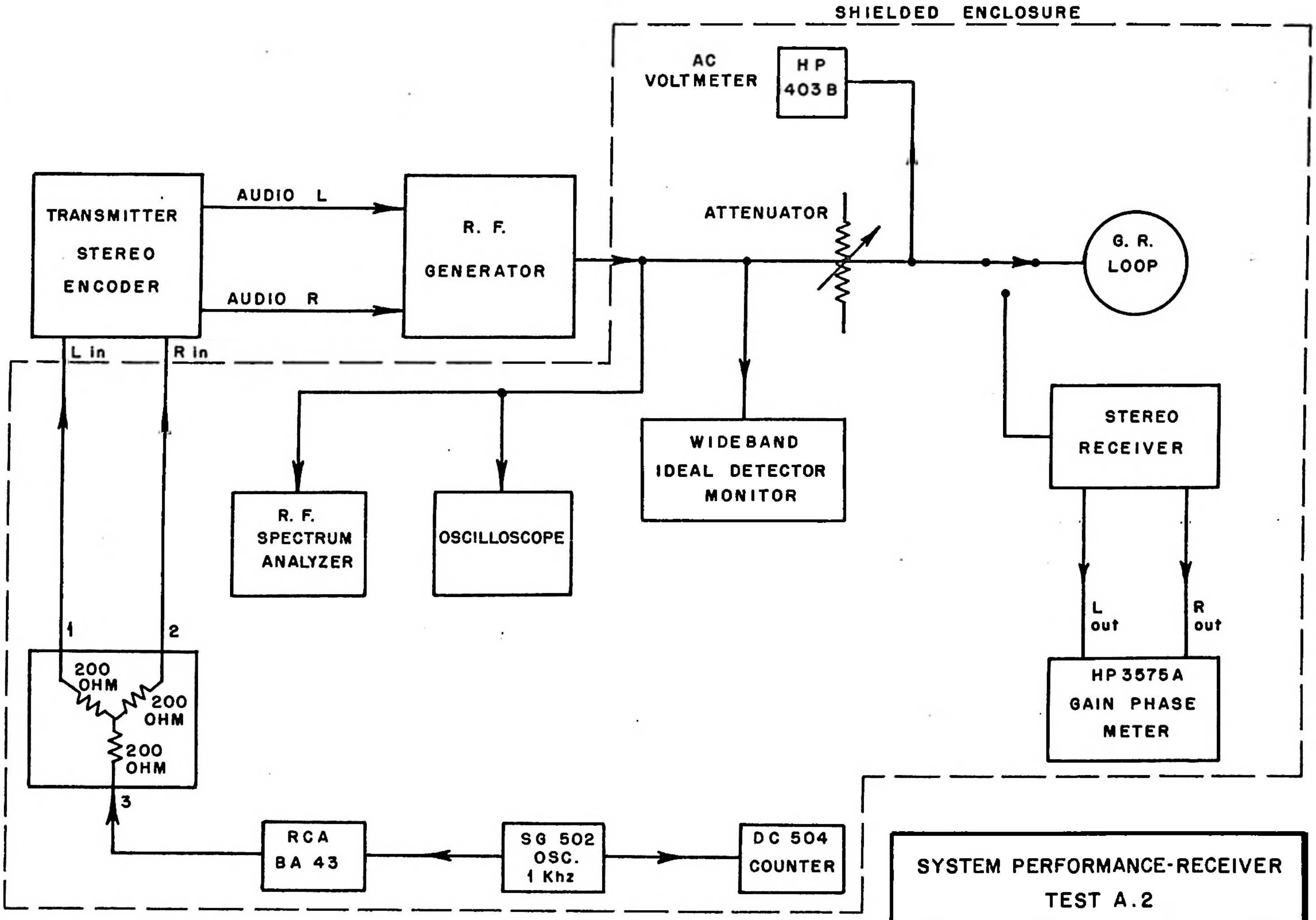
7. Stereo Tracking R only. Receiver may not be retuned from setting of 6) above. Test performed as in 6), except desired signal is now R channel (L is disconnected at the exciter and terminated). Separations for 5 dB variations of signal level are again recorded for the same range of RF fields.



SYSTEM PERFORMANCE-RECEIVER
TEST A.2



SYSTEM PERFORMANCE-RECEIVER
TEST A.2
± 45° CONDITION



SYSTEM PERFORMANCE-RECEIVER
TEST A.2
SEPARATION VS. FIELD INTENSITY

Page 1

Test A.2

SYSTEM PERFORMANCE - RECEIVER

Note: All tests done with 25 mV/M (or equivalent input level)

Proponent Magnavox

"Normal" Bandwidth

Date 6/21/77

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.1	Mono, L=R	L	019	12	-28.5dB	019	5.3 %
		R	020	12.1 dB	-26 dB	020	5.2 %

(100uS Deemphasis not used on the tests below)

No.	Input Signal	Output Channel	Response Chart #	Reference Level	Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.2	Mono, L=R	L		dB	dB		%
		R		dB	dB		%
A.3	Stereo, L=-R	L	023	12 dB	-28 dB	023	4.2 %
		R	024	13.2 dB	-26 dB	024	2.2 %
A.4a	Left Only	L	027	12 dB	-27 dB	027	4.4 %
		~~R~~		~~dB~~	~~dB~~		~~%~~
A.4b	Left Separation L Modulated	R	027				
A.5a	Right Only	R	029	12.8 dB	-27. dB	029	2.0 %
A.5b	Right Separation R Modulated	L	029				

A.6 L/ -45°, R/+ 45°

Modulation

Harmonic Distortion

LtR 59 % L 4.6 aHC %

L-R 58.5 % R 3.3 %

(as measured on proponents meter)

Gain	Phase
Transmitter	
-0.35 dB	-90.1 °
Receiver	
-1.9 dB	-94.65 °

Notes:

Technicians aHC

Witness ADS

Page 3

Test A.2

SYSTEM PERFORMANCE - RECEIVER

Note: All tests done with 25 mV/M (or equivalent input level)

Proponent Magnavox "Fidelity" Bandwidth

Date 6/21/77

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.1	Mono, L=R	L	031	11.5	-27 dB	031	16 %
		R	032	12.5 dB	-27 dB	032	18 %

(100uS Deemphasis not used on the tests below)

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.2	Mono, L=R	L		dB	dB		%
		R		dB	dB		%
A.3	Stereo, L=-R	L	036	12 dB	-29 dB	036	3.2 %
		R	037	13.2 dB	-27 dB	037	2.3 %
A.4a	Left Only	L	040	11.8 dB	-28 dB	040	2.8 %
		~~R~~		~~dB~~	~~dB~~		~~%~~
A.4b	Left Separation L Modulated	R	040				
A.5a	Right Only	R	041	13 dB	-27.5 dB	041	3.3 %
A.5b	Right Separation R Modulated	L	041				

			Modulation ~~Level~~	Harmonic Distortion
A.6	L/ -45°, R/+ 45°	L+R	59 % L	2.4 %
		L-R	58.5 % R	3.1 %

(as measured on proponents meter)

Gain	Phase
Transmitter	
-0.35 dB	-90.1 °
Receiver	
-~~0~~1.95 dB	-94.75°

Notes:

Technicians

Witness RDS

Page 5

Test A.2

SYSTEM PERFORMANCE - RECEIVER

Note: All tests done with 25 mV/M (or equivalent input level)

Proponent Magnavox

Date 6/21/77

"Normal" Bandwidth

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.1	Mono, L=R	L			dB		%
		R		dB	dB		%

(100uS Deemphasis used on the tests below)

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.2	Mono, L=R	L	043	12 dB	-29 dB	043	%
		R	044	12.2 dB	-28 dB	044	%
A.3	Stereo, L=-R	L	046	12 dB	-29.5 dB	046	%
		R	045	13.2 dB	-27 dB	045	%
A.4a	Left Only	L	047	12 dB	-29 dB	047	%
		~~R~~		~~dB~~	~~dB~~		~~%~~
A.4b	Left Separation L Modulated	R	047				
A.5a	Right Only	R	048	12.8 dB	-29.5 dB	048	%
A.5b	Right Separation R Modulated	L	048				

No.	Input Signal		Signal Level	Harmonic Distortion
A.6	L/ -45°, R/+ 45°	L	dB	%
		R	dB	%

Notes:

Technicians AHC

Witness

Page 6

Test A.2

SYSTEM PERFORMANCE - RECEIVER

Note: All tests done with 25 mV/M (or equivalent input level)

Proponent Magnavox "Fidelity" Bandwidth

Date 6/21/77

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.1	Mono, L=R	L			dB		%
		R		dB	dB		%

(100uS Deemphasis used on the tests below)

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.2	Mono, L=R	L	050	11.5 dB	-28.5 dB	050	%
		R	049	12.5 dB	-29 dB	049	%
A.3	Stereo, L=-R	L	051	12 dB	-28.5 dB	051	%
		R	052	13.2 dB	-28. dB	052	%
A.4a	Left Only	L	054	11.8 dB	-28.5 dB	054	%
		~~R~~		~~dB~~	~~dB~~		~~%~~
A.4b	Left Separation L Modulated	R	054				
A.5a	Right Only	R	053	13 dB	-29 dB	053	%
A.5b	Right Separation R Modulated	L	053				

No.	Input Signal		Signal Level	Harmonic Distortion
A.6	L/ -45°, R/+ 45°	L	dB	%
		R	dB	%

Notes:

Technicians

Witness RDS

Test A.2

System Performance - Receiver

Proponent Magnavox

Date 6/22/77

"Normal" Bandwidth

Separation vs. R.F. Field Intensity

Objective: To determine the ability of the receiver to maintain separation of the left and right channels over wide variations in field intensity or R.F. input level.

Procedure: An 85% L + R signal is set with a 1000 Hz. audio input signal. One audio channel is disconnected and terminated. The receiver is illuminated with 25 mv/m (or equivalent input level) and the separation is measured. Separation is again measured at the indicated R.F. levels down to 0.44 mv/m. The test is repeated with the opposite separation measured.

R.F. Field Intensity		Left Modulated Right Measured			Right Modulated Left Measured		
Voltage	db-ref= 25 mv/m	R/L	Left Level	Right Level	Left Level	Right Level	R/L
25 mv/m	0 db	-38.8 dB	-9.2 dBV	-48 dBV	-43.15 dBV	-7.75 dBV	+35.5 dB
14.0	-5 db	-36.4	-9.25	-46	-42.2	-7.8	+34.4
7.9	-10 db	-35.6	-9.35	-45.3	-41.3	-7.9	+33.6
4.4	-15 db	-37.2	-9.55	-47.1	-41.3	-8.05	+33.3
2.5	-20 db	-35.7	-9.85	-45.6	-40.7 aHC	-8.15	+32.7
1.4	-25 db	-33.6	-9.95	-43.6	-38.95	-8.25	+31.1
0.79	-30 db	-31.7	-10.15	-41.9	-36.8	-8.4	+28.9
0.50	-34	-30.7	-10.15	-40.7	-35.3	-8.45	+27.0
0.44	-35	-29.9	-10.15	-39.1	-34.9	-8.5	+26.6

aHC a.S.K.

Test A.2

System Performance - Receiver

Proponent Magnavox

Date 6/22/77

"Fidelity" Bandwidth

Separation vs. R.F. Field Intensity

Objective: To determine the ability of the receiver to maintain separation of the left and right channels over wide variations in field intensity or R.F. input level.

Procedure: An 85% L + R signal is set with a 1000 Hz. audio input signal. One audio channel is disconnected and terminated. The receiver is illuminated with 25 mv/m (or equivalent input level) and the separation is measured. Separation is again measured at the indicated R.F. levels down to 0.44 mv/m. The test is repeated with the opposite separation measured.

R.F. Field Intensity			Left Modulated Right Measured		Right Modulated Left Measured		
Voltage	db-ref= 25 mv/m	R/L	Left Level	Right Level	Left Level	Right Level	R/L
25 mv/m	0 db	-35.2 dB	-8.95 dBV	-44.5 dBV	-33.65 dBV	-7.35 dBV	+26.3 dB
14.0	-5 db	-34.6	-9.05	-43.8	-33.25	-7.4	+25.95
7.9	-10 db	-33.3	-9.05	-42.6	-32.55	-7.45	+25.15
4.4	-15 db	-30.4	-9.2	-39.8	-31.25	-7.55	+23.85
2.5	-20 db	-29.5	-9.3	-36.9	-30.1	-7.6	+22.6
1.4	-25 db	-25.0	-9.35	-34.6	aFC Dwg -29.0	-7.7	+21.35
0.79	-30 db	Dwg aFC -23.1	-9.5 aFC Dwg	-32.7 aFC Dwg	-27.95	-7.8	+20.2
0.50	-34	-21.7	-9.65	-31.3	-26.95	-7.9	+19.15
0.44	-35	-21.1	-9.65	-30.9	-26.7	-7.9	+18.95

aFC ILK
Dwg MWP

Page 1

SYSTEM PERFORMANCE - RECEIVER

Note: All tests done with 25 mV/M (or equivalent input level)

Proponent Motorola

Krohn-Hite
60 Hz, 10kHz

Date July 11, 1977

Pilot Tone On

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.1	Mono, L=R	L	130	+7.0	-40.5 dB	130	2.3 %
		R	129	+7.0 dB	-40.5 dB	129	3.2 %

(100uS Deemphasis not used on the tests below)

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.2	Mono, L=R	L		dB	dB		%
		R		dB	dB		%
A.3	Stereo, L=-R	L	131	+7.0 dB	-41.5 dB	131	4.0 %
		R	132	+7.0 dB	-41.0 dB	132	3.5 %
A.4a	Left Only	L	133	+7.5 dB	-41.5 dB	133	4.8 %
		~~R~~		~~dB~~	~~dB~~		~~%~~
A.4b	Left Separation L Modulated	R	133				
A.5a	Right Only	R	134	+7.25 dB	-40.75 dB	134	1.7 %
A.5b	Right Separation R Modulated	L	134				

A.6 L/ -45°, R/+ 45°

~~Signal Level~~ Modulation % | Harmonic Distortion

L+R 59% dB L [illegible] 1.90 ajhc %

L- R ______ dB R 2.15 %

Gain	Phase
Transmitter	
±0.15	90.45
Receiver	
-0.25	86.0

Notes:

Technicians ajhc

Witness

Page 2

Test A.2

SYSTEM PERFORMANCE - RECEIVER

Note: All tests done with 25 mV/M (or equivalent input level)

Proponent Motorola

Date July 11, 1977

Pilot Tone On

Kroh-Hite
60 Hz, 10kHz

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.1	Mono, L=R	L			dB		%
		R		dB	dB		%
	(100uS Deemphasis used on the tests below)						
A.2	Mono, L=R	L	136	+7.0 dB	-40.5 dB	136	%
		R	135	+7.0 dB	-40.5 dB	135	%
A.3	Stereo, L=-R	L	137	+7.0 dB	-41.0 dB	137	%
		R	138	+7.0 dB	-40.6 dB	138	%
A.4a	Left Only	L	139	+7.5 dB	-41.2 dB	139	%
A.4b	Left Separation L Modulated	R	139				
A.5a	Right Only	R	140	+7.5 dB	-40.5 dB	140	%
A.5b	Right Separation R Modulated	L	140				

No.	Input Signal		Signal Level	Harmonic Distortion
A.6	L/ -45°, R/+ 45°	L	dB	%
		R	dB	%

Notes:

Technicians

Witness

Page 3

Test No. 2

System Performance - Receiver

Proponent Motorola

Date July 11, 1977

Pilot Tone On

Krohn-Hite
60 Hz, 10 kHz

Separation vs. R.F. Field Intensity

Objective: To determine the ability of the receiver to maintain separation of the left and right channels over wide variations in field intensity or R.F. input level.

Procedure: An 85% L + R signal is set with a 1000 Hz. audio input signal. One audio channel is disconnected and terminated. The receiver is illuminated with 25 mv/m (or equivalent input level) and the separation is measured. Separation is again measured at the indicated R.F. levels down to 0.44 mv/m. The test is repeated with the opposite separation measured.

mV Input	R.F. Field Intensity Voltage	db-ref= 25 mv/m	R/L	Left Modulated Right Measured		Right Modulated Left Measured		R/L
				Left Level	Right Level	Left Level	Right Level	
40mV	25 mv/m	0 db	-29.1 dB	+7.15 dBV	-22.2 dBV	-24.6 dBV	+6.8 dBV	+31.3 dB
22.4	14.0	-5 db	-31.7	+6.7	-24.6	-24.9	+6.45	+31.3
12.64	7.9	-10 db	-31.4	+6.25	-25.6	-25.5	+6.15	+31.8
7.04	4.4	-15 db	-31.8	+5.75	-26.1	-26.2	+5.7	+31.9
4.0	2.5	-20 db	-31.4	+5.1	-26.7	-27.1	+5.15	+32.2
2.24	1.4	-25 db	-29.7	+4.35	-25.9	-28.0	+4.55	+32.7
1.26	0.79	-30 db	-26.9	+3.3	-23.9	-30.4	+3.65	+34.2
0.8	0.50	-34	-23.9	+2.25	-21.8	-32.9	+2.75	+35.7
0.7	0.44	-35	-22.9	+1.95	-21.1	-33.4	+2.45	+35.8

aHC

Page 1

Test A.2

SYSTEM PERFORMANCE - RECEIVER

Note: All tests done with 25 mV/M (or equivalent input level)

Proponent BeLAR

Date 18 July 1977

Krohn-Hite, 80 Hz, 10kHz

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.1	Mono, L=R (L-R ~~detector~~ out on Test A.1 with no Deemphasis)	L	174	+7.5	-632 dB	174	%
		R	175	-8.0 dB	-64.0 dB	175	%
		(100uS Deemphasis NOT used on the tests below) (L-R Detector in on Tests Below)					
A.2	Mono, L=R	L	177	-8.9 dB	-47.5 dB	177	%
		R	176	-6.8 dB	-45.5 dB	176	%
A.3	Stereo, L=-R	L	178	-7.8 dB	-48.2 dB	178	%
		R	179	-7.2 dB	-45.7 dB	179	%
A.4a	Left Only	L	181	-8.2 dB	-47.9 dB	181	%
		~~R~~		~~dB~~	~~dB~~		~~%~~
A.4b	Left Separation L Modulated	R	181				
A.5a	Right Only	R	180	-6.9 dB	-45.8 dB	180	%
A.5b	Right Separation R Modulated	L	180				

No.	Input Signal		Signal Level	Harmonic Distortion
A.6	L/ -45°, R/+ 45°	L	dB	%
		R	dB	%

Notes:

Technicians

Witness RDS TJM JK

Page 2

Test A.2

SYSTEM PERFORMANCE - RECEIVER

Note: All tests done with 25 mV/M (or equivalent input level)

Proponent Belar

Date 18 July 1977

Krohn-Hite, 80 Hz, 10kHz

No deemphasis

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.1	Mono, L=R	L	182	-7.2 aHC	-62.5 aHC dB	182	5.2 %
		R	183	-8.0 aHC dB	-63.1 aHC dB	183	5.2 %
A.2	Mono, L=R	L	185	-8.0 dB	-48.0 dB	185	7.0 %
		R	184	-7.0 dB	-45.8 dB	184	4.3 %
A.3	Stereo, L=-R	L	186	-8.0 dB	-48.5 dB	186	2.4 %
		R	187	-7.0 dB	-45.8 dB	187	0.95 %
A.4a	Left Only	L	188	-8.0 dB	-48.5 dB	188	1.7 %
		~~R~~		~~dB~~	~~dB~~		~~%~~
A.4b	Left Separation L Modulated	R	188				
A.5a	Right Only	R	189	-7.0 dB	-45.8 aHC dB	189	0.95 %
A.5b	Right Separation R Modulated	L	189				

(L-R detector out on test A.1 with 100 uSec deemphasis)

(100uS Deemphasis used on the tests below)

No.	Input Signal		Signal Level (Modulation %)	Harmonic Distortion
A.6	L/ -45°, R/+ 45°	L+R	59 %	L 2.9 %
		L-R	66 %	R 3.3 %

No aHC Deemphasis's

Gain	Phase
Transmitter	
0.75 dB	+90.15 °
Receiver	
+1.55 dB	+85.55°

Notes:

Technicians aHC

Witness RDS PJM JR

Page 3

System Performance - Receiver

Proponent Belar

Date 18 July 77

Krohn-Hite
80 Hz, 10 kHz

Separation vs. R.F. Field Intensity

Objective: To determine the ability of the receiver to maintain separation of the left and right channels over wide variations in field intensity or R.F. input level.

Procedure: An 85% L + R signal is set with a 1000 Hz. audio input signal. One audio channel is disconnected and terminated. The receiver is illuminated with 25 mv/m (or equivalent input level) and the separation is measured. Separation is again measured at the indicated R.F. levels down to 0.44 mv/m. The test is repeated with the opposite separation measured.

R.F. Field Intensity			Left Modulated Right Measured		Right Modulated Left Measured		
Voltage	db-ref= 25 mv	R/L	Left Level	Right Level	Left Level	Right Level	R/L
25 mv	0 db	-27.6 dB	-7.85 dBV	-35.6 dBV	-30.6 dBV	-6.45 dBV	+24.3 dB
14.0	-5 db	-28.85	-7.55	-36.45	-32.55	-6.5	+26.1
7.9	-10 db	-29.6	-7.45	-37.2	-33.5	-6.6	+27.05
4.4	-15 db	-30.1	-7.35	-37.55	-33.65	-6.65	+27.25
2.5	-20 db	-30.6	-7.35	-38.00	-33.7	-6.65	+27.15
1.4	-25 db	-29.6	-7.35	-37.1	-33.85	-6.65	+27.4
0.79	-30 db	-28.5	-7.35	-36.1	-34.05	-6.65	+27.6
0.50	-34	-27.2	-7.35	-34.85 AHC	-34.0	-6.65	+27.45
0.44	-35	-26.7	-7.35	-34.3	-33.8	-6.65	+27.3

AHC DMO
PDS JK
PEN

Test A.3

MONAURAL COMPATIBILITY

Objective: To provide data on the compatibility of the proponent's stereo operation on existing AM receivers. The test employs a left + right signal as a reference (equivalent to AM) for comparing fidelity received from the stereo transmissions.

Compatibility is considered to be related to the ability of conventional radios to receive stereophonic transmissions without substantial additional degradation.

Because most AM stereo systems transmit left + right as standard AM, the conventional radio will demodulate this component of AM stereo identically as with present standard broadcast transmissions. Any receiver mistuning effects due to the L + R will be the same for all proponents tested.

The additional of some form of angular modulation in stereophonic transmissions will produce varied effects on standard AM radios, especially if the radio is mistuned. It is the purpose of this test to discover the effects of the stereo transmissions on the 5 selected compatibility receivers.

Procedure: The proponent's equipment is set up for 85% L+R modulation on 570 kHz* and a compatibility receiver tuned for maximum audio output. The modulation frequency is as noted below. The field intensity shall be 25 mV/m for the tests or the equivalent input level.

*The part of the AM Band where the receivers have the least bandwidth.

The compatibility receiver was mistuned in specific increments by observing a null in the audio output when a signal generator of known frequency was appropriately FM modulated. This method was used only to provide a very repeatable method of precisely tuning the AM ratios. The source of RF for the AM and AM stereo measurements was the proponent's equipment.

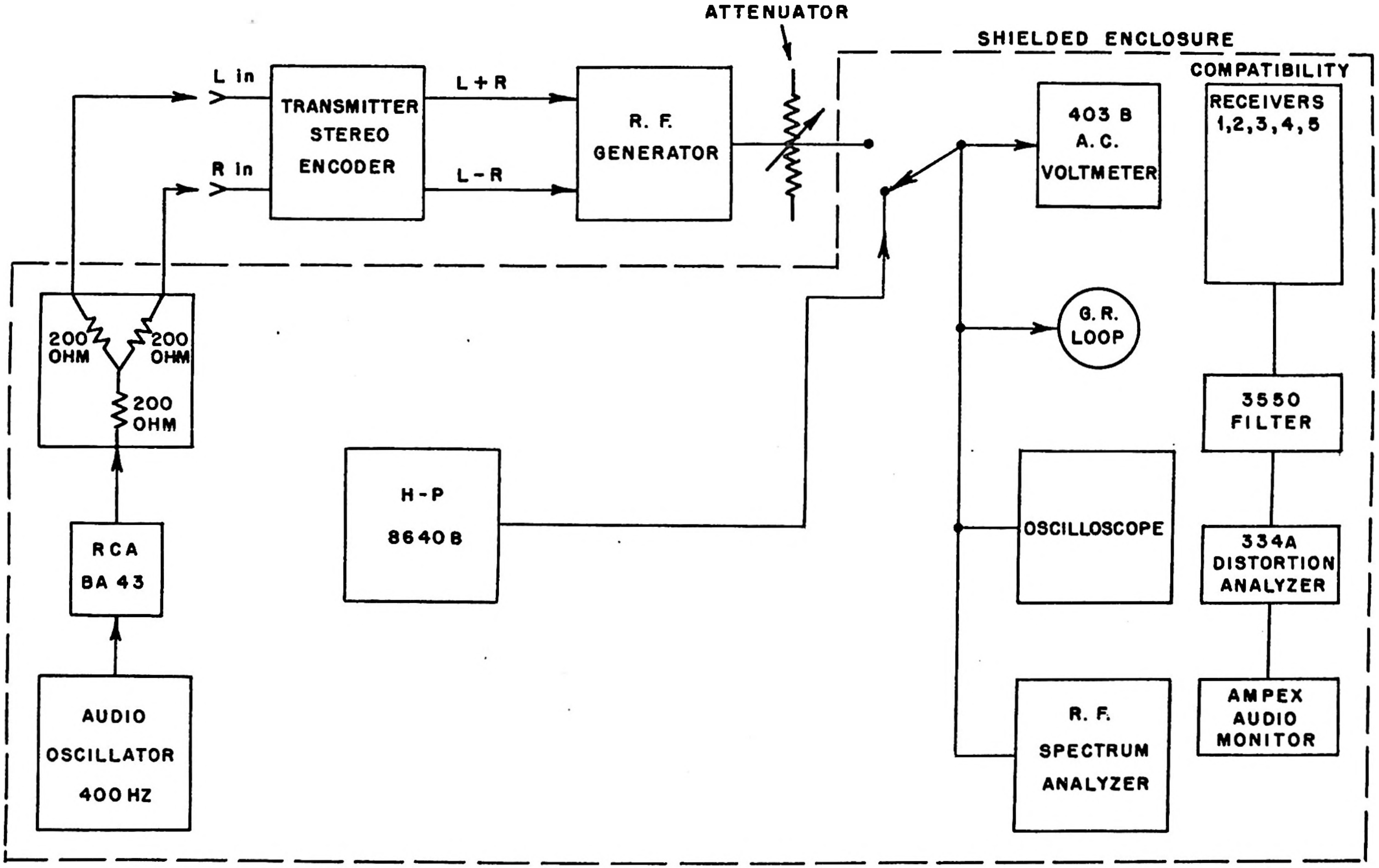
The receiver is mistuned in certain specified steps and the following is measured: For L+R modulation, audio output level and distortion products refered to center tuning output. For L - R modulation, audio output level refered to center tuning L+R output, and distortion products refered to center tuning L+R output. Thus the AM characteristics vs. tuning and the linear and non-linear angular modulation vs. tuning can be shown.

The linear products from the L-R modulation are not expected to harm the L+R information because it should simply add or subtract in volume without creating objectional distortion. The non-linear demodulation of the L-R signal would create objectionable distortion.

Notes:

Receiver	RF Input	Input to Loop	Proponent Modulation	Tuning Method
T-1o1, Delco	5.0 mv	----	400 Hz, 85%	400 Hz, 400 Hz dev. FM
T-102, Dymec	4.0 mv	----	400 Hz, 85%	5 kHz, 5 kHz dev. FM
T-103, Magnavox	---	25 mv	400 Hz 85%	400, Hz, 400 Hz dev. FM
T-104, K Mart	---	25 mv	1000 Hz 30%*	1000 Hz, 500 Hz dev. FM
T-105, Panasonic	---	25 mv	400 Hz 85%	400 Hz, 400 Hz dev. FM

*Selected to minimize distortion effects due to the receiver.



MONAURAL COMPATIBILITY
TEST A.3

Proponent Magnavox

Date July 15, 1977

Test A.3

T-101 Delco

MONAURAL COMPATIBILITY

400 Hz, 85% modulation

(All measurements refered to 570 KHz)

	L+R		L - R	
Frequency	Level	Distortion	Level	Distortion
545 kHz.				
550				
555				
560	-14.8	-33.9	-28.2	-47.1 *
565	-5.4	-28.9	-16.8	-44.5
567	-2.8	-30.3	-16.4	-48.5 *
569	-0.6	-35.6	-25.9	-45.0
570 1.53%	0 db	-36.4	-40.2 ~~-38.9~~ RDS	-44.8 ~~-45.3~~ RDS
571	+0.4	-36.1	-25.6	-45.3
573	-0.25	-37.8	-15.7	-47.4
575	-2.7	-34.8	-14.8	-44.1
580	-12.2	-33.6	-24.5	-45.3
585	–			
590	–			
595	–			

05
agte
AMM

Note: An FM signal of 400 Hz. modulation at 400 Hz deviation and minimum recovered audio is used for a tuning indication.

* noise

Tests made with 5 mv applied to dummy impedance used in compatibility tests.

Proponent Magnavox

Date July 15, 1977

Test A.3

MONAURAL COMPATIBILITY

T-102 Dymec

400 Hz, 85% modulation

(All measurements refered to 570 kHz L+R level)

Frequency		L+R Level	L+R Distortion	L-R Level	L-R Distortion
545 kHz.					
550		-15.1	-30.2	-27.2	-34.7
555		-2.2	-38.3	-16.4	-38.4
560		-0.15	-34.5	-17.6	-41.7
565		+0.2	-37.6	-35.0	-52.5
570	1.0%	0 db	-40.0	-42.2	-43.4
575		+0.25	-38.8	-36.6	-50.2
580		+0.3	-32.8	-19.6	-42.9
585		-0.6	-30.6	-15.0	-33.7
590		-41.4	-45.7	-46.4	-49.0
595					

Note: An FM signal with 5 kHz modulation and a deviation of 5 kHz and tuning for minimum recovered audio output is used as a tuning indicator.

Tests made with a 4 millivolt RMS input to antenna terminals

aHC

Magnavox T-103

Proponent Magnavox

Date July 14, 1977

MONAURAL COMPATIBILITY

L+R   400 Hz, 85% Modulation   L-R

(All measurements refered to 570 kHz L+R level)

Frequency		L+R Level	L+R Distortion	L-R Level	L-R Distortion
545 kHz.		____ db	____ db	____ db	____ db
550					
555					
560		-20.7	30.9 -20.9 ** a+e PDS	-30.1	-30.8 *
565		-4.1	-28.7	-19.1	-30.7 *
567		-1.2	-29.2	-18.0	-34.0 *
569		0.0	-32.7	-21.7	-37.8 *
570	a+e PDS 1.8%	0 db	-34.9	-36.0	-38.2 *
571		-0.3	-35.7	-25.6	-38.4 *
573		-1.8	-31.9	-19.5	-36.8 *
575		-4.5	-31.7	-19.2	-32.4 *
580		-16.6	-31.3	-29.9	-31.2 *
585					
590					
595					

a+C ~~N~~ote: An FM signal of 400 Hz modulation at 400 Hz deviation, and minimum recovered audio output is used for a tuning indication.

Tests made with 2.5 millivolt per meter field intensity

2.45 mv/m   H-55

PDS

* NOISE

NOISE FLOOR = -39db

** INCORRECT DATA

Magnavox

Date July 15, 1977

I-104 K-Mart

MONAURAL COMPATIBILITY

L+R 1000 Hz., 30% modulation L-R

(All measurements refered to 570 kHz L+R level)

Frequency		L+R Level	L+R Distortion	L-R Level	L-R Distortion
545 kHz.		db	db	db	db
550					
555					
560					
565		-11.0	-35.6	-24.0	-42.8 *
567 566.58		-6.3	-36.5 *	-18.7	-38.3 *
569 568.64		-1.3	-35.0	-13.6	-34.8
~~570~~ 569.71 569.92	1.90% 1.95%	0 db	-34.2 -34.1	-20.2 -27.2	-33.3 -32.2
571 570.66		+0.1	-34.1	-13.8	-33.6
573 572.73		-6.3	-29.4	-13.3	-34.8 *
575 575.10		-40.2	-51.5	-49.5	-60.6
580					
585					
590					
595					

CONSECUTIVE RUNS TO CHECK DISPLAS,

PDS

Note: An FM signal of 1000 Hz modulation and 500 Hz deviation and minimum recovered audio output is used for a tuning indication.

* NOISE

Tests made with 8 millivolt per meter field intensity

MAGNAVOX
7-14-77

Test A.3

T-105 Panasonic

MONAURAL COMPATIBILITY

400 Hz. 85% modulation

Frequency	Level	Distortion	Level	Distortion
kHz.				
545				
550				
555				
560	-11.3	-37.0	-29.6	-44.0 *
565	-1	-24.4	-17.0	-42.6 *
570 5.170	0 db	-26	-39.2	-45.3
575	-0.7	-25.1	-17.0	-42.9 *
580	-8.9	-41.4	-27.8	-44 *
585	-23.6	-39.2	-43.5	-47.7 *
590				
595				

Note: A~~n~~ ~~AM~~ FM signal of 400 Hz. modulation & 400 HZ DEVIATION and ~~maximum~~ MINIMUM recovered audio output is used for a tuning indication.

Tests made with 2.5 millivolt per meter field intensity
2.4 mv/m

* NOISE

MWB
RDS

Proponent *Motorola* Test A.3 T-101 Delco

Date *July 15, 1977*

MONAURAL COMPATIBILITY

400 Hz. 85% modulation

(All measurements refered to 570 KHz)

Frequency	L+R Level	L+R Distortion	L - R Level	L - R Distortion
545 kHz.				
550				
555				
560	-15.1	-33.9	-29.4	-45.3
565	-5.6	-28.8	-17.9	-37.6
567	-2.8	-30.0	-17.2	-38.9 *
569	-0.8	-34.7	-25.1	-43.9
570 1.57%	0 db	-35.9	-45.0	~~-36.5~~ -46.5 RDS
571	+0.45	-35.9	-27.4	-45.1
573	-0.1	-37.4	-17.0	-38.5 *
575	-2.4	-35.0	-15.6	-36.2
580	-11.9	-33.3	-25.2	-42.4
585	—			
590	—			
595	—			

RDS

Note: An FM signal of 400 Hz. modulation at 400 Hz deviation and minimum recovered audio is used for a tuning indication.

* NOISE

Tests made with 5 mv applied to dummy impedance used in compatibility tests.

Proponent Motorola

Date July 14, 1977

Test A.3

MONAURAL COMPATIBILITY

T-102 Dymec

400 Hz, 85% modulation
(All measurements refered to 570 kHz L+R level)

	L+R		L-R	
Frequency	Level	Distortion	Level	Distortion
545 kHz.				
550	-14.2	-32.8	-17.0	-38.1
555	-2.15	-42.4	-17.8	~~[illegible]~~ -32.6 aHe
560	-0.1	-37.5	-18.3	-36.1
565	+0.2	-37.0	-34.1	~~[illegible]~~ -46.8 aHe
570 1.1%	0 db	-39.4	-42.0	-44.2
575	+0.2	-38.1	-38.2	-52.6
580	+0.3	-32.9	-21.0	-38.3
585	-0.6	-31.2	-14.9	-30.0
590	-45.8	-55.0	-48.5	-53.4
595				

Note: An FM signal with 5 kHz modulation and a deviation of 5 kHz and tuning for minimum recovered audio output is used as a tuning indicator.

Tests made with a 4 millivolt RMS input to antenna terminals

aHe

Test A.3 I-103 Magnavox

Proponent MOTOROLA

Date JULY 14, 1977

MONAURAL COMPATIBILITY

L+R 400 Hz, 85% Modulation L-R

(All measurements refered to 570 kHz L+R level)

		L+R		L-R	
Frequency		Level	Distortion	Level	Distortion
545 kHz.		db	db	db	db
550					
555					
560		-19.6	-30.9 *	-29.9 *	-30.6 *
565		-4.0	-28.8	-19.8	-30.2 *
567		-1.1	-29.2	-19.0	-32.8
569	1.75 RMS [illegible]	0.0	-32.6	-22.4	-36.9
570	1.95%	0 db	-34.7	-37.2	-38.3 *
571		-0.3	-35.6	-26.7	-38.3 *
573		-1.75	-37.1	-20.6	-35.3 A BIT of SIGNAL
575		-4.4	-32.1	-20.0	-31.9 *
580		-16.1	-31.6 *	-30.0 *	-31.3 *
585					
590					
595					

Note: An FM signal of 400 Hz modulation at 400 Hz deviation, and minimum recovered audio output is used for a tuning indication.

Tests made with 2.5 millivolt per meter field intensity
2.50 mv/m

* NOISE
Noise floor = 38.9

RDS

Motorola

Date July 14, 1977

k-Mart T-104

MONAURAL COMPATIBILITY

L+R 1000 Hz., 30% modulation L-R

(All measurements refered to 570 kHz L+R level)

Frequency	L+R Level	L+R Distortion	L-R Level	L-R Distortion
545 kHz.	db	db	db	db
550				
555				
560				
565	-11.7	-34.5	-25.5	-42.0*
567	-5.8	-34.5	-18.3	-36.4*
569	-1.0	-33.3*	-13.5	-33.7
570 2.4%	0 db	-32.7*	-22.2	-31.6*
571	-0.05	-32.2*	-12.5	-32.2*
~~573~~ 572.81	-7.4	-28.2	-14.0	-33.7*
~~575~~ 574.79	-37.1	-47.5	-45.6	-55.9
580				
585				
590				
595				

Note: An FM signal of 1000 Hz modulation and 500 Hz deviation and minimum recovered audio output is used for a tuning indication.

Tests made with 8 millivolt per meter field intensity

MOTOROLA

7-14-77

Test A.3

T-105 Panasonic

0.5V/10Ω

MONAURAL COMPATIBILITY

400 Hz. 35% modulation

		L+R		L-R	
Frequency		Level	Distortion	Level	Distortion
kHz.					
545					
550					
555					
560		-12.0	~~-25.9~~ afc -35.8 RDS	-31.0	-43.4 *
565		-1.1	-24.5	-17.8 17.8 RS afc	-38.4
570	5.1%	0 db	-25.8	-38.7	-45.3
575		-0.8	-25.0	-17.9	-38.4
580		-9.6	~~-29.4~~ afc -40.4 RDS	-29.3	-42.4
585		-25.2	-40.2	-45.0	-48 *
590					
595					

Note: An AM signal of 400 Hz. modulation and maximum recovered audio output is used for a tuning indication.

Tests made with 2.5 millivolt per meter field intensity

* NOISE

afc
mvo
RDS

Proponent Belar

Date July 15, 1977

Test A.3

T-101 Delco

MONAURAL COMPATIBILITY

400 Hz. 85% modulation

(All measurements refered to 570 KHz)

Frequency		L+R Level	L+R Distortion	L - R Level	L - R Distortion
545 kHz.					
550					
555					
560		-14.8	-33.6	-17.5	-33.3
565		-5.5	-28.6	-6.7	-23.9
567		-2.8	-29.8	-6.3	-34.0
569		-0.6	-34.9	-15.0	-29.7
570	1.58%	0 db	-35.7	-28.2	-29.8
571		+0.4	-35.7	-16.5	-30.2
573		-0.3	-37.0	-6.1	-42.2
575		-2.7	-33.7	ate RDS - ~~5~~ 4.9	-35.9
580		-12.2	-33.4	-14.4	-30.8
585	agte	–			
590	Amos	–			
595	RDS	–			

H-63

Note: An FM signal of 400 Hz. modulation at 400 Hz deviation and minimum recovered audio is used for a tuning indication.

Tests made with 5 mv applied to dummy impedance used in compatibility tests.

Proponent Belar

Date July 15, 1977

Test A.3

T-102 Dymec

MONAURAL COMPATIBILITY

400 Hz, 85% modulation

(All measurements refered to 570 kHz L+R level)

	L+R		L-R	
Frequency	Level	Distortion	Level	Distortion
545 kHz.				
550	-12.2	-29.0	-12.7	-23.6
555	-1.8	-38.8	-5.3	-20.1
560	-0.05	-36.6	-7.6	-33.7 aHe
565	+0.2	-36.4	-19.9	-37.2
570 1.2%	0 db	-38.3	-30.1	-32.8
575	+0.25	-37.4	-29.85	-46.7
580	+0.35	-32.4	-9.9	-33.7
585	-0.6	-29.6	-15.0	-17.6
590	-30.4	-36.2	-11.3	-17.6
595				

Note: An FM signal with 5 kHz modulation and a deviation of 5 kHz and tuning for minimum recovered audio output is used as a tuning indicator.

Tests made with a 4 millivolt RMS input to antenna terminals

aHe

AMM

T-103 MAGNAVOX

Proponent BELAR

Date 7-14-77

MONAURAL COMPATIBILITY

L+R 400 Hz, 85% Modulation L-R

(All measurements refered to 570 kHz L+R level)

Frequency		L+R Level	L+R Distortion	L-R Level	L-R Distortion
545 kHz.		db	db	db	db
550					
555					
560		-19.6	-31.0 *	-25.2	-30.5 *
565		-3.9	-28.4	-8.6	-26.2
567		-1.1	-28.9	-7.7	-29.0
569		0.0	-32.5	-11.4	-27.5
570	1.9 %	0 db	-34.5	-23.9	-34.7
571		-0.3	-35.8	-17.1	-31.8
573		-1.8	-32.2	-9.55	-36.4 *
575		-4.4	-32.3	-9.25	-27.3
580		-16.4	-31.6 *	-24.0	-31.3 *
585					
590					
595					

JRL

RDS

Note: An FM signal of 400 Hz modulation at 400 Hz deviation, and minimum recovered audio output is used for a tuning indication.

Tests made with 2.5 millivolt per meter field intensity

2.54 mv/m

* NOISE

NOISE FLOOR = 39.6

[redacted] Belar

July 14, 1977

K-Mart T-104

MONAURAL COMPATIBILITY

L+R 1000 Hz., 30% modulation L-R

(All measurements refered to 570 kHz L+R level)

Frequency		Level	Distortion	Level	Distortion
545 kHz.		db	db	db	db
550					
555					
560					
~~565~~ 564.69		-12.3	-35.0	-21.6	-42.0*
567		-5.7	-34.0*	-14.0	-35.2*
569		-1.2	-32.7*	-9.9	-32.1*
570	2.4%	0 db	-32.6*	-19.5	-30.3
571		-0.3	-32.0*	-8.4	-30.0
~~573~~ 573.07		-10.0	-29.2	-12.6	-32.0
~~575~~ 575.09		-39.1	-50.5	-44.0	-54.6
580					
585					
590					
595					

MWB

Note: An FM signal of 1000 Hz modulation and 500 Hz deviation and minimum recovered audio output is used for a tuning indication.

AHC

JK

Tests made with 8 millivolt per meter field intensity

BELAR
7-14-77

I105 PANASONIC

MONAURAL COMPATIBILITY

400 Hz. 85% modulation

	L+R		L-R	
Frequency	Level	Distortion	Level	Distortion
kHz.				
545				
550				
555				
560	-11.4	-37.0	-19.1	-40.1
565	-1.0	-24.6	-6.4	-29.7
570 5.0 %	0 db	-26.1	-25.7	-26.7
575	-0.8	-25.2	-6.8	-29.8
580	-9.0	-41.5	-17.9	-40.6
585	-23.8	-39.3	-35.4	-47 *
590	—			
595	—			

Note: An AM signal of 400 Hz. modulation and maximum recovered audio output is used for a tuning indication.

Tests made with 2.5 millivolt per meter field intensity

2.54 mv/m

* NOISE

ajte
RDS
JEK
nws

Test A.4

ENVELOPE MODULATION LIMIT TEST

To determine the limitations in envelope modulation depth of the proponent's stereo transmissions. This relates to the amount of amplitude modulation obtainable under stereo conditions and thus the limitation in audio recoverable by standard AM receivers. This can have an effect on the apparent loudness of stereo transmissions as heard on AM receivers.

Average modulation is should be limited only by the expected sophistication of the AM stereo audio processing equipment.

Procedure: Two distortion audio oscillators are set to 200 and 2500 Hz and are connected to the generator inputs of the Crown Intermodulation meter. In addition, they can be alternately connected to the left and right inputs of the proponent's stereo encoder. The RF output of the exciter is connected to the TFT modulation monitor, the spectrum analyzer, and the oscilloscope.

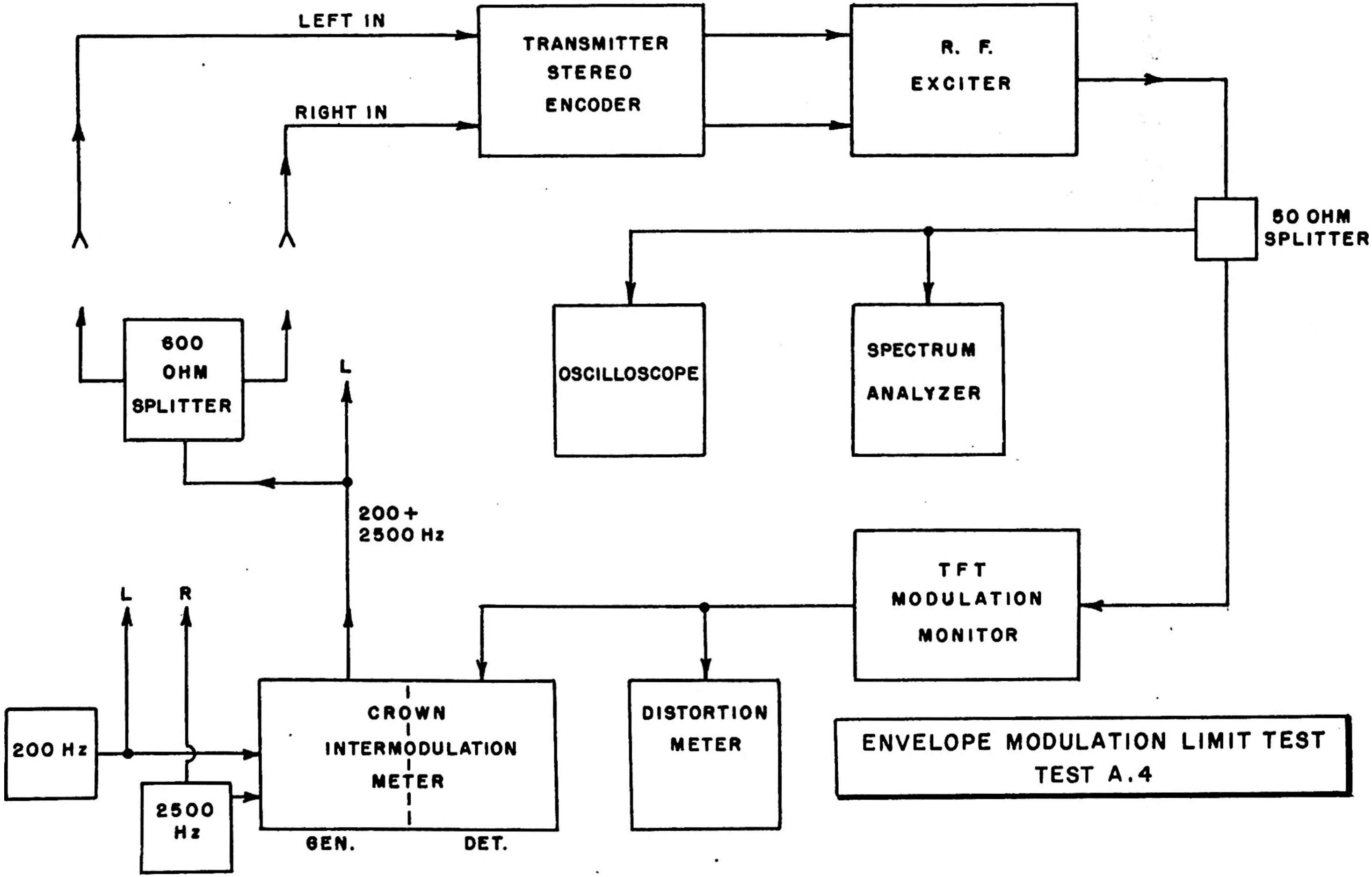
The audio output of the TFT monitor is connected to the inputs of the noise and distortion meter and the intermodulation meter. The three modes of operation for measurement of intermodulation distortion are:

200 and 2500 Hz combined for L+R (AM case)
200 and 2500 Hz combined for left only
200 in Left and 2500 Right

The modes of operation for harmonic distortion are:

200 and 2500 Hz combined for L+R (AM case)
200 and 2500 Hz combined for Left only

Distortion is measured for levels of modulation from 50% to 98%. As can be observed from the data, there is no point at which the amplitude modulation is limited up to 98%. It is expected that assymetrical modulation toward the positive peak polarity has no specific limitation in the AM stereo systems tested by the NAMSRC. Audio processing equipment will have to be especially designed to control the polarity switching, but the systems place no constraint on the positive modulation.



ENVELOPE MODULATION LIMIT TEST
TEST A.4

Proponent *Magnavox*

Date *18 July 77*

Test A.4

Envelope Modulation Limit Test

334 Filter In

Harmonic [redacted] Distortion

% Modulation	L+R *1000 Hz* [redacted].	L= 200 Hz. R= 2500 Hz.	L only *1000 Hz* [redacted]
50%	*0.200* %	%	*0.191* %
70%	*0.176*		*0.187*
80%	*0.1775*		*0.205*
90%	*0.214*		*0.255*
92%	*0.224*		*0.265*
94%	*0.243*		*0.278*
96%	*0.250*		*0.293*
98%	*0.257*		*0.305*

Notes:

Proponent Magnavox

Date 18 July 77

Test A.4

Envelope Modulation Limit Test

	Intermodulation Distortion		
% Modulation	L+R 200 + 2500 Hz.	L= 200 Hz. R= 2500 Hz.	L only 200 + 2500 Hz.
50%	0.220 %	0.385 %	0.190 %
70%	0.245	0.510	0.245
80%	0.260	0.555	0.285
90%	0.290	0.610	0.320
92%	0.300	0.635	0.330
94%	0.310	0.655	0.340
96%	0.330	0.680	0.345
98%	0.345	0.685	0.360

Notes:

aHC

PJN

JR

RDS

Proponent Motorola

Date 18 July 77

Pilot Tone On

Test A.4

334 Filter In

Envelope Modulation Limit Test

Harmonic [redacted] Distortion

% Modulation	L+R 1000 Hz [redacted]	~~L= 200 Hz. R= 2500 Hz.~~	L only 1000 Hz [redacted]
50%	0.053 %	%	0.068 %
70%	0.048		0.064
80%	0.0505		0.0675
90%	0.118		0.127
92%	0.130		0.147
94%	0.149		0.156
96%	0.161		0.170
98%	0.166		0.176

Notes:

AHC

P.J.N. ADS

Proponent Motorola

Date 19 July 1977

Test A.4

Envelope Modulation Limit Test

Pilot Tone On

Intermodulation Distortion

% Modulation	L+R 200 + 2500 Hz.	L= 200 Hz. R= 2500 Hz.	L only 200 + 2500 Hz.
50%	0.063 %	0.058 %	0.036 %
70%	0.066	0.064	0.041
80%	0.066	0.065	0.045
90%	0.083	0.069	0.124 aHC
92%	0.088	0.070	0.132 aHC
94%	0.099	0.075	0.143
96%	0.115 aHC	0.085	0.157
98%	0.126	0.098	0.167

Notes:

aHC

PJM JR

RDS

Proponent Belar

Date 18 July 77

334 Filter In

Test A.4

Envelope Modulation Limit Test

Harmonic [redacted] Distortion

% Modulation	L+R 1000 Hz [redacted]	~~L= 200 Hz. R= 2500 Hz.~~	L only 1000 Hz [redacted]
50%	0.140 %	%	0.105 %
70%	0.171		0.132
80%	0.184		0.141
90%	0.170		0.126
92%	0.161		0.118
94%	0.156		0.1125
96%	0.148		0.109
98%	0.149		0.106

Notes:

JR

P.J.M.

RDS

Proponent Belar

Date 18 July 77

Test A.4

Envelope Modulation Limit Test

Intermodulation Distortion

% Modulation	L+R 200 + 2500 Hz.	L= 200 Hz. R= 2500 Hz.	L only 200 + 2500 Hz.
50%	0.245 %	0.225 %	0.20 aHe [illegible] %
70%	0.338	0.320	0.275
80%	0.375	0.340	0.305
90%	0.390	0.350	0.310
92%	0.385	0.345	0.305
94%	aHe [illegible] 0.380	0.350	0.301
96%	0.375	0.340	0.295
98%	0.375	0.340	0.290

Notes:

aHe

Test A.5

STEREO RECEIVER NOISE PERFORMANCE

Objective: This test is designed to measure any differences in transmission efficiency between normal AM and AM stereo. The test is performed under the two modulating conditions of 85% L+R and 42 1/2% L+R.

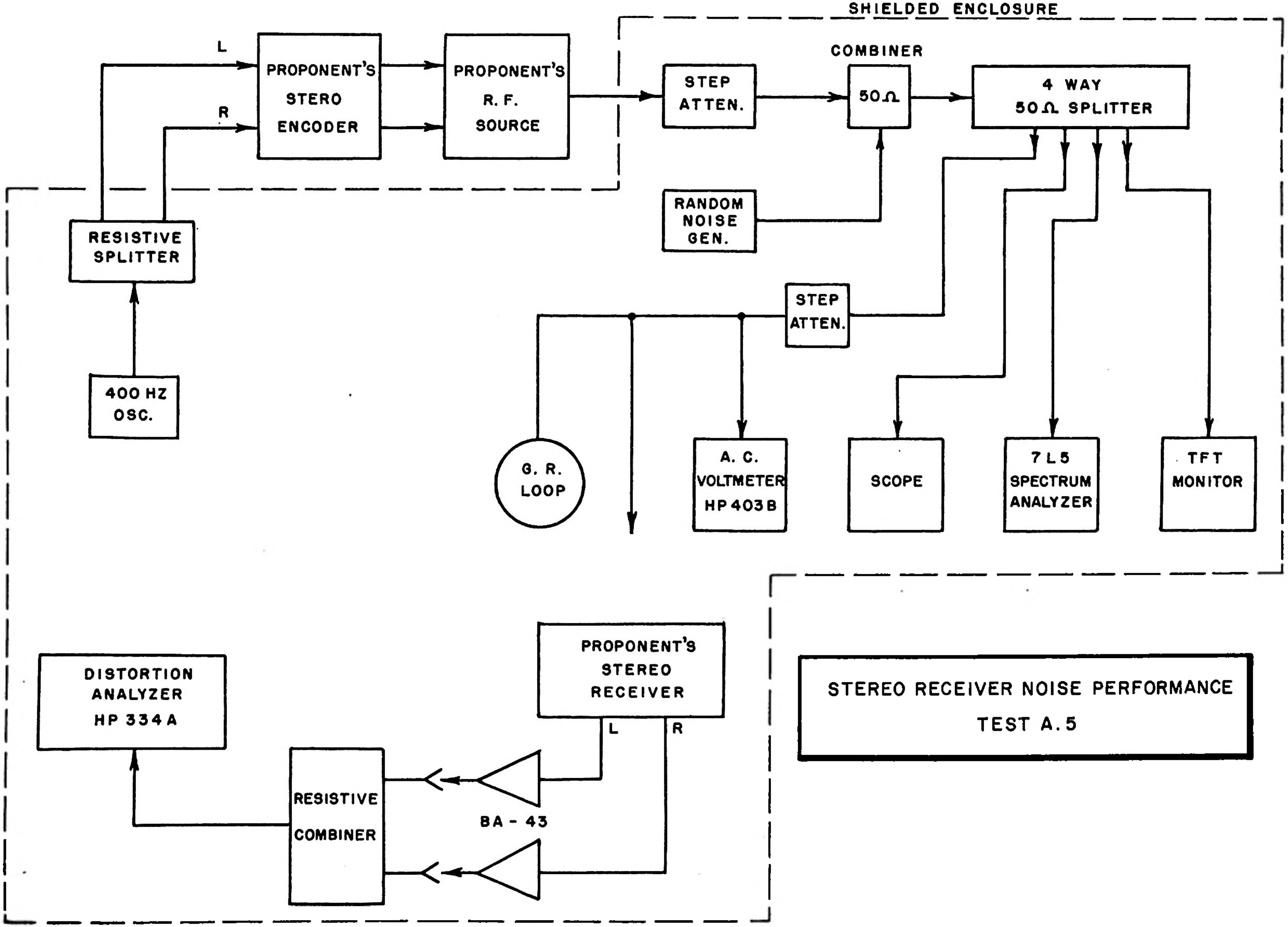
Procedure: A stereo receiver is illuminated with a level of 25 mV/m and the left and right outputs are applied to a combining network such that left only, right only and a left plus right may be obtained. The levels at the network outputs are adjusted for equal voltage using the program amplifiers (RCA BA-43). The combining network is then adjusted for center null using an L-R transmission signal.

The left plus right level (S+N+D) is measured with a wideband voltmeter (set level). A distortion meter is then used to measure the distortion plus noise (D+N). The RF level is reduced until levels of 18, 24 and 30 dB S+N+D/N+D are read. The absolute values of RF field intensity are recorded.

The RF level is then raised to re-establish 18, 24 or 30 dB S+N+D/N+D in the left and then the right output ports of the combining network. The absolute values of these RF levels are recorded.

The difference in RF levels required for equal quieting, at the center port or at the left and right ports is the change in transmission efficiency between normal AM and AM stereo for that transmission condition.

The test is re-performed for the condition of 42 1/2% L+R.



STEREO RECEIVER NOISE PERFORMANCE

TEST A.5

Proponent Magnavox

Date 22 July 77

Test A.5
System Noise Performance

"Fidelity" BW

Krohn-Hite 60 Hz, 10kHz

~~Noise Injected~~ Noise not Injected

R. F. Input Level	L+R S+N+D	L+R N+D	L Only S+N+D / N+D	R Only S+N+D / N+D	% Mod
mV/M	V	-30 dB	dB	dB	95 %
		-24			95
		-18			95
0.382 mV/M	0.395 V	-30 dB	-15.3 dB	-17.7 dB	85 %
0.195	0.278	-24	-6.9	-9.8	85
0.109	0.168	-18	aHe -2.2 Dmo	-5.8	85
0.98 mV/M	0.222 V	-30 dB	-25.6 dB	-25.6 dB	42.5%
0.385	0.200	-24	-18.2	-18.6	42.5
0.196	0.140	-18	-9.6	-11.4	42.5

aHe
Dmo

Proponent Magnavox

Date 22 July 77

Test A.5

System Noise Performance

"Normal" BW

Krohn-Hite 60 Hz, 10 kHz

~~Noise Injected~~ Noise not Injected

R. F. Input Level	L+R S+N+D	L+R N+D	L Only S+N+D/N+D	R Only S+N+D/N+D	% Mod
mV/M	V	-30 dB	dB	dB	95 %
		-24			95
		-18			95
0.175 mV/M	0.400 V	-30 dB	-13.4 dB	-16.3 dB	85 %
0.088	0.272	-24	-6.2	-11.5	85
0.0495	0.161	-18	-1.2	-7.0	85
0.49 mV/M	0.224 V	-30 dB	-25.9 dB	-25.3 dB	42.5 %
0.196	0.204	-24	-19.2	-19.5	42.5
0.088	0.137	-18	-9.3	-12.1	42.5

Proponent Magnavox

Date July 22, 77

Test A.5

System Noise Performance

"Fidelity" BW

Krohn-Hite 60 Hz, 10 kHz

Noise Injected ~~Noise not Injected~~

R. F. Input Level	L+R S+N+D	L+R N+D	L Only S+N+D / N+D	R Only S+N+D / N+D	% Mod
mV/M	V	-30 dB	dB	dB	95 %
		-24			95
		-18			95
2.46 mV/M	0.46 V	-30 dB	-18.8 dB	-19.4 dB	85 %
1.22	0.45	-24	-14.1	-14.9	85
0.615	0.42	-18	-4.5	-4.2	85

Noise Voltage 0.159 V

R. F. Input Level	L+R S+N+D	L+R N+D	L Only S+N+D / N+D	R Only S+N+D / N+D	% Mod
2.47 mV/M	0.234 V	-30 dB	-26.9 dB	-26.75 dB	42.5 %
0.982	0.222	-24	-19.8	-19.65	42.5
0.428	0.205	-18	-12.5	-12.9	42.5

Noise Voltage 0.055 V

aHe

Proponent Magnavox

Date 22 July 77

Test A.5
System Noise Performance

"Normal" BW

Krohn-Hite 60 Hz, 10 kHz

	Noise Injected		Noise not Injected		
R. F. Input Level	L+R S+N+D	L+R N+D	L Only S+N+D / N+D	R Only S+N+D / N+D	% Mod
mV/M	V	-30 dB	dB	dB	95 %
		-24			95
		-18			95
2.49 mV/M	0.465 V	-30 dB	-18.5 dB	-16.4 dB	85 %
1.24	0.455	-24	-14.9	- 15.4	85
0.62	0 .440	-18	-7.5	-7.8	85

Noise Voltage 0.21 V

2.49 mV/M	0.238 V	-30 dB	-26.1 dB	-25.4 dB	42.5%
1.10	0.23	-24	-19.9	-19.5	42.5
0.55	0.22	-18	-14.3	-13.9	42.5

Proponent Motorola

Date 22 July 77

Test A.5
System Noise Performance

Krohn-Hite 60 Hz, 10 kHz

~~Noise Injected~~ **Noise not Injected**

R. F. Input Level	L+R S+N+D	L+R N+D	L Only S+N+D / N+D	R Only S+N+D / N+D	% Mod
0.92 mV/M	1.42 V	-30 dB	-31 dB	-27.3 dB	95 %
0.46	0.92	-24	-27.5	-19.5	95
0.234	0.42	-18	-22.1	-15.1	95
0.729 mV/M	1.15 V	-30 dB	-29.6 dB	-25.7 dB	85 %
0.407	0.75	-24	-26.7	-19.4	85
0.202	0.295	-18	-21.5	-14.9	85
0.808 mV/M	0.63 V	-30 dB	-27.8 dB	-27.5 dB	42.5%
0.361	0.34	-24	-22.0	-21.7	42.5
0.223	0.17	-18	-17.9	-16.9	42.5

Residual Levels predominately consist of distortion, until 42.5 % modulation, where both noise and distortion were present.

Proponent Motorola

Date 22 July 77

Test A.5
System Noise Performance

Krohn-Hite 60 Hz, 10kHz

Noise Injected ~~Noise not Injected~~

R. F. Input Level	L+R S+N+D	L+R N+D	L Only S+N+D/N+D	R Only S+N+D/N+D	% Mod
2.50 mV/M	1.90 V	-30 dB	-28.0 dB	-27.1 dB	95 %
1.10	1.54	-24	-21.6	-21.5	95
0.558	1.08	-18	-15.6	-15.7	95
				Noise Voltage 0.018 V	
2.50 mV/M	1.75 V	-30 dB	[illegible] Dmo aHe -27.2 dB	-27.1 dB	85 %
[illegible] Dmo aHe 1.24	1.46	-24	-21.3	-22.1	85
0.621	1.06	-18	-15.5	-16.4	85
				Noise Voltage 0.018 V	
2.50 mV/M	0.90 V	-30 dB	-27.5 dB	-27.1 dB	42.5%
1.24	0.76	-24	-21.9	-22.3	42.5
0.555	0.52	-18	-15.4	-16.5	42.5
				Noise Voltage [illegible] Dmo aHe 0.0082 V	

Residual levels predominately noise.

aHe Dmo

Proponent Belar

Date 22 July 77

Test A.5
System Noise Performance

Krohn-Hite 80Hz, 10kHz

~~Noise Injected~~ Noise not Injected

R. F. Input Level	L+R S+N+D	L+R N+D	L Only S+N+D / N+D	R Only S+N+D / N+D	% Mod
0.092 mV	0.75 V	-30 dB	-20.8 dB	-20.2 dB	95 %
0.0442	0.74	-24	-14.3	-12.7	95
0.0278	0.74	-18	-11.2	-7.9	95
0.0915 mV	0.72 V	-30 dB	-23.1 dB	-23.5 dB	85 %
0.0439	0.72	-24	-16.5	-16.5	85
0.0270	0.72	-18	-11.9	-9.4	85
0.178 mV	0.36 V	-30 dB	-25.1 dB	-25.9 dB	42.5%
0.090	0.36	-24	-19.9	-20.9	42.5
0.0462	0.36 Dmo aHC ~~[illegible]~~	-18	-14.4	15.3 Dmo -~~[illegible]~~ aHC	42.5

aHC Dmo

Proponent Belar

Date 22 July 77

Test A.5
System Noise Performance

Krohn-Hite 80 Hz, 10 kHz

Noise Injected ~~Noise not Injected~~

R. F. Input Level	L+R S+N+D	L+R N+D	L Only S+N+D / N+D	R Only S+N+D / N+D	% Mod
2.54 mV	0.80 V	-30 dB	-20.3 dB	-20.1 dB	95 %
1.275	0.80	-24	-13.2	-12.9	95
0.67	0.80	-18	-7.7	-7.2	95

Noise Voltage 0.078 V

R. F. Input Level	L+R S+N+D	L+R N+D	L Only S+N+D / N+D	R Only S+N+D / N+D	% Mod
2.54 mV	0.72 V	-30 dB	-21.5 dB	-22.1 dB	85 %
1.26	0.72	-24	-16.5	-16.9	85
0.661	0.72	-18	-10.1	-10.3	85

Noise Voltage 0.070 V

R. F. Input Level	L+R S+N+D	L+R N+D	L Only S+N+D / N+D	R Only S+N+D / N+D	% Mod
2.54 mV	0.36 V	-30 dB	-25.1 dB	-26.2 dB	42.5%
1.26	0.36	-24	-19.8	-20.75	42.5
0.642	0.36	-18	-14.1	-15.0	42.5

Noise Voltage 0.0338 V

Test A.6

OCCUPIED BANDWIDTH

Objective: To provide data on the occupied bandwidth of stereophonic transmissions by employing methods which will provide accurate comparisons between the various AM stereo systems as well as a comparison with standard AM.

Discussion: The choice of a specific modulating signal for this test is a difficult one. It is probably desirable to simulate actual program conditions for the test, but program material is widely.varied as to spectural distribution, is difficult to measure control and tends to be more difficult to repeat.

Because this test is as much an evaluation of the difference in bandwidth between standard AM and the different systems, as well as the absolute characteristics, a modulating test signal was chosen which would lend itself to accurate quantification, ready comparison to theory, and would be very repeatable. In addition, the signal chosen is believed to approximate the spectral distribution of programming. This signal consists of four sinusoids with frequencies and modulating amplitudes as follows:

400 Hz @ 35% modulation
2500 Hz @ 25%
5500 Hz @ 15%
9500 Hz @ 10%

This 4 tone combination was used to modulate the stereo systems under the following conditions:

Left + Right @ 85% total peak modulation, standard AM

Left - Right (as above with one phase reversed)

Left Only @ 42.5% AM

Right Only @ 42.5% AM

A further test was made to stress the bandwidth requirements. This consisted of a single 8 kHz tone modulating the stereo transmitters at 85% left minus right which is all PM or FM and no AM.

In addition a modulating signal of 1000 Hz with a phase difference of 90 degrees at approximately 60% amplitude modulation was employed to observe systems under quadrature conditions.

It should be noted that under Section 73.40 (a)(12) of the FCC Rules, an AM station may occupy up to plus and munus 15 kHz with full sideband power, thus permitting an AM station to dully modulate with audio signals out to 15 kHz. From 15 kHz to 30 kHz, the emissions must be at least 25 dB below the unmodulated carrier, and from 30 kHz to 75 kHz, attenuated at least 35 dB.

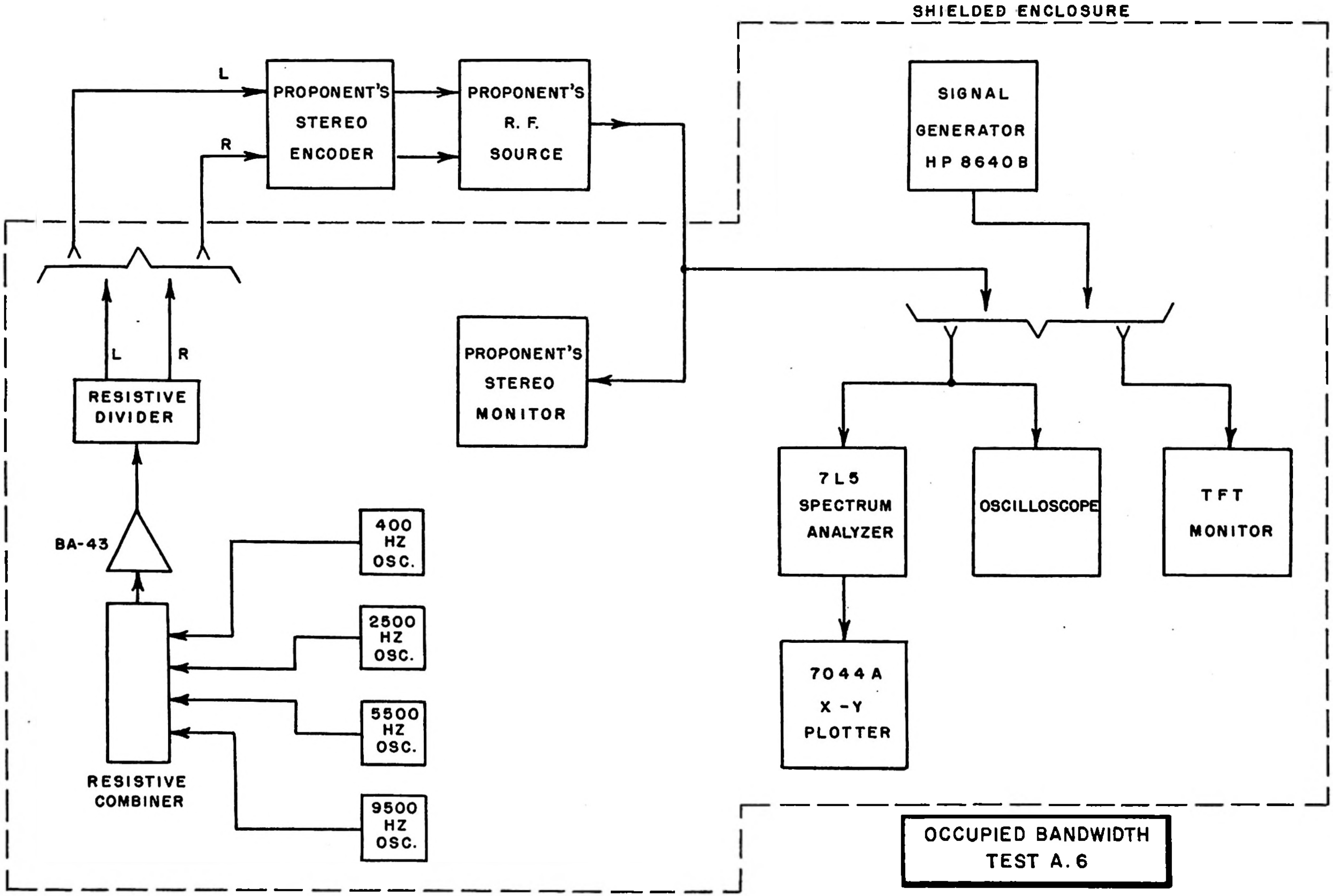
Test Procedure: The device for measuring the spectrum was a Tektronix 7L5 plug in digital storage unit, connected to a Hewlett-Packard X-Y plotter. The test equipment was arranged so that on standard one inch grid graph paper, the calibration would be vertically 10 dB per major division and horizontally 10 kHz per major division. The spectrum analyzer was set to 300 Hz bandwidth.

The four tones were set to their appropriate modulation level employing the TFT modulation monitor flasher light under AM conditions. The spectrum analyzer was then operated at a very slow rate and the spectrum recorded on the X-Y recorder.

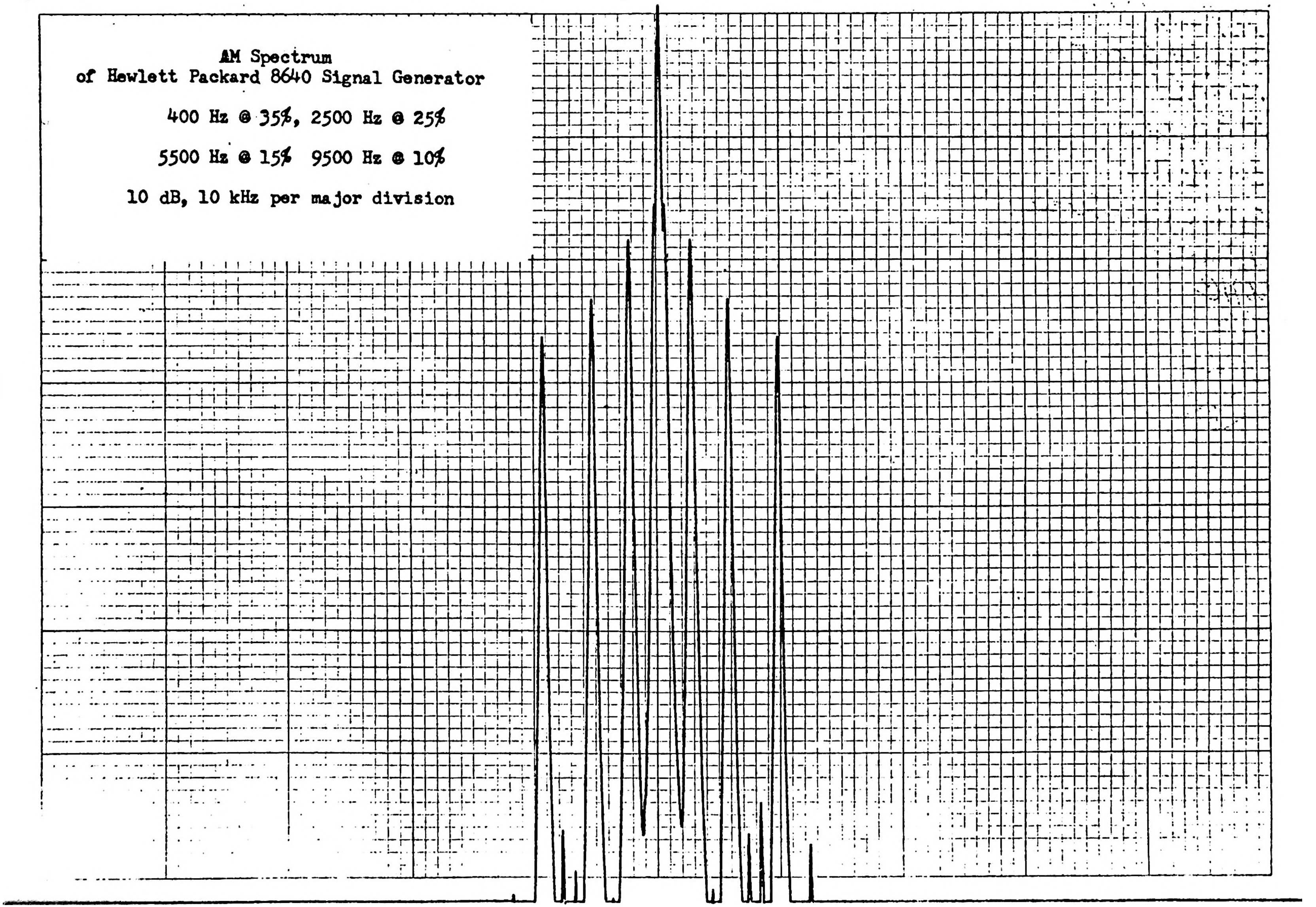
The graphs are reproduced with the equivalent test for each proponent presented one after another so that a ready comparison can be made. The spectrum for standard AM is shown first.

As can be observed from the spectrum plots, under the 4 tones test, all systems have sideband components well within the present FCC limit. The additional stress test of an 8 kHz 85% modulation L-R signal just places one sideband pair slightly above or below the limit depending upon the system.

Although this characteristic may place limitations of tone measurements performed on the air, it is believed however, that the 4 tone spectrum is more representative of the actual spectrum to be occupied by AM stereo stations. In order to place a sideband near the FCC limit, the program material must have an extreme concentration of high frequency energy only such as a pure sine wave tone. If there were any other frequencies present, the depth of modulation available for the high frequency information would be limited because the total peak value at any time must not exceed 100% L-R modulation. Even with modern music, with multi-band limiting, it is improbable that the power in the sidebands would exceed the existing FCC limits.



OCCUPIED BANDWIDTH
TEST A.6



AM Spectrum
of Hewlett Packard 8640 Signal Generator

400 Hz @ 35%, 2500 Hz @ 25%

5500 Hz @ 15% 9500 Hz @ 10%

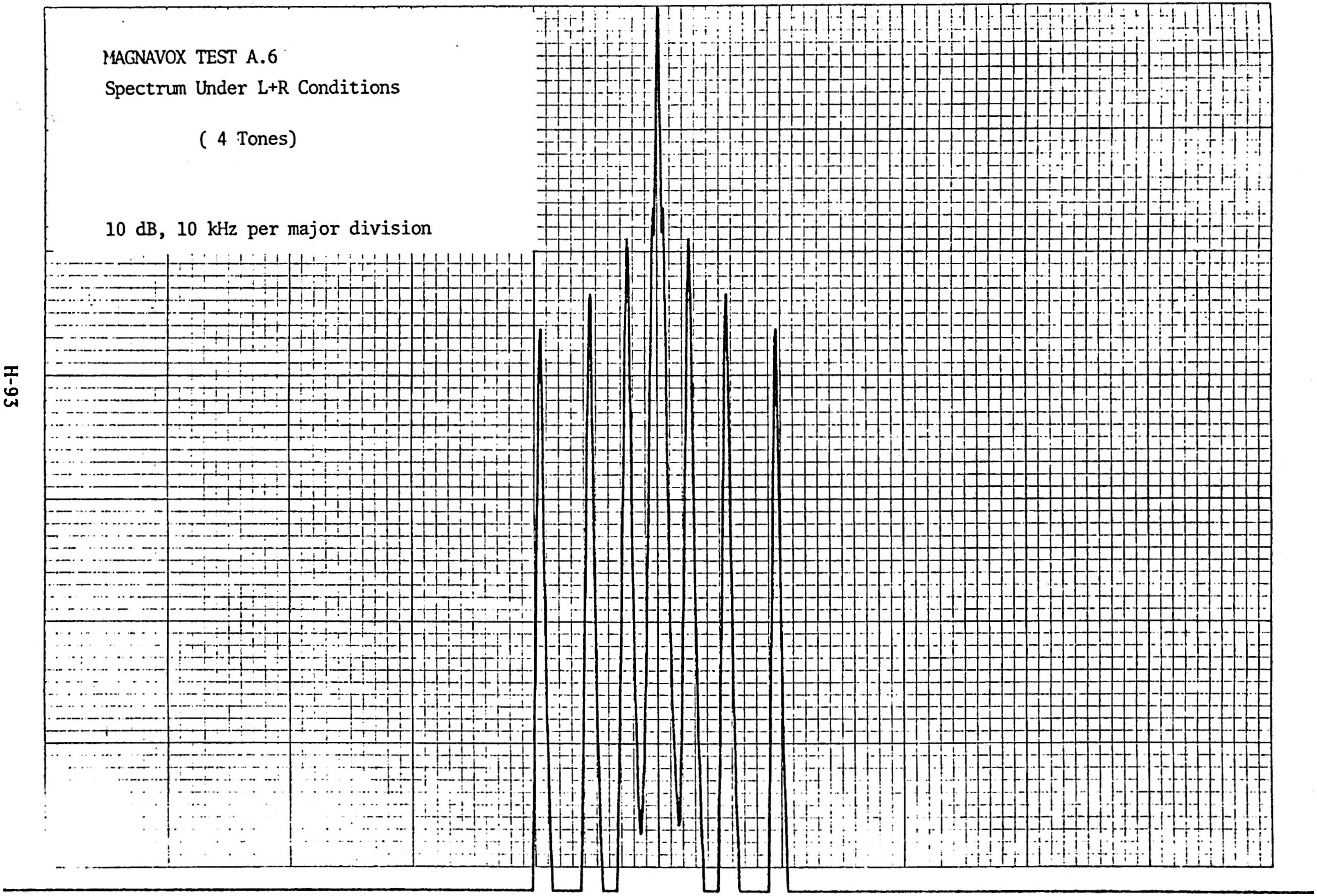
10 dB, 10 kHz per major division

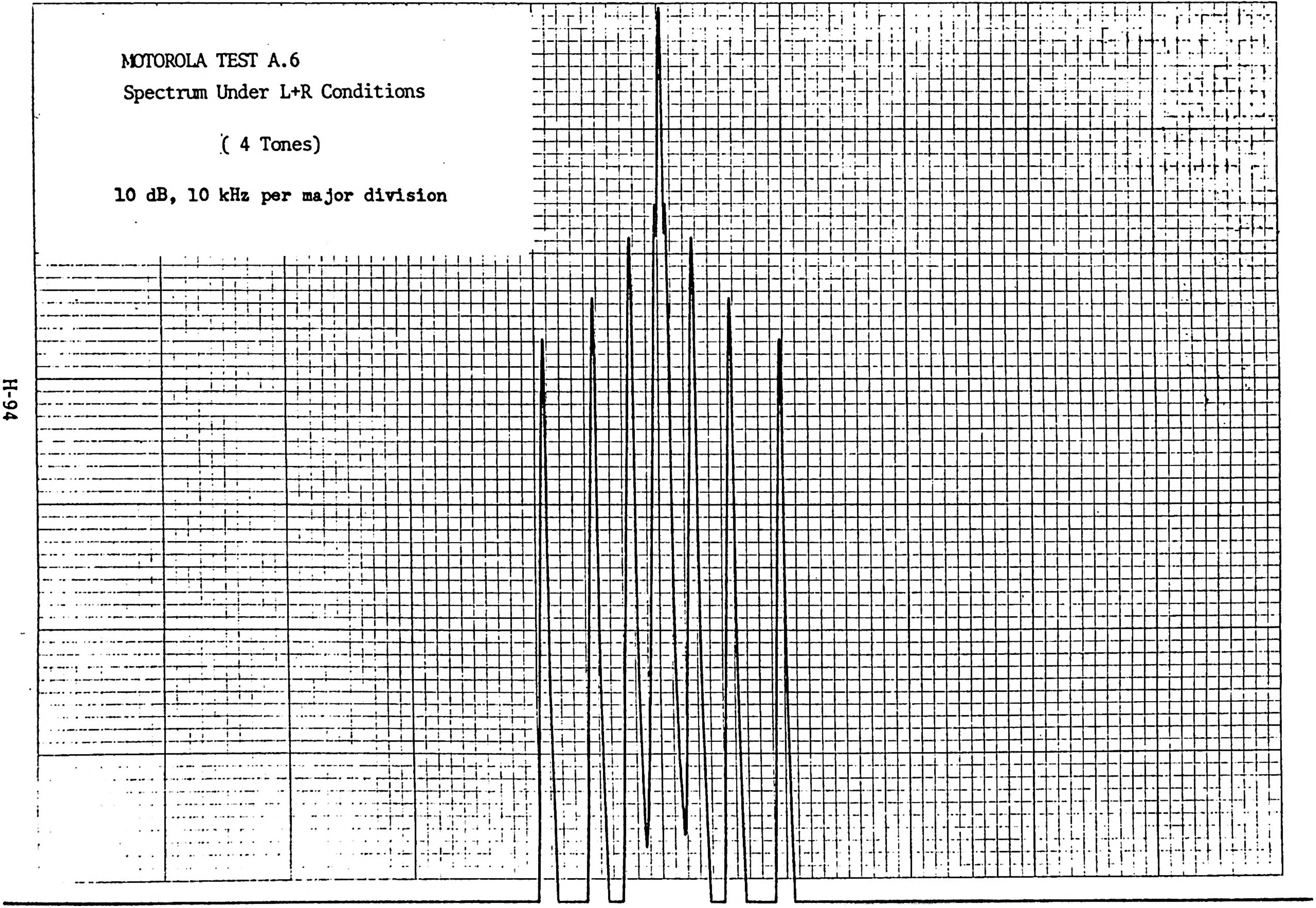
MAGNAVOX TEST A.6

Spectrum Under L+R Conditions

(4 Tones)

10 dB, 10 kHz per major division





MOTOROLA TEST A.6
Spectrum Under L+R Conditions

(4 Tones)

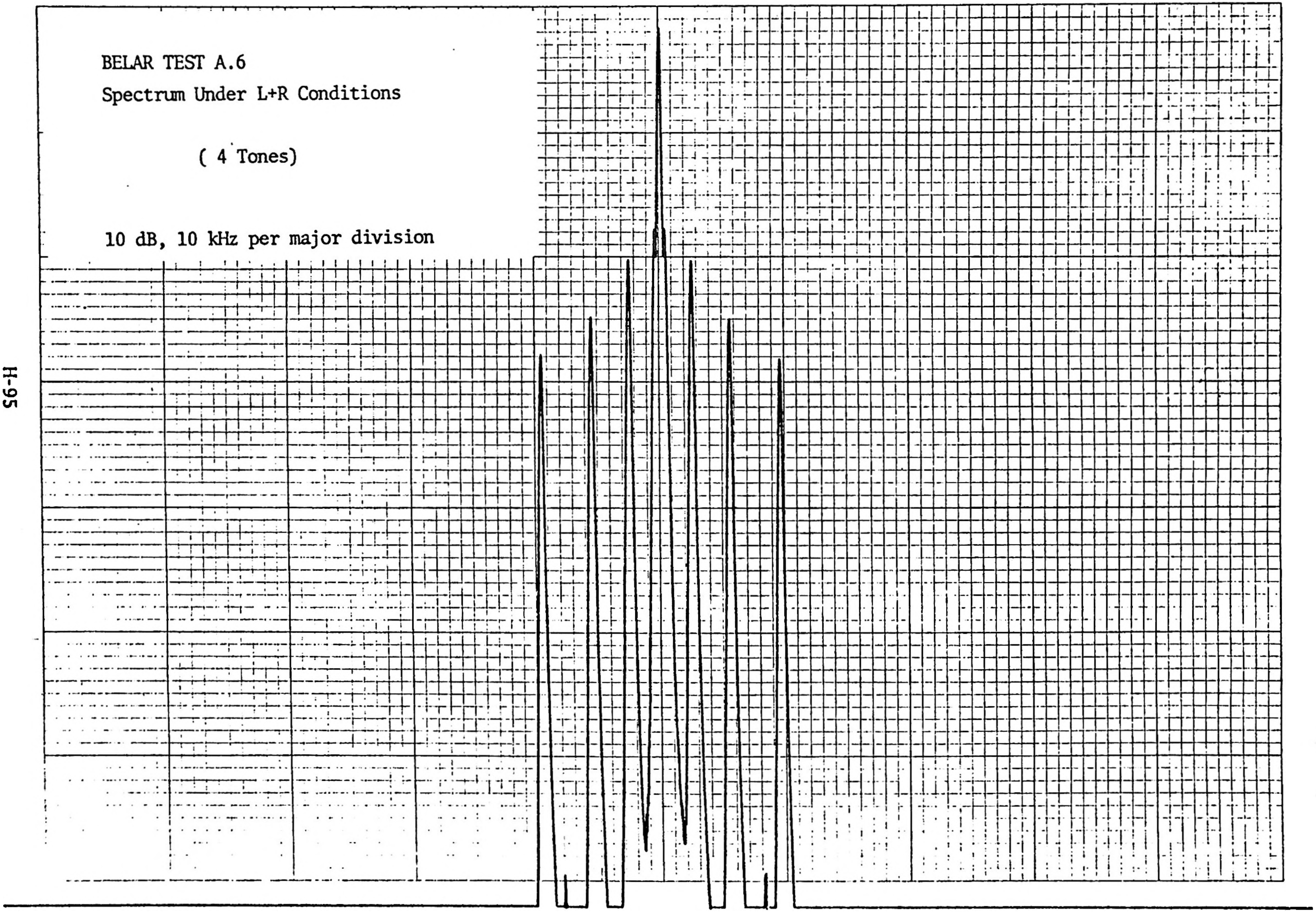
10 dB, 10 kHz per major division

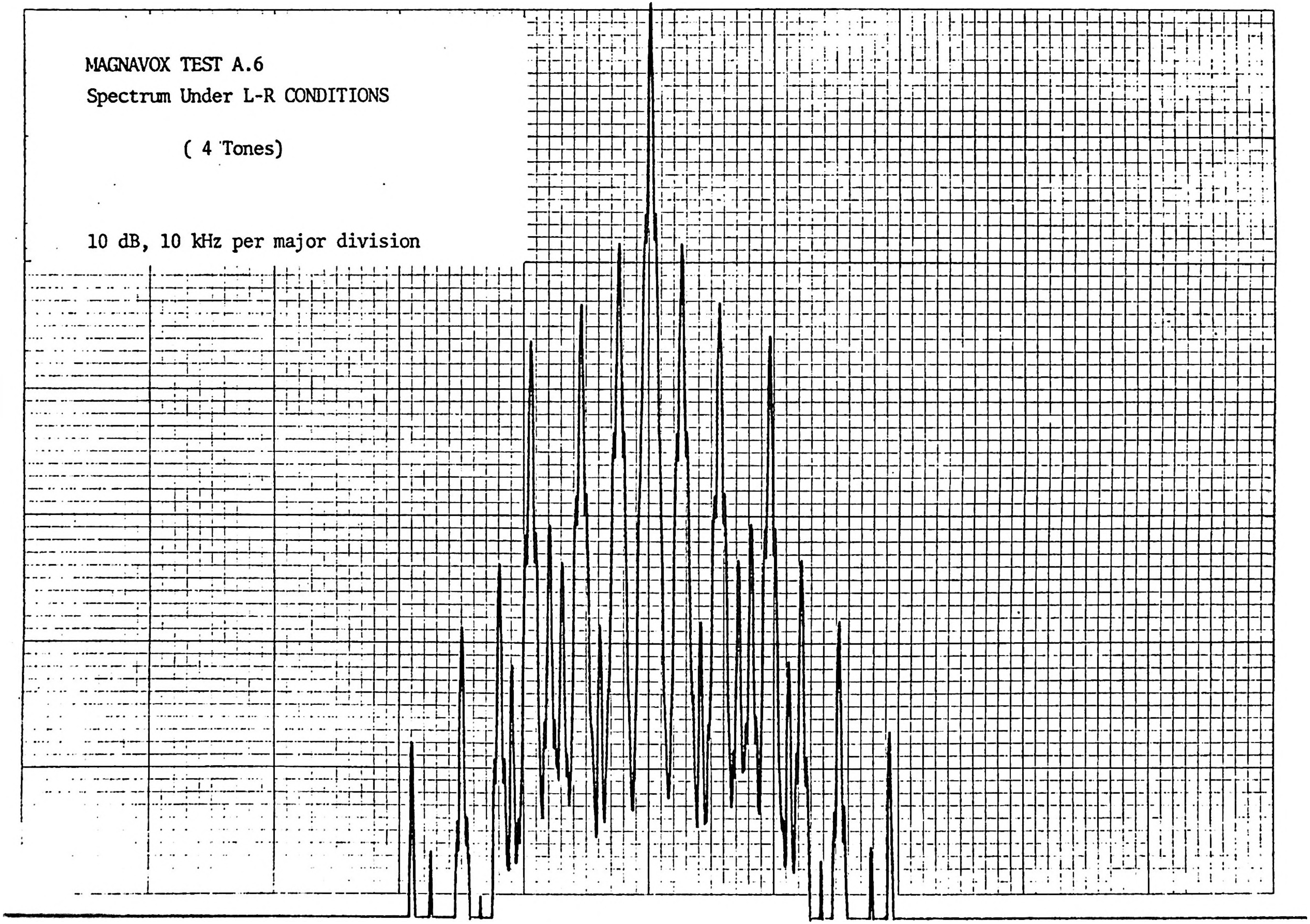
BELAR TEST A.6

Spectrum Under L+R Conditions

(4 Tones)

10 dB, 10 kHz per major division



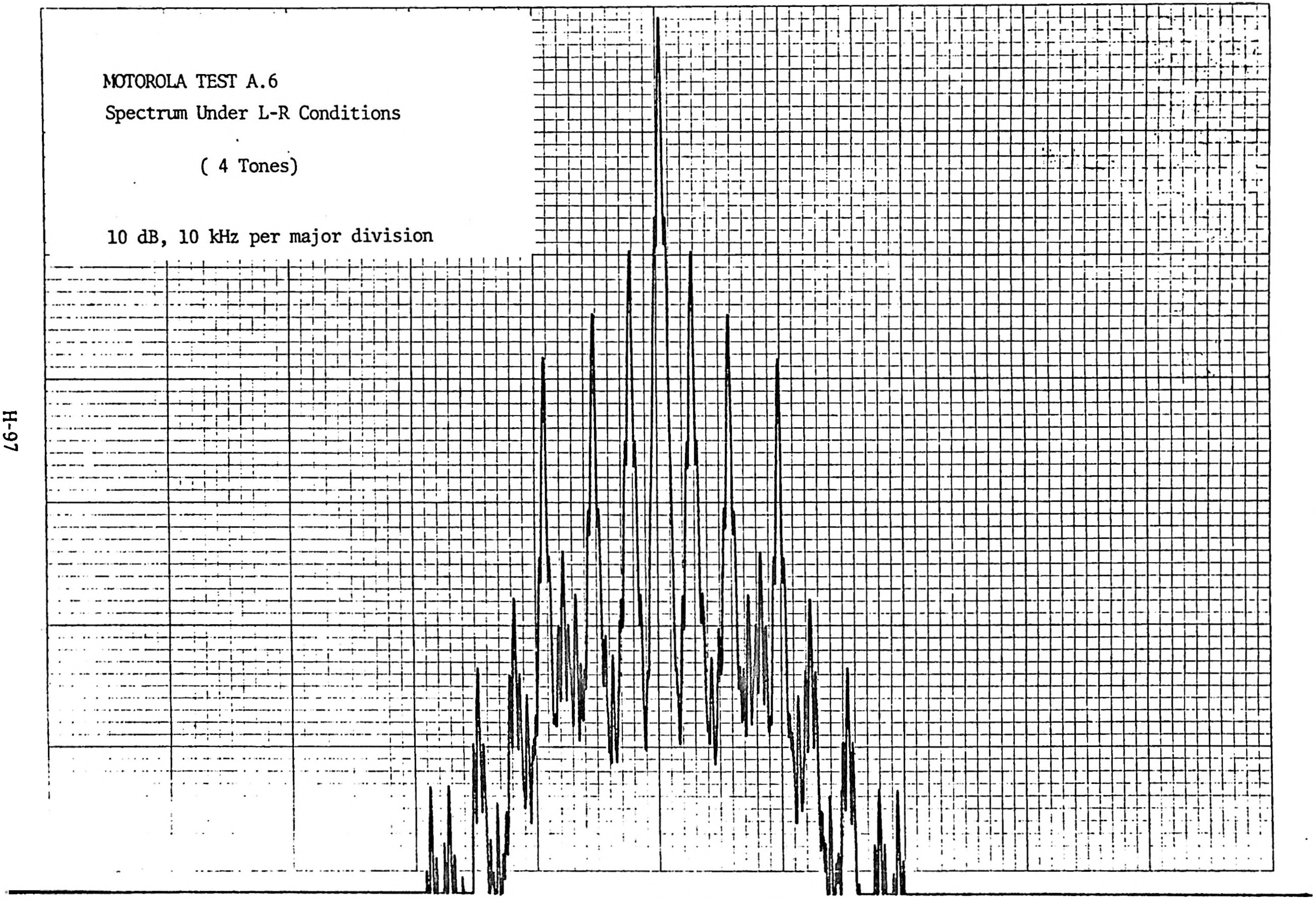


MAGNAVOX TEST A.6

Spectrum Under L-R CONDITIONS

(4 Tones)

10 dB, 10 kHz per major division

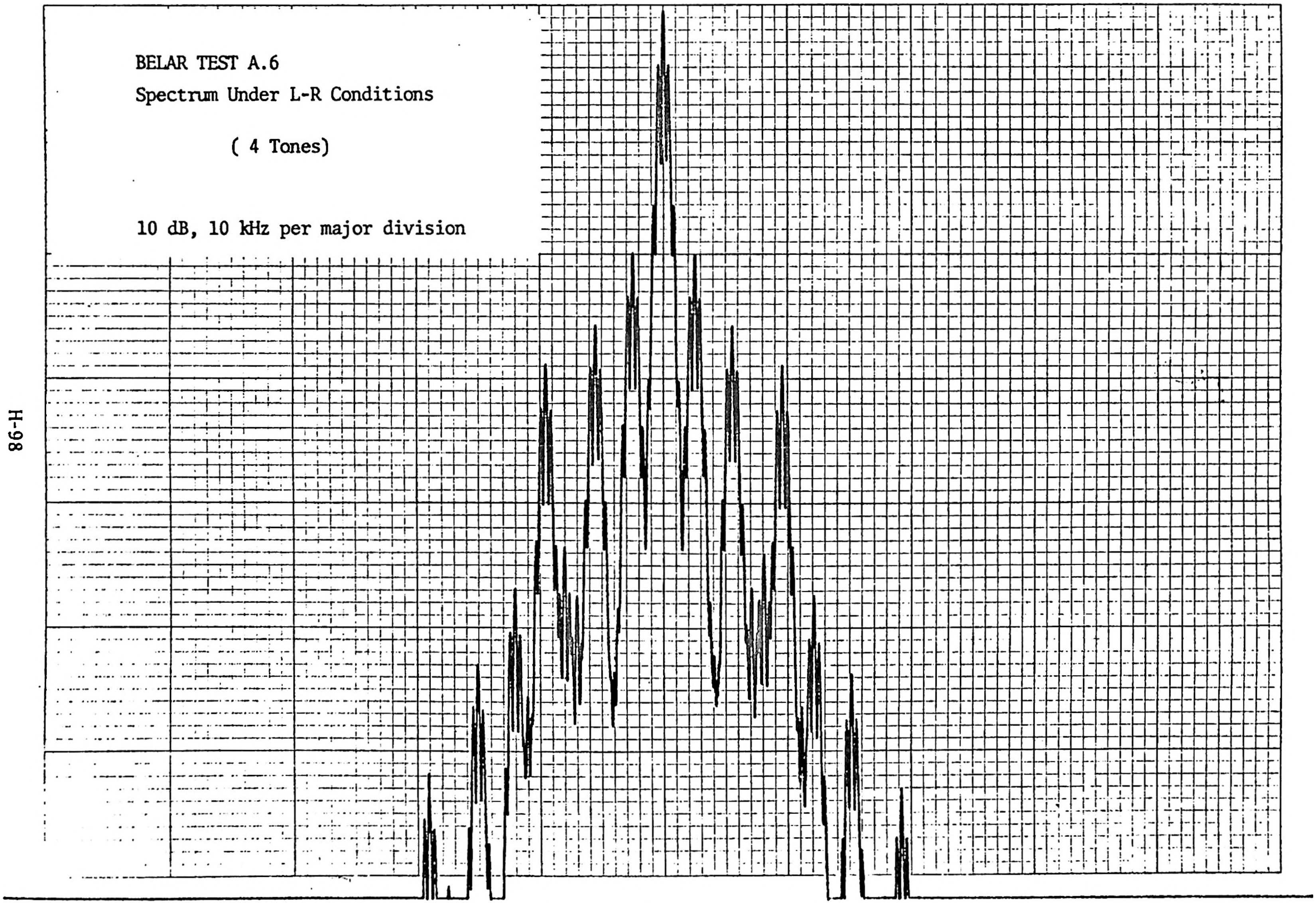


MOTOROLA TEST A.6

Spectrum Under L-R Conditions

(4 Tones)

10 dB, 10 kHz per major division

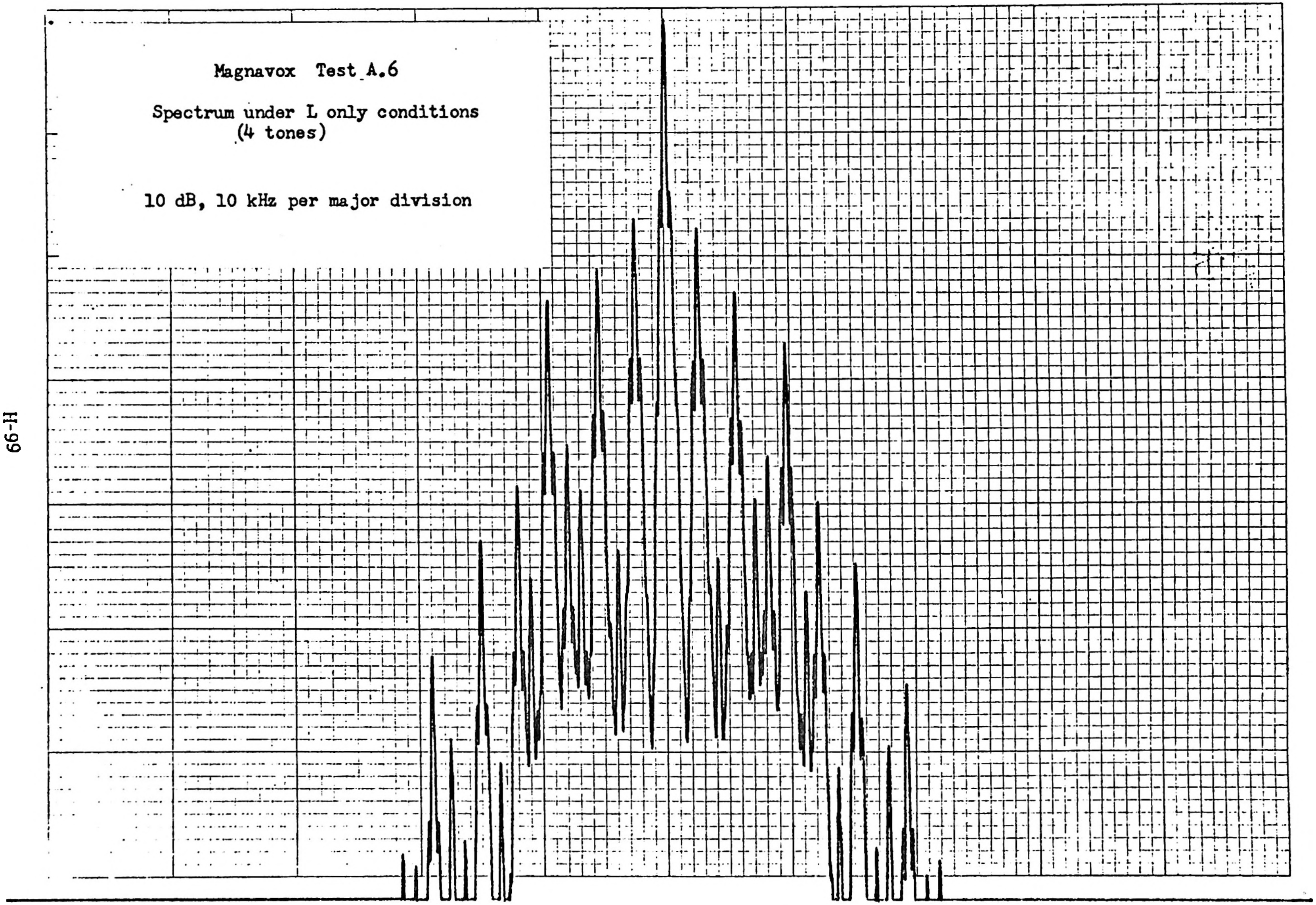


BELAR TEST A.6

Spectrum Under L-R Conditions

(4 Tones)

10 dB, 10 kHz per major division



Magnavox Test A.6

Spectrum under L only conditions
(4 tones)

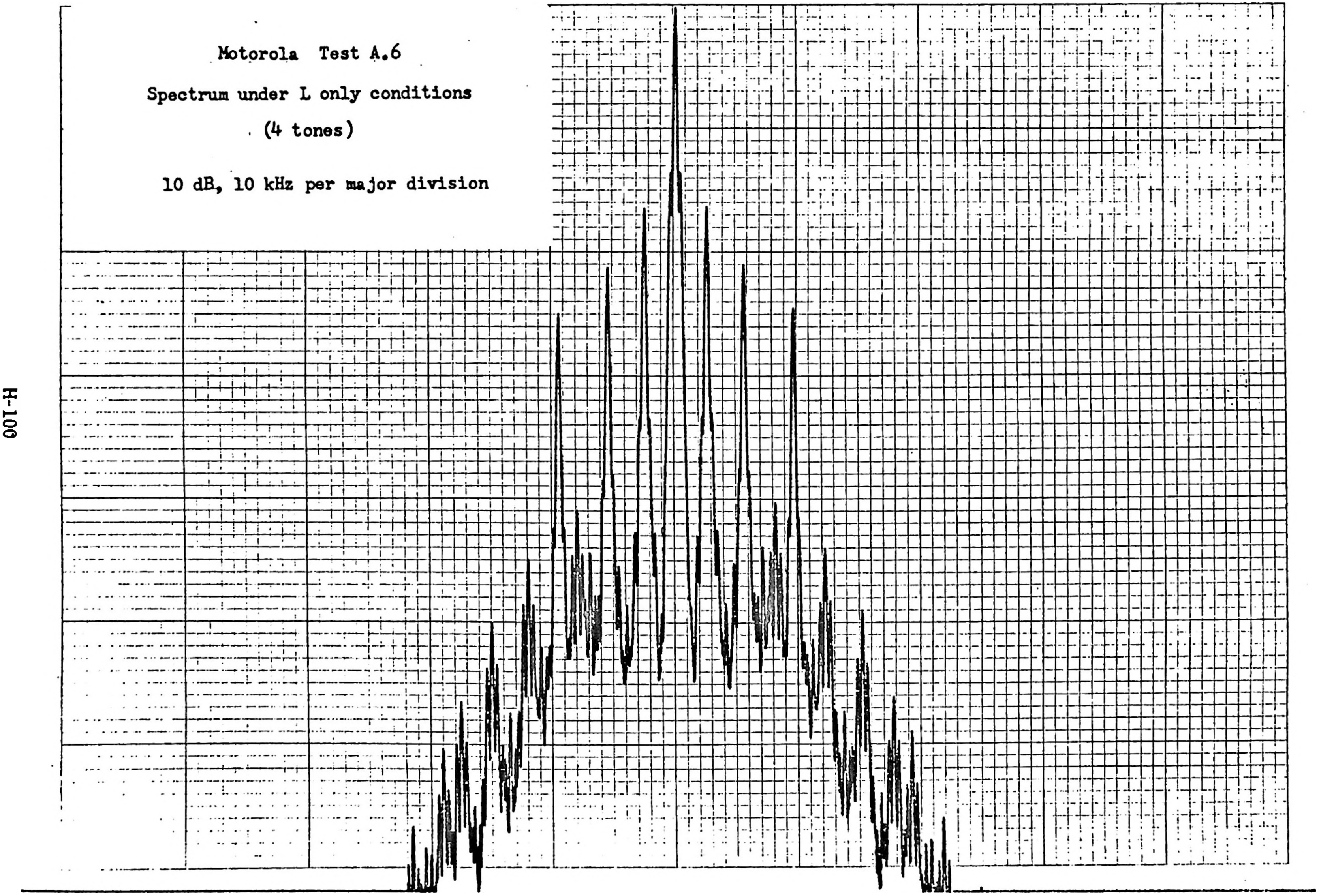
10 dB, 10 kHz per major division

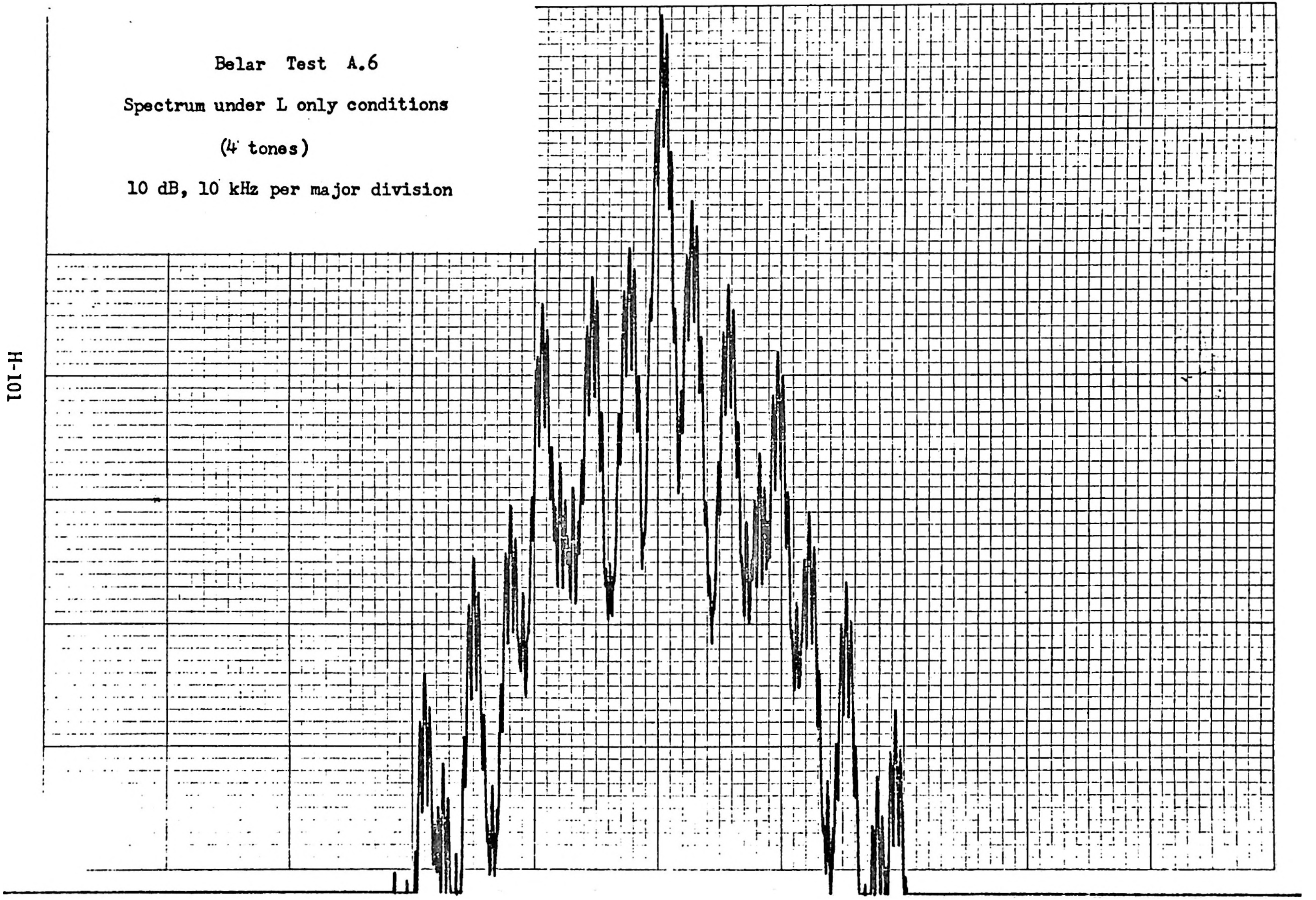
Motorola Test A.6

Spectrum under L only conditions

(4 tones)

10 dB, 10 kHz per major division



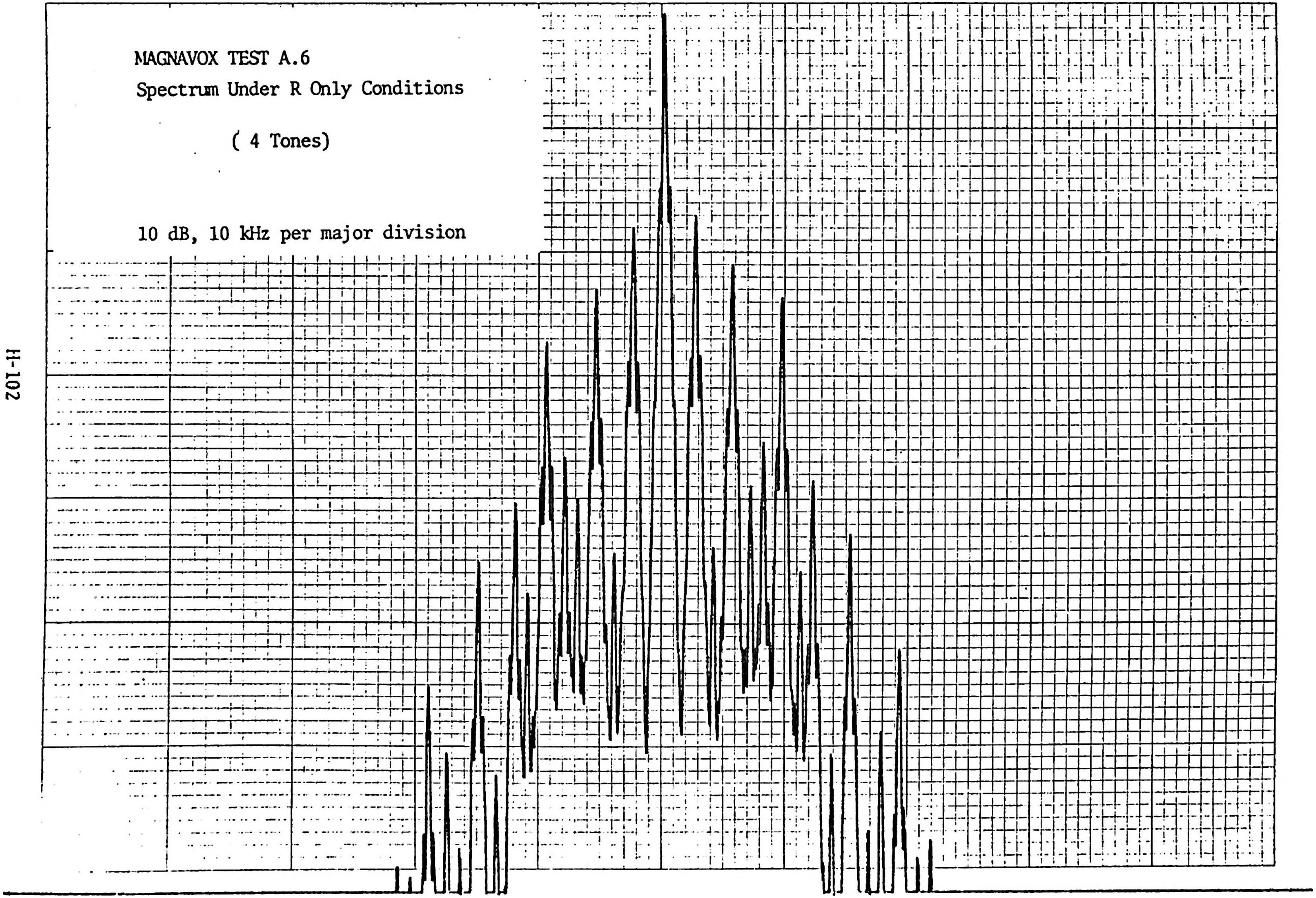


Belar Test A.6

Spectrum under L only conditions

(4 tones)

10 dB, 10 kHz per major division

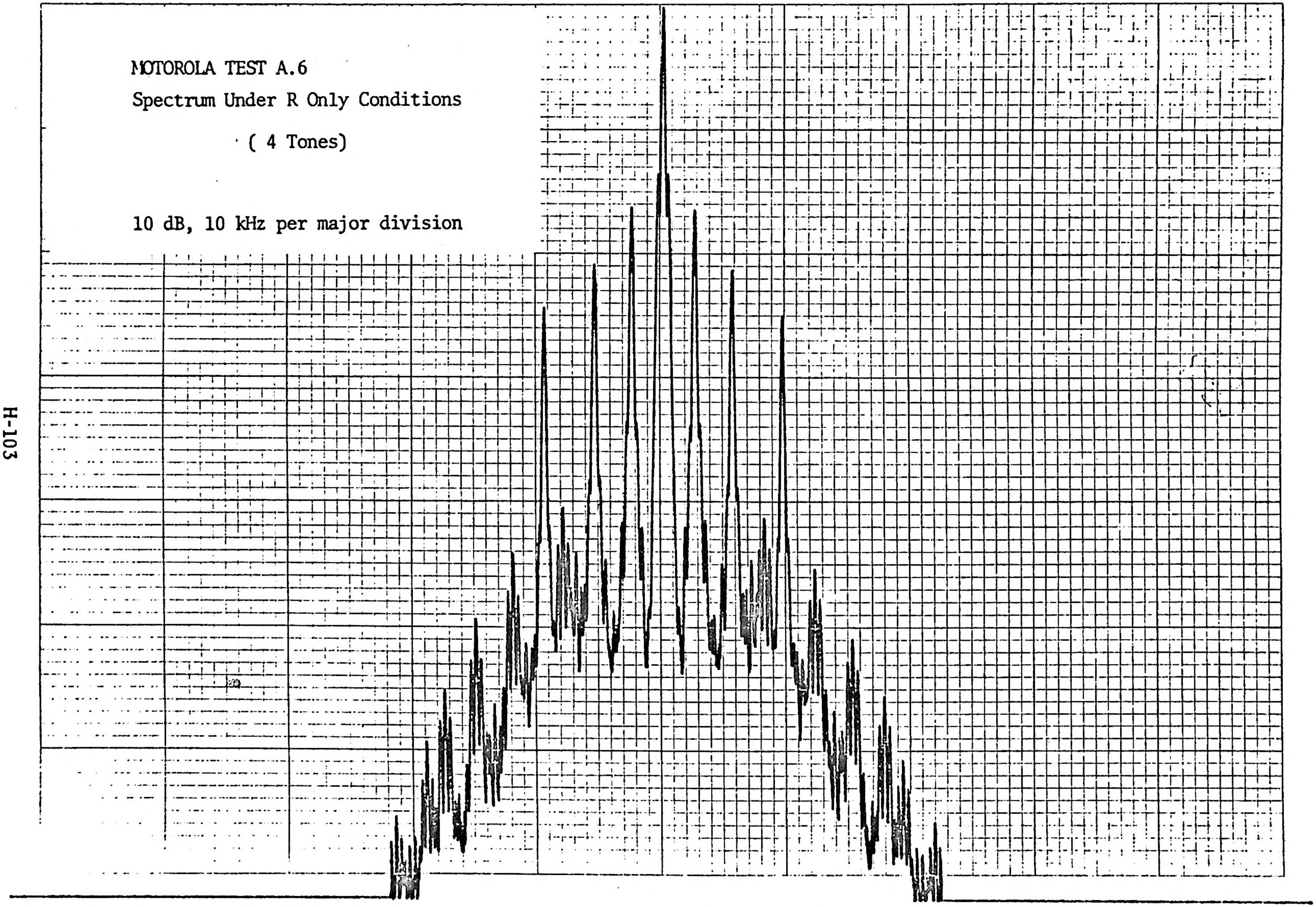


MAGNAVOX TEST A.6

Spectrum Under R Only Conditions

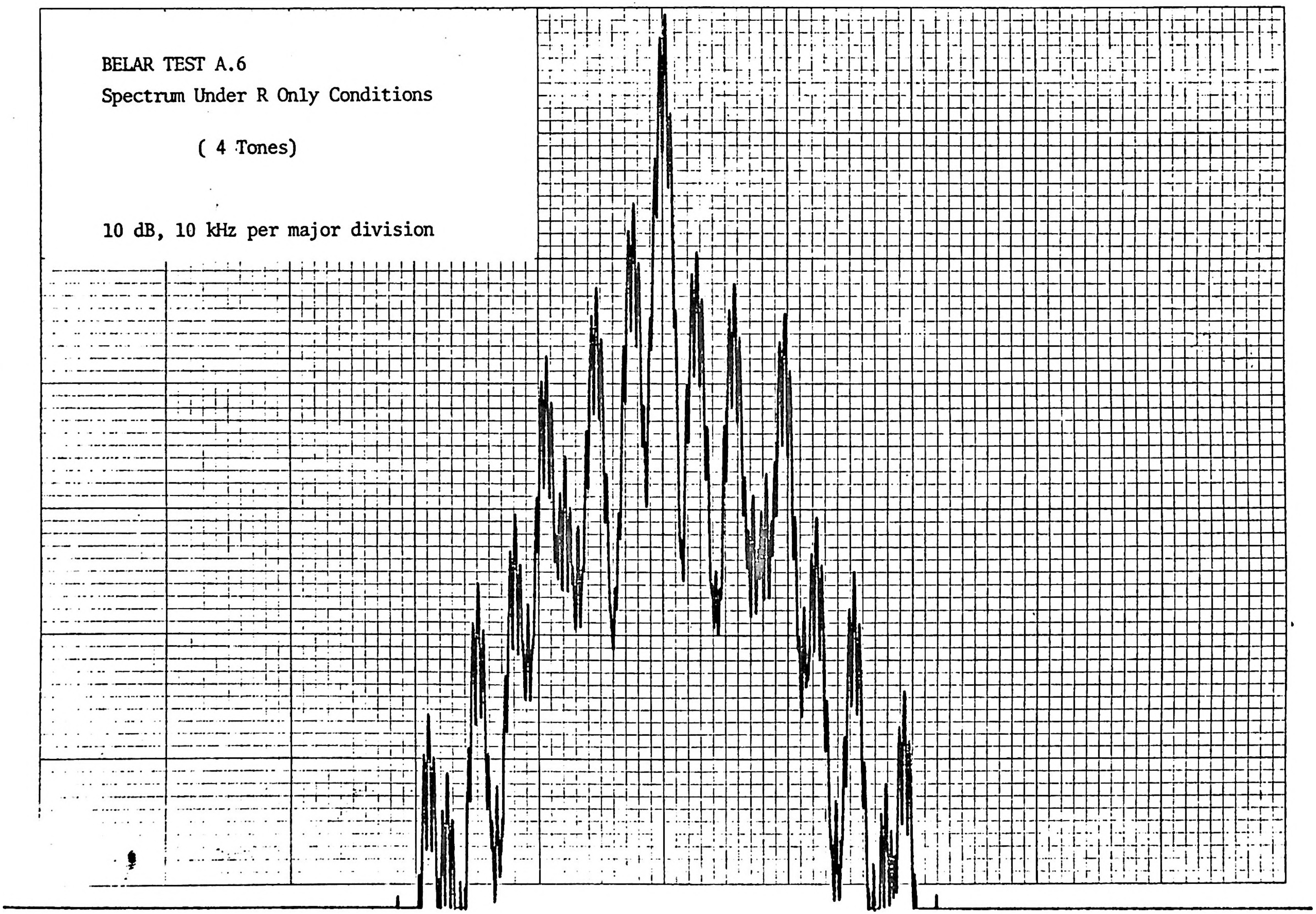
(4 Tones)

10 dB, 10 kHz per major division



MOTOROLA TEST A.6
Spectrum Under R Only Conditions
(4 Tones)

10 dB, 10 kHz per major division



BELAR TEST A.6
Spectrum Under R Only Conditions

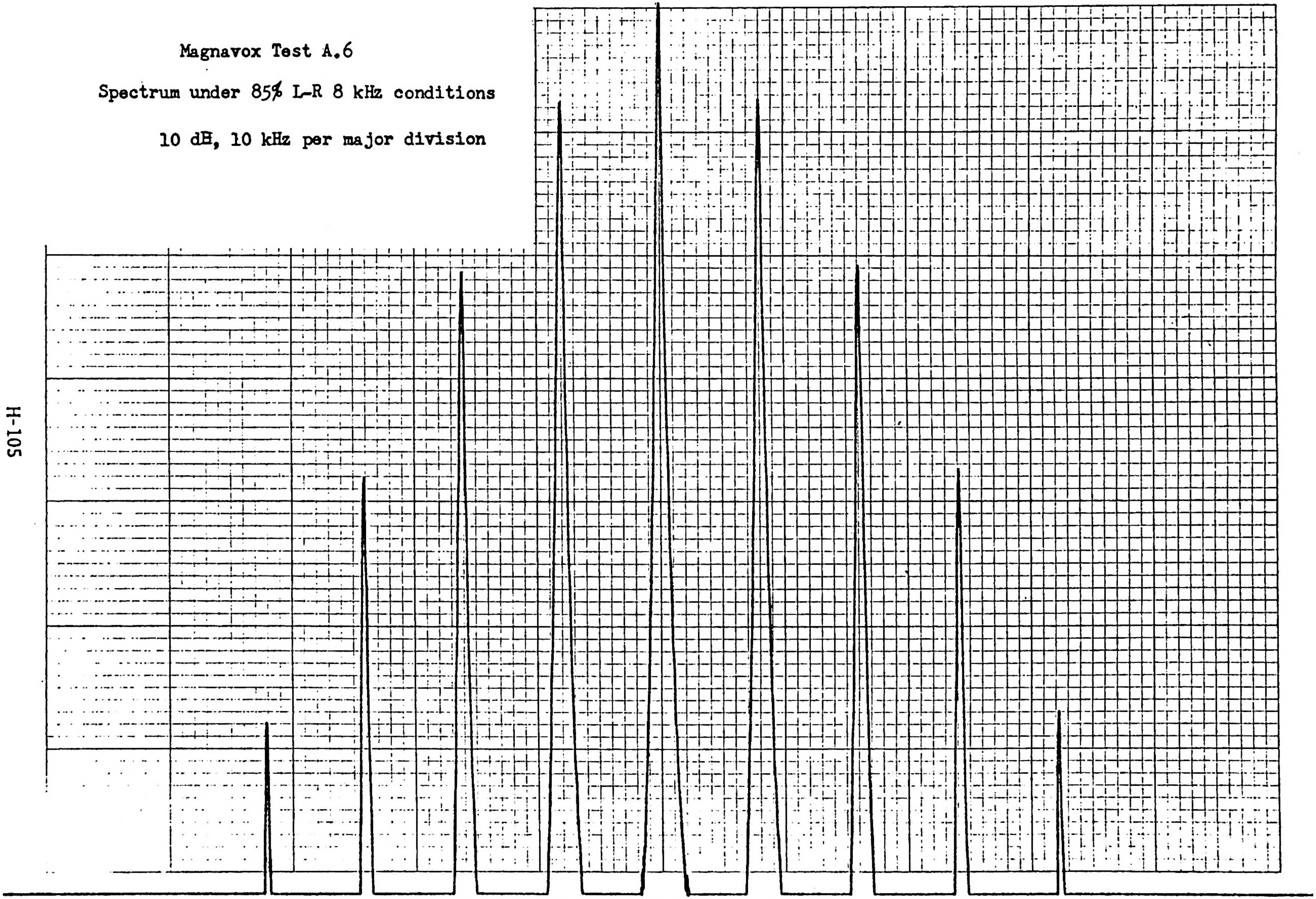
(4 Tones)

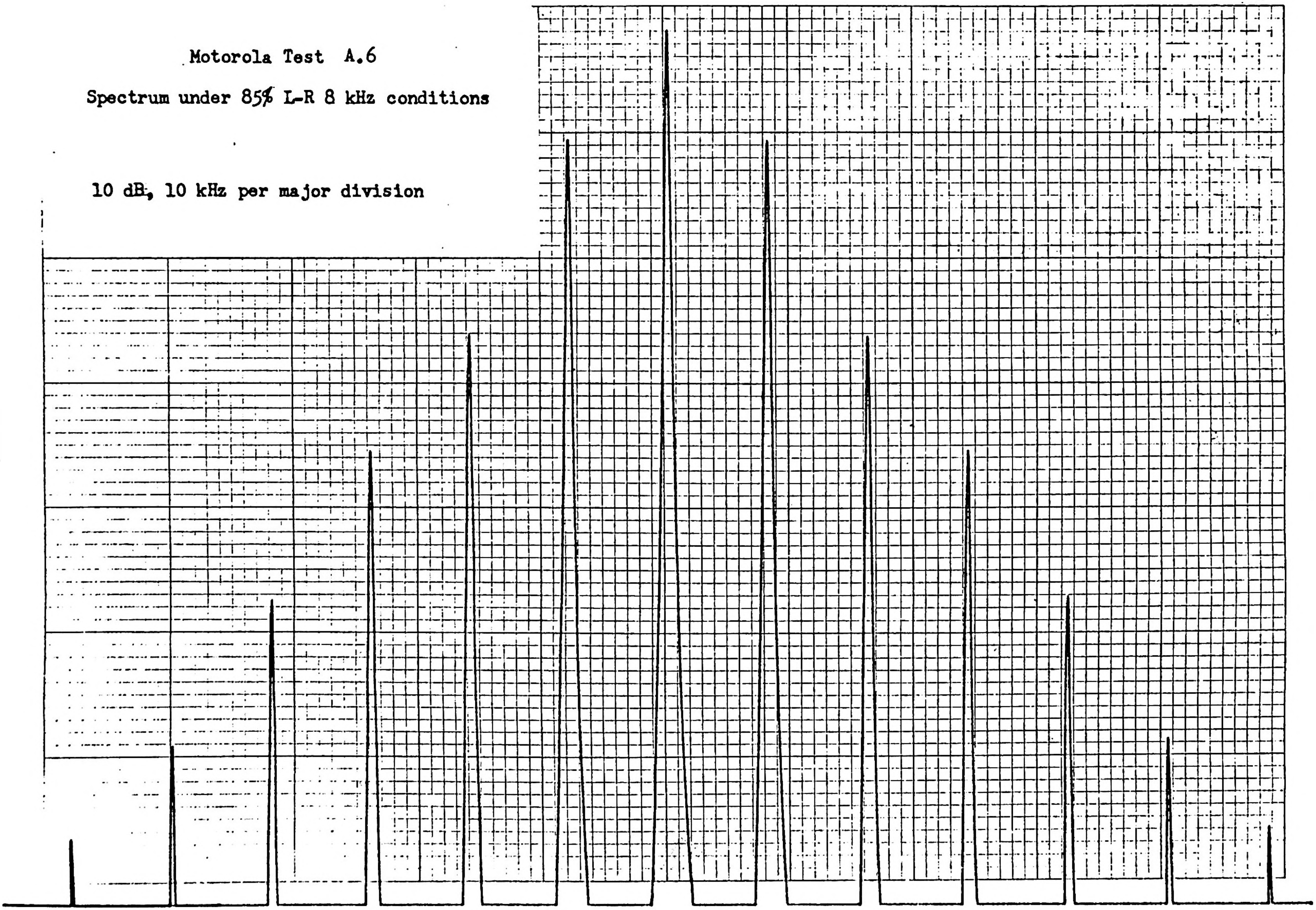
10 dB, 10 kHz per major division

Magnavox Test A.6

Spectrum under 85% L-R 8 kHz conditions

10 dB, 10 kHz per major division

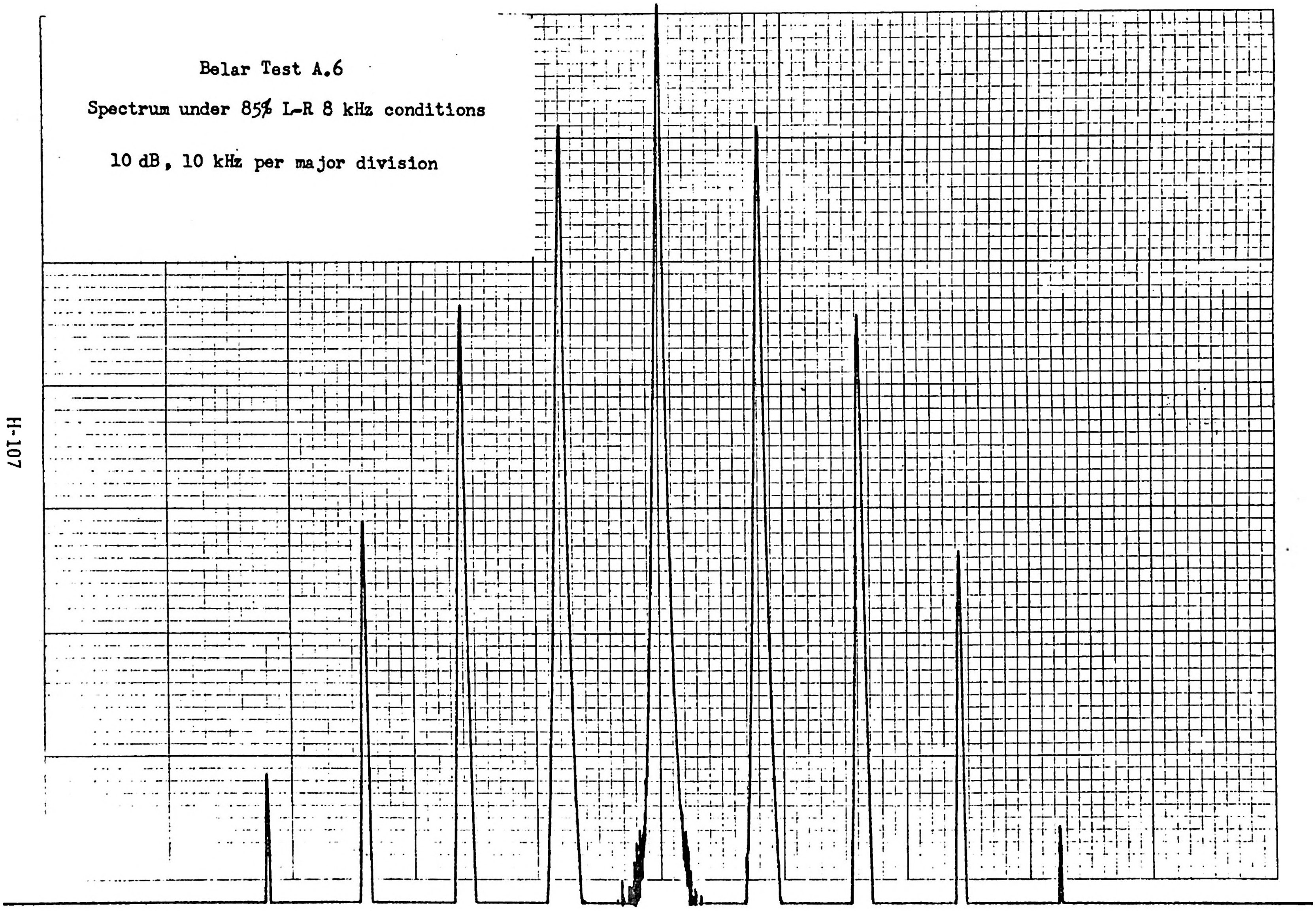




Motorola Test A.6

Spectrum under 85% L-R 8 kHz conditions

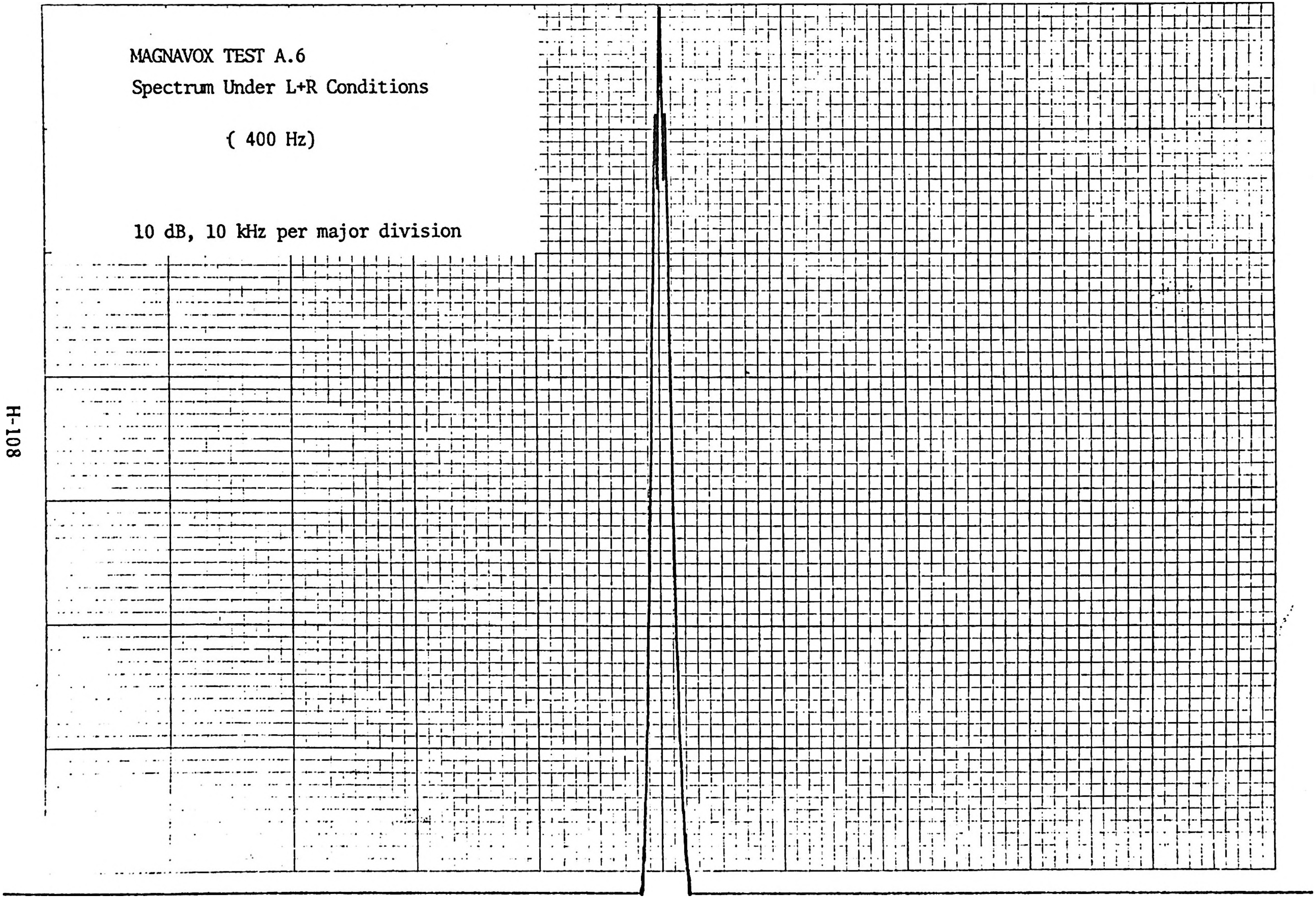
10 dB, 10 kHz per major division



Belar Test A.6

Spectrum under 85% L-R 8 kHz conditions

10 dB, 10 kHz per major division



MAGNAVOX TEST A.6

Spectrum Under L+R Conditions

(400 Hz)

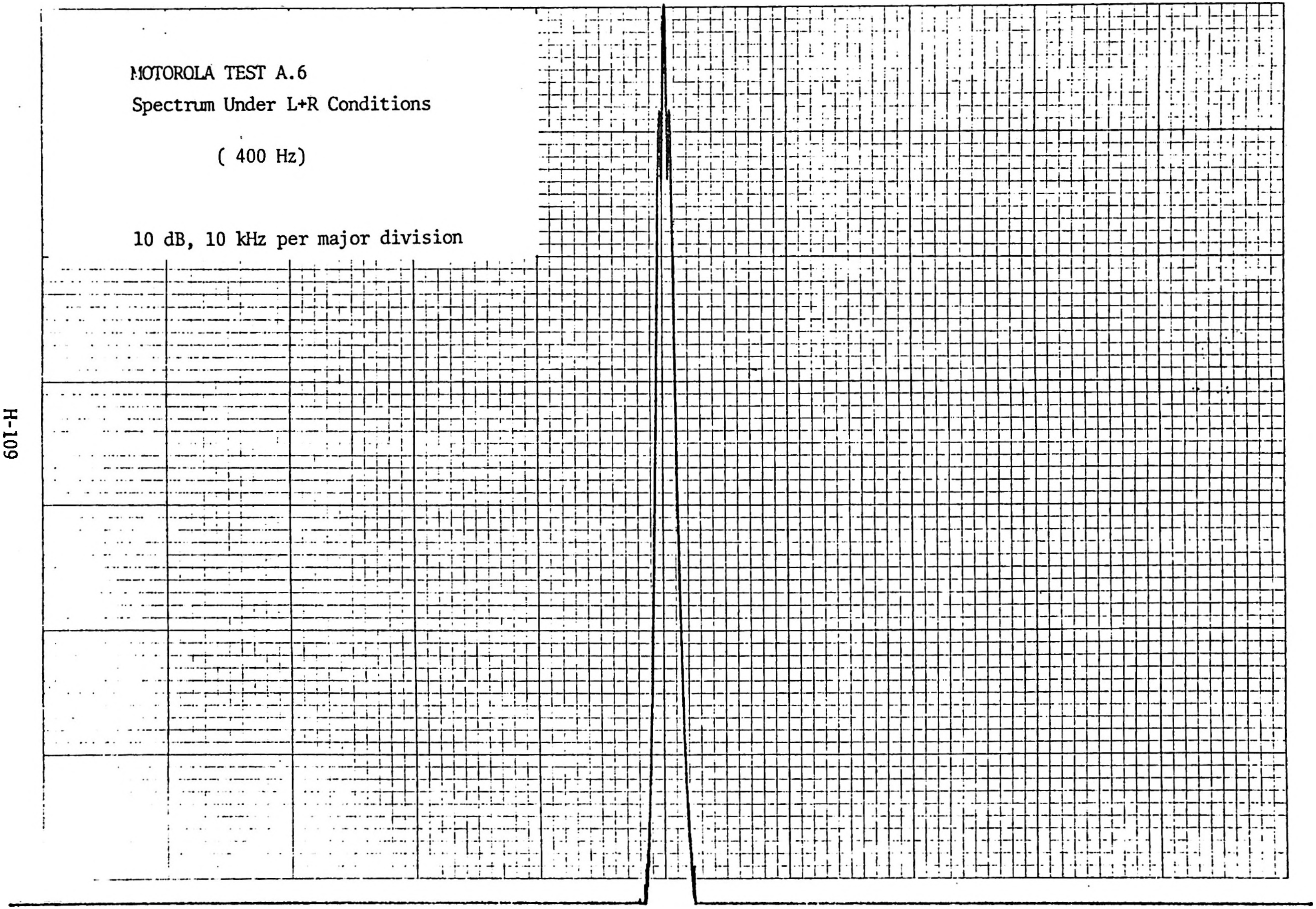
10 dB, 10 kHz per major division

MOTOROLA TEST A.6

Spectrum Under L+R Conditions

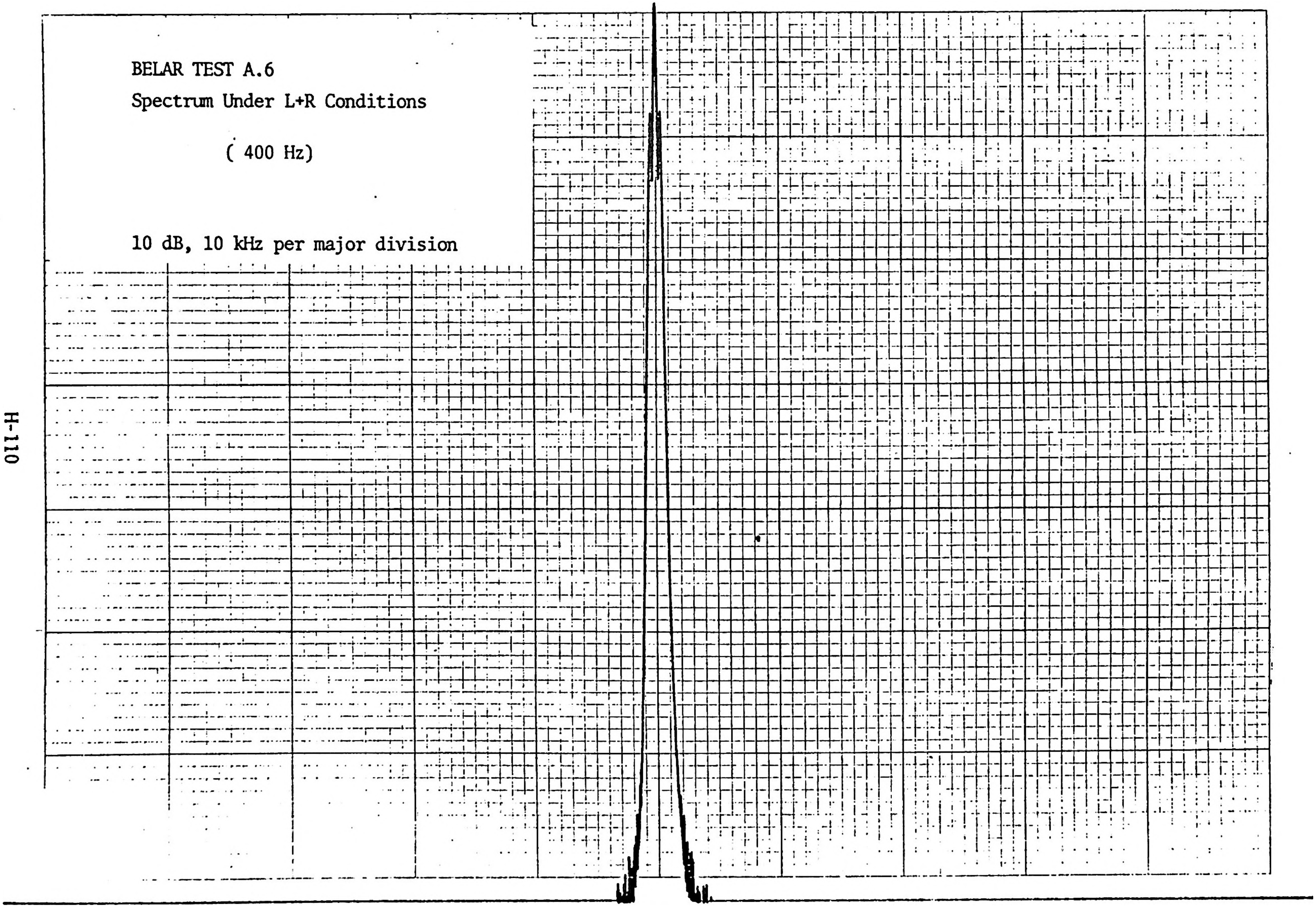
(400 Hz)

10 dB, 10 kHz per major division

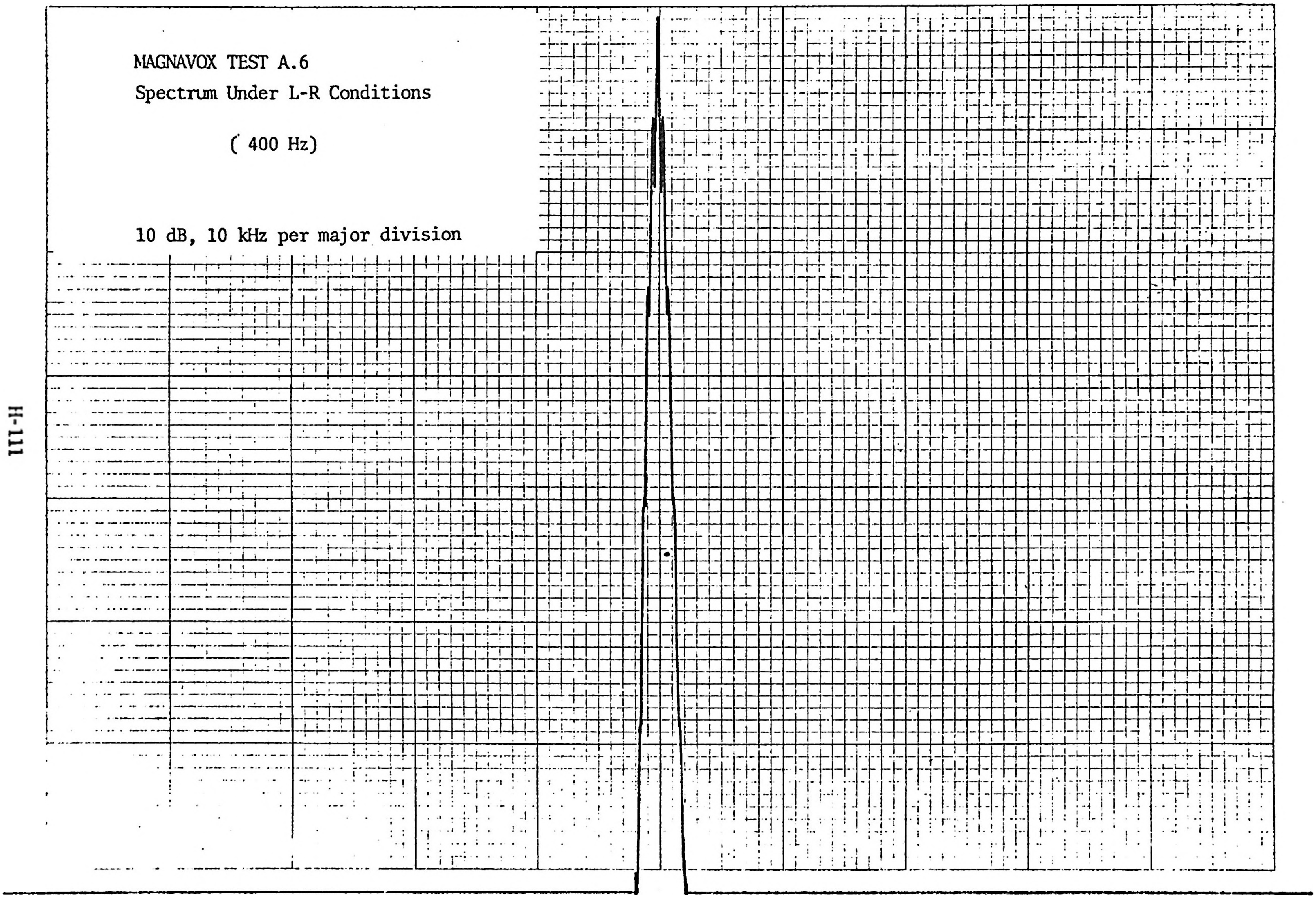


BELAR TEST A.6
Spectrum Under L+R Conditions

(400 Hz)



10 dB, 10 kHz per major division

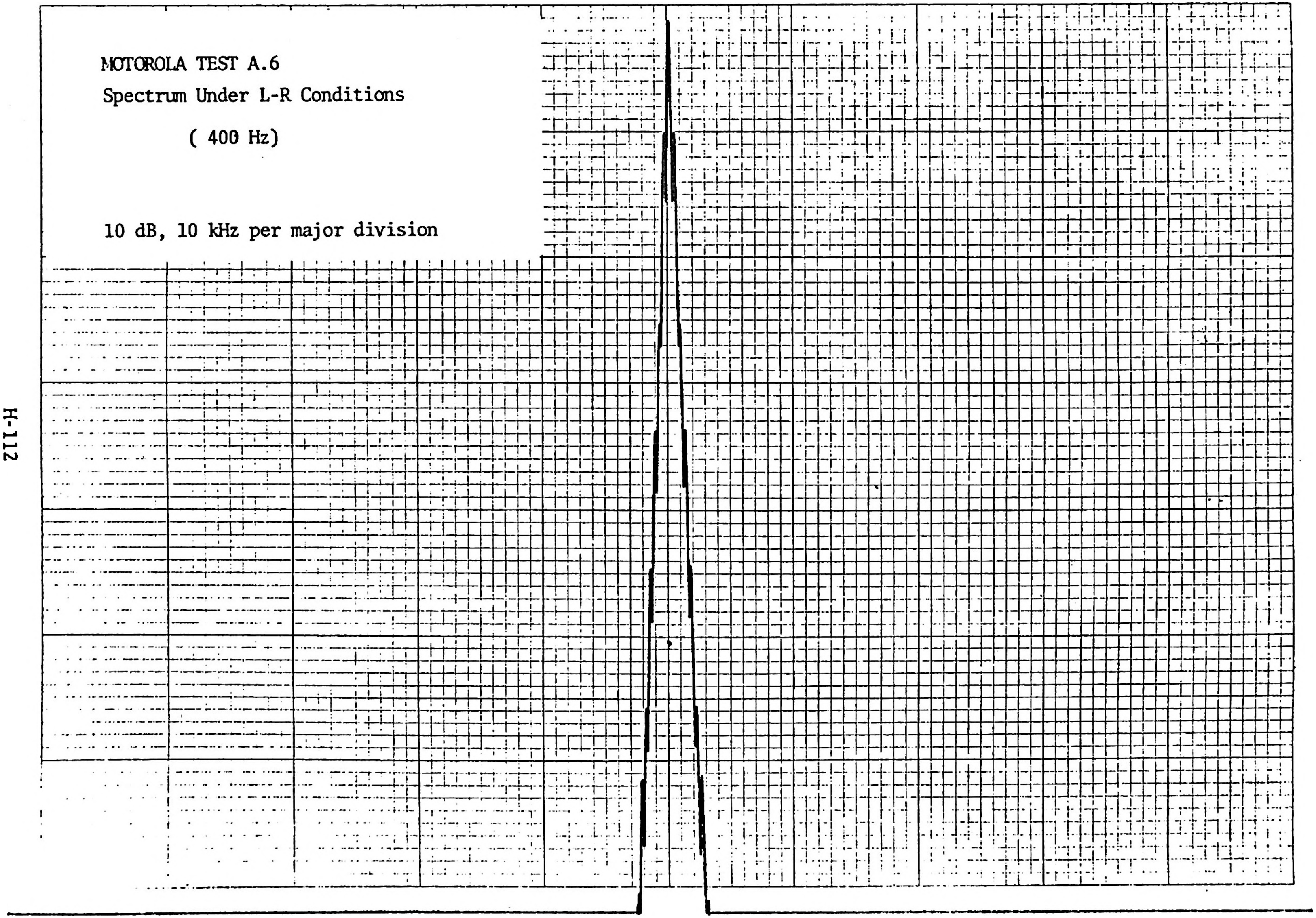


MAGNAVOX TEST A.6

Spectrum Under L-R Conditions

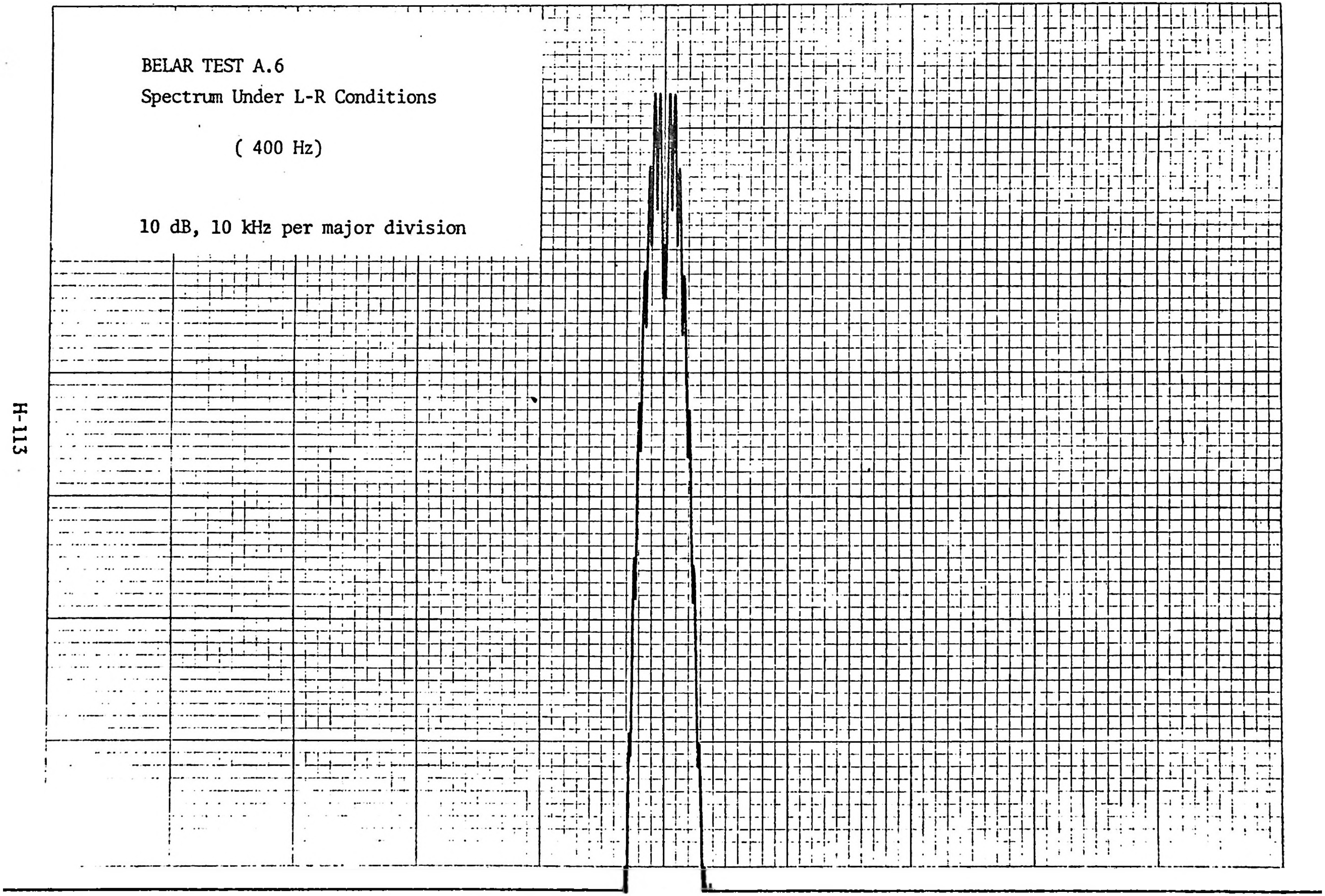
(400 Hz)

10 dB, 10 kHz per major division



MOTOROLA TEST A.6
Spectrum Under L-R Conditions
(400 Hz)

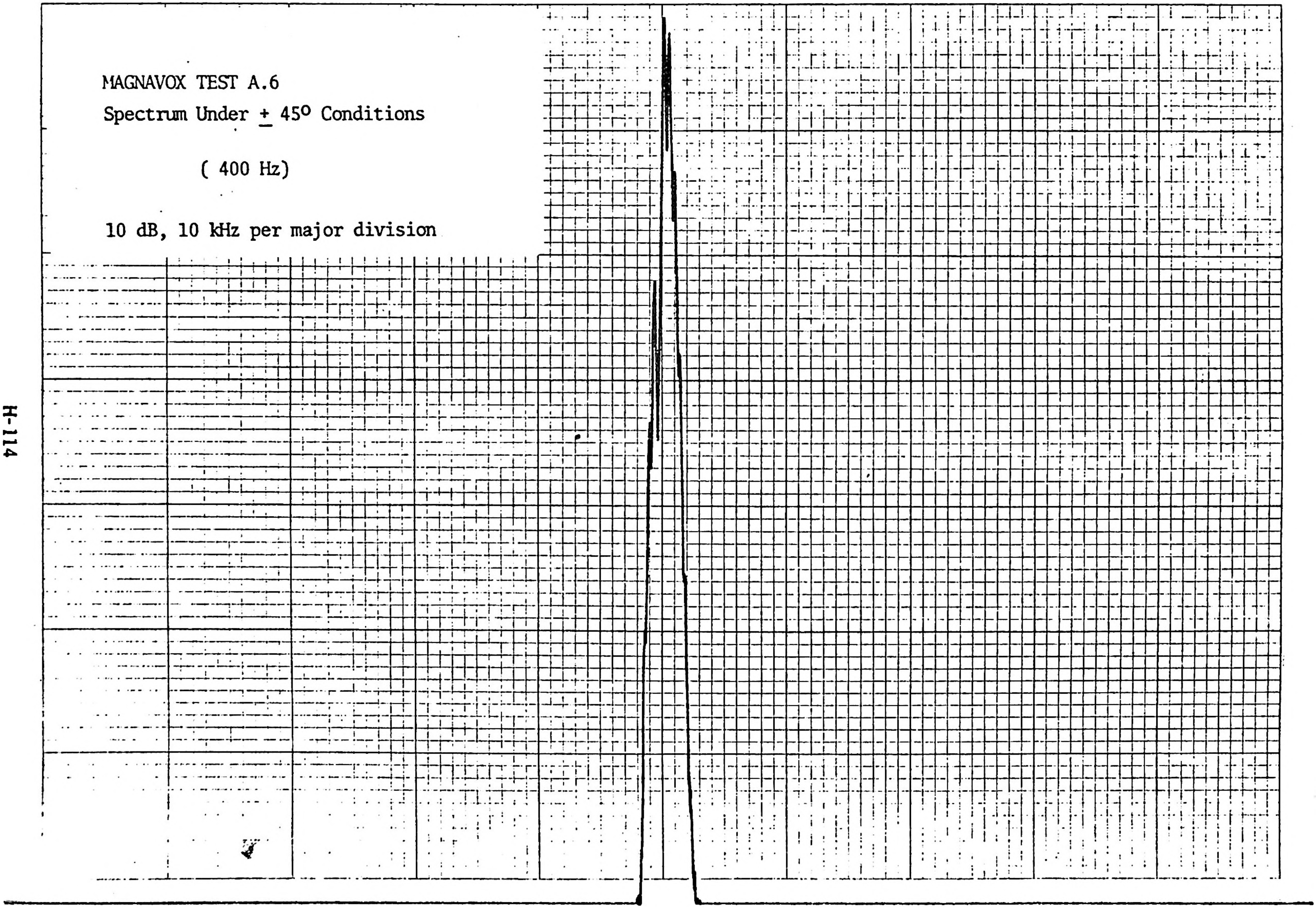
10 dB, 10 kHz per major division



BELAR TEST A.6
Spectrum Under L-R Conditions

(400 Hz)

10 dB, 10 kHz per major division

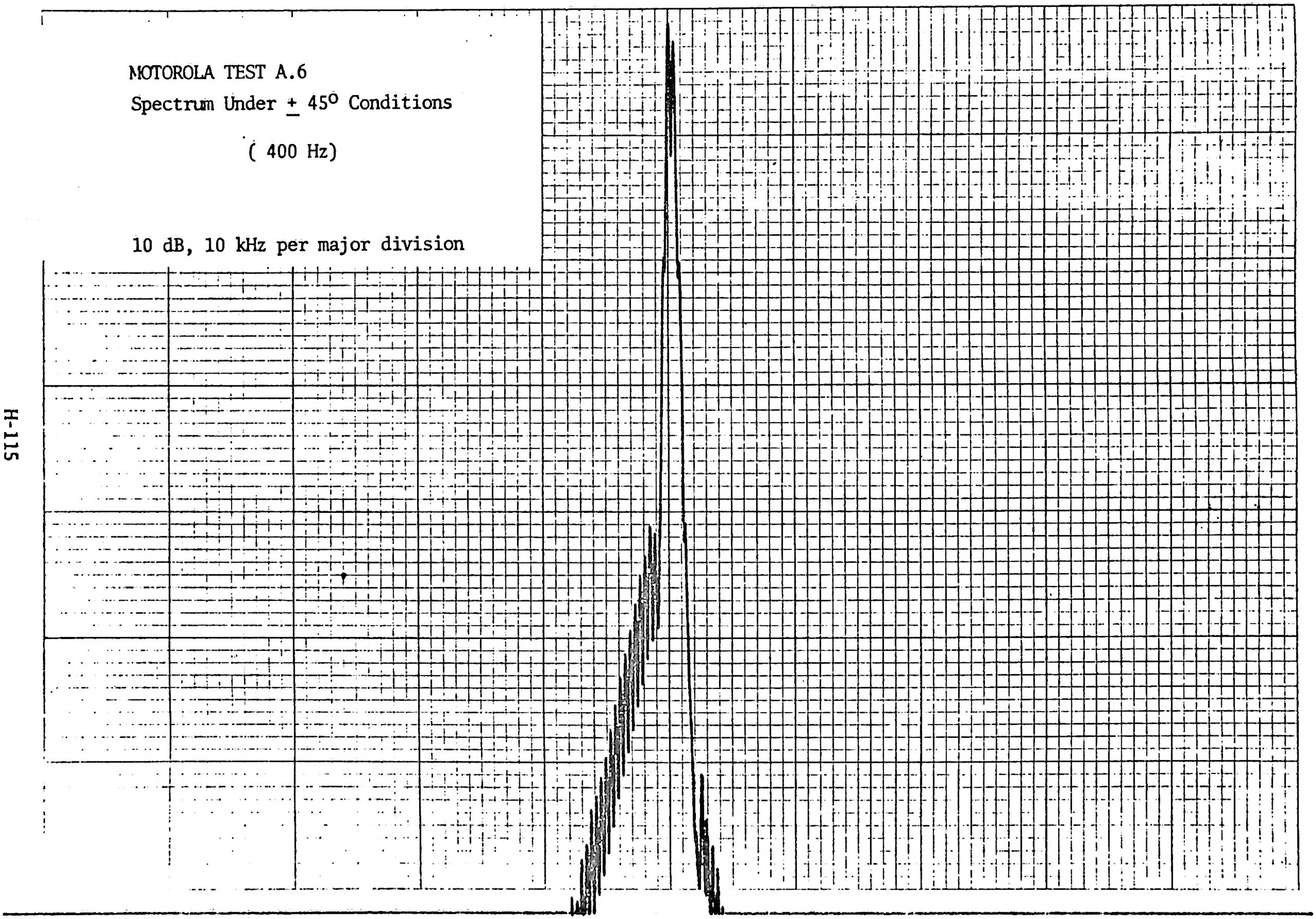


MAGNAVOX TEST A.6

Spectrum Under ± 45° Conditions

(400 Hz)

10 dB, 10 kHz per major division

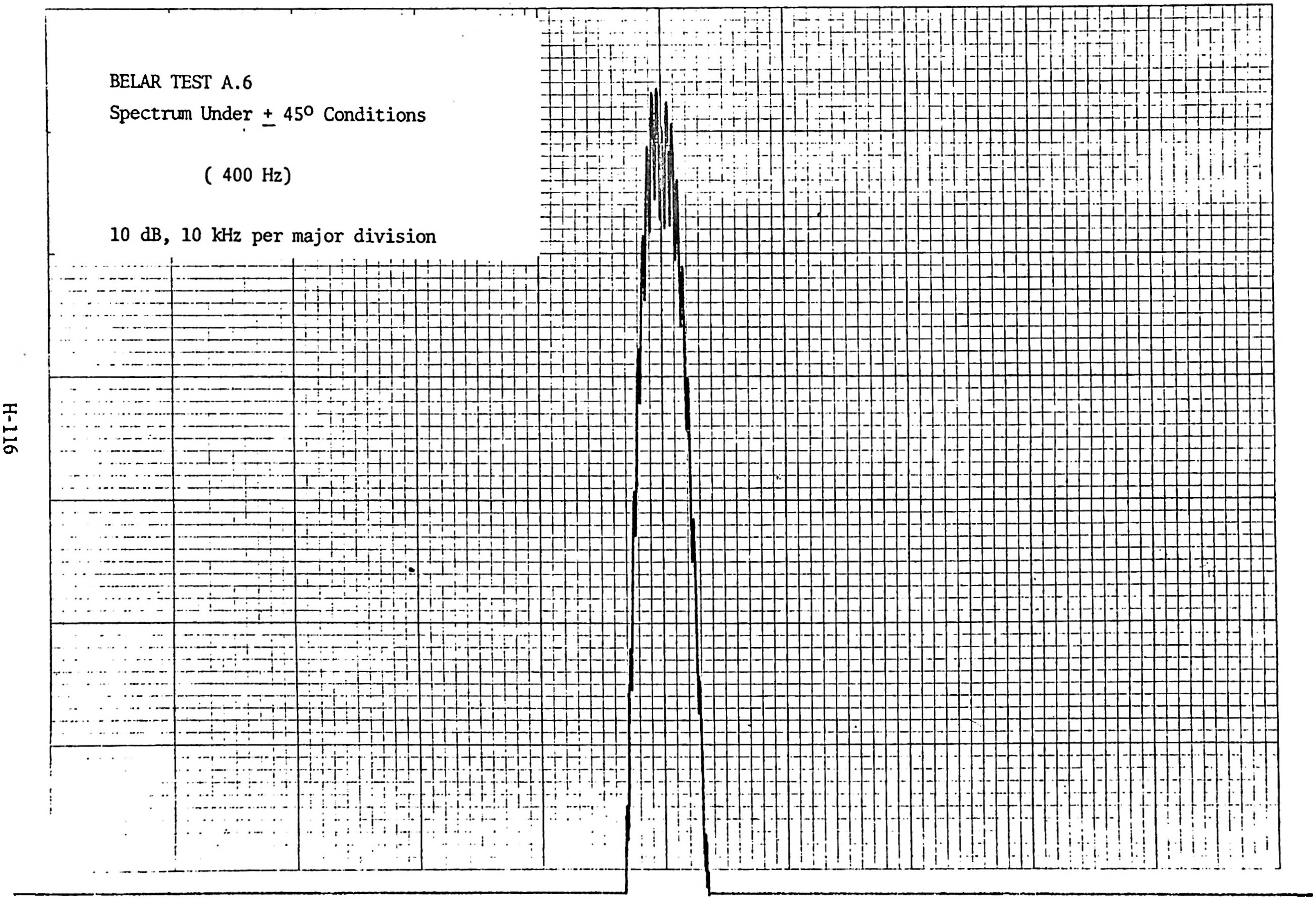


MOTOROLA TEST A.6

Spectrum Under ± 45° Conditions

(400 Hz)

10 dB, 10 kHz per major division



BELAR TEST A.6

Spectrum Under ± 45° Conditions

(400 Hz)

10 dB, 10 kHz per major division

Test A.7

PROTECTION RATIO

Objective: To determine the direct interference effect of stereophonic transmissions on the reception capability of a typical "middle grade" AM radio receiver. The test compares the effects of AM Stereo, and standard AM co-channel, first, second and third adjacent channel interference.

Procedure: Standard AM or AM stereo signals are generated on 570 kHz and a second RF carrier is introduced on co-, first, second and third adjacent channels. The "middle grade" compatibility receiver is tuned to the quiet carrier frequency and the noise is measured at the receiver audio output. The modulating signal is the same 4 tone combination employed in the occupied bandwidth tests. For each RF frequency tested, the following transmitting modes are used:

a. 4 tones combined for 85% L+R (standard AM)

b. 4 tones combined for 85% L-R (as above with one phase reversed)

c. 4 tones combined into the left channel only, 42.5% AM

d. 4 tones combined into right channel only, 42.5% AM

e. 400 and 9500 Hz combined into right channel, and 2500 and 5500 Hz combined into left channel for a total of 85% AM

Co-channel

A quiet stable carrier is set up on 570.010 kHz at 25 mV/m (or equivalent receiver RF input level) using a phase locked Hewlett-Packard 8640 signal generator. The proponent's stereo generating equipment is set to 570.000 kHz at 1.25 mV/m. The receiver is tuned to 570 kHz and a reference audio output level is derived by amplitude modulating the 8640 with the 4 tone combination at 85% peak modulation. The proponent's equipment is then modulated with the various combinations as previously described, and the audio output of the receiver measured with the 8640 unmodulated.

First Adjacent

The signal generator is set for 0.5 mV/m at 560.000 or 580.000 kHz. The proponent's equipment is set to 0.5 mV/m on 570.000 kHz. The same process of modulating the 8640 with the 4 tones to obtain an audio reference output from the receiver which is also tuned to one adjacent channel and then the other. Again the proponent's equipment is modulated through the various combinations and the noise at the audio output of the receiver is measured.

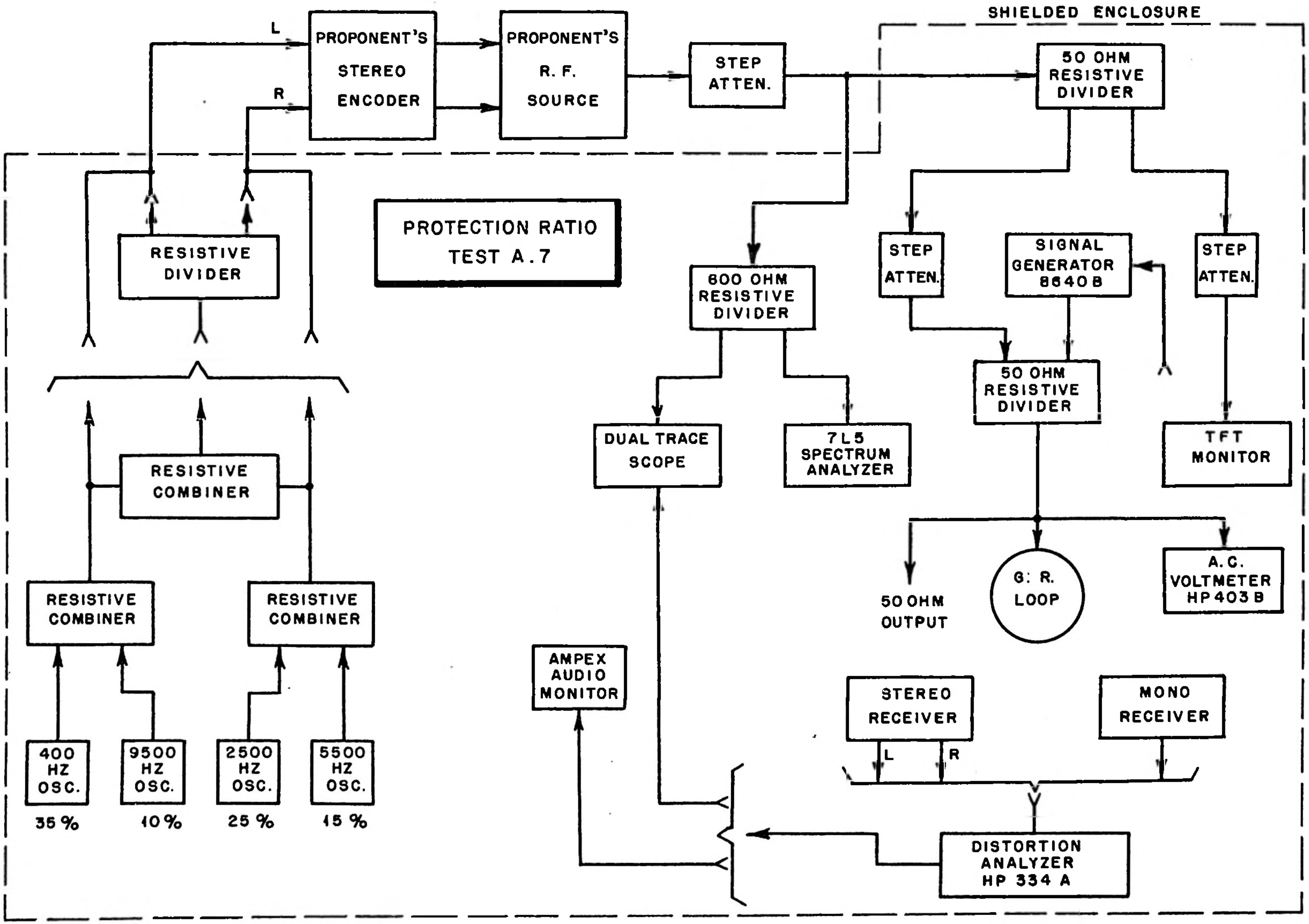
Second Adjacent

The same process is above except the receiver and the signal generator are tuned to 550.000 kHz, and 590.000 kHz. The signal generator is set to 2 mV/m and the proponent's equipment set to 25 mV/m.

Third Adjacent

The receiver and the signal generator are set to 540.000 and 600 kHz. The signal generator and the proponent's equipment are both set to 25 mV/m.

Some of the results of the test are discussed in Section I of this report.


SHIELDED ENCLOSURE
L
R
PROPONENT'S STEREO ENCODER
PROPONENT'S R. F. SOURCE
STEP ATTEN.
50 OHM RESISTIVE DIVIDER
PROTECTION RATIO TEST A.7
RESISTIVE DIVIDER
600 OHM RESISTIVE DIVIDER
STEP ATTEN.
SIGNAL GENERATOR 8640 B
STEP ATTEN.
50 OHM RESISTIVE DIVIDER
DUAL TRACE SCOPE
7 L 5 SPECTRUM ANALYZER
TFT MONITOR
RESISTIVE COMBINER
50 OHM OUTPUT
G. R. LOOP
A.C. VOLTMETER HP 403 B
RESISTIVE COMBINER
RESISTIVE COMBINER
AMPEX AUDIO MONITOR
STEREO RECEIVER
MONO RECEIVER
L
R
400 HZ OSC.
9500 HZ OSC.
2500 HZ OSC.
5500 HZ OSC.
35 %
10 %
25 %
15 %
DISTORTION ANALYZER HP 334 A

Proponent Magnavox

Test A.7

Date 7/21/77

Protection Ratio

"Normal" BW

Muting On

Noise level in Proponent's Stereo Receiver
compared to 85% AM on channel

25

25

.5

	mv/m	25	2	.5	25, 1.25	.5	2	25
Modulating Sig.	Freq,	540	550	560	570	580	590	600
4 tone signal AM modulated on channel, output set to .78 volts = 0 db reference		.21V 0 db	Dmo aHe .215V [illegible] 0 db	.215V 0 db	.215V 0 db	.241V 0 db	.255V 0 db	.24V 0 db
4 tones all combined into L+R, 85% AM		-39.7	-34.9	-16.0	-24.9	-18.5	-35.4	-39.0
4 tones all combined into L =-R (reverse phase of one channel as above)		-40.5	-25.8	-16.3	-25.0	-18.5	-29.9	-40.0
4 tones all combined into L only, 42.5% AM		-40.5	-28.9	-17.8	-25.9	Dmo -22.6 aHe [illegible]	-33.7	-40.0
4 tones all combined into R only, 42.5% AM		-40.5	-30.8	-20.3	-25.9	-20.1	-32.6	-39.5
400 Hz and 9500 Hz combined into right channel for 45% AM, and 2500 Hz and 5500 Hz combined into left channel for 40% AM, 85% total AM		-39.5	-21.3	-13.7	-23.2	-13.6	-21.9	-39.0

aHe
Dmo

Noise Floor -40.5

Proponent Magnavox

Date 7/21/77

"Fidelity" BW

Test A.7

Protection Ratio

Muting On

Noise level in ~~[illegible]~~ proponent's stereo ~~receiver~~
compared to 85% AM on channel

Modulating Sig.	Freq,	540	550	560 no filter	560 filter	570	580 no filter	580 filter	590	600
	mv/m	25	2	.5		25, 1.25	.5		2	25
		25 (with 600)	25 (with 590)	.5 (with 580)			.5 (with 560)		25 (with 550)	25 (with 540)
4 tone signal AM modulated on channel, output set to .78 volts = 0 db reference		.235V 0 db	.235V 0 db	.183V 0	db	.24V 0 db	.194V 0 db		.248V 0 db	.252V 0 db
4 tones all combined into L+R, 85% AM		-40.0	-7.2	+1.0	Dmo aHC -9.7 ~~[illegible]~~	-25.6	-7.8	-12.1	-18.6	-38.4
4 tones all combined into L =-R (reverse phase of one channel as above)		-41.0	-7.4	+0.9	Dmo aHC -10.1 ~~[illegible]~~	-25.5	-8.2	-12.2	-17.4	-40.5
4 tones all combined into L only, 42.5% AM		-41.0	-8.9	+0.9	-11.9	-26.6	-8.9	-15.5	-22.0	-40.0
4 tones all combined into R only, 42.5% AM		-41.0	-12.0	+0.8	-13.2	-26.6	-8.6	-13.9	-19.5	-40.0
400 Hz and 9500 Hz combined into right channel for 45% AM, and 2500 Hz and 5500 Hz combined into left channel for 40% AM, 85% total AM		-39.8	-5.2	+1.1	-7.0	-23.5	-6.5	-8.8	-12.6	-39.0

aHC
Dmo

Noise Floor, -41.0 dB

Magnavox

Date 7/20/77

Protection Ratio

Page 3

Noise Level in compatibility receiver compared to 85% AM on channel

	mv/m	25	2	.5	25, 1.25	.5	2	25
Modulating Sig.	Freq.	540	550	560	570	580	590	600
4 tone signal AM modulated on channel, output set to .78 volts = 0 db reference		0 db	0 db	0 db	0 db	0 db	0 db	0 db
4 tones all combined into L+R, 85% AM		-44.6	-37.4 ~~[illegible]~~	-16.9	-30.5	-17.0	-37.9	-45.9
4 tones all combined into L =-R (reverse phase of one channel as above)		-50.2	-33.0 ~~[illegible]~~	-17.6	-31.2	-17.4	-32.7	-50.0
4 tones all combined into L only, 42.5% AM		-48.6	-35.1 ~~[illegible]~~	-18.7	-33.8	-21.6	-36.3	-49.1
4 tones all combined into R only, 42.5% AM		-48.5	-36.2 ~~[illegible]~~	-21.5	-33.6	-18.7	-35.4	-49.0
400 Hz and 9500 Hz combined into right channel for 45% AM, and 2500 Hz and 5500 Hz combined into left channel for 40% AM, 85% total AM		-44.8	-26.7	-15.7	-27.8	-12.7	-23.9	-46.1

Radio Tuned with 400 Hz, 400 Hz deviation FM signal for minmum out put.

noise floor -49.7 dB

Proponent Motorola

Test A.7 Page 3

Date July 12, 1977

Pilot Tone On

Protection Ratio

Krohn-Hite
60 Hz, 10 kHz

Noise level in proponent's stereo receiver
compared to 85% AM on channel

	mv/m	40	3.2	0.8		40, 2.0	0.8		3.2	40
Modulating Sig.	Freq,	540	550	560		570	580		590	600
		.98 V	.74 V *	.66 no filter	filter	.97	.70 no filter	filter	.185 V *	.93 V
4 tone signal AM modulated on channel, output set to volts = 0 db reference		0 db	0 db	0 db		0 db	0 db		0 db	0 db
4 tones all combined into L+R, 85% AM		-42.8	+0.3	-0.8	-4.0	-26.2	-0.6	-4.4	+13.3	-42.5
4 tones all combined into L =-R (reverse phase of one channel as above)		-42.8	-1.6	-1.2	-6.2	-26.9	-1.1	-6.4	+8.1	-42.5
4 tones all combined into L only, 42.5% AM		-43.0	-3.5	-1.2	-8.0	-29.4	-1.0	-8.6	+8.5	-42.5
4 tones all combined into R only, 42.5% AM		-43.0	-2.7	-1.2	-7.3	-29.2	-1.0	-8.0	+9.2	-42.5
400 Hz and 9500 Hz combined into right channel for 45% AM, and 2500 Hz and 5500 Hz combined into left channel for 40% AM, 85% total AM		-42.5	+3.6	-0.6	-2.1	-22.8	-0.6	-2.6	+13.8	-42.5

JHH

Noise Floor: -43.2

* The discrepancies noted in both alternate channel measurements are believed due to a gross receiver overload in the 590 measurements and the beginnings of receiver overload in the 550 measurements.

aHe

RDS

Proponent Motorola   Test A.7

Date 7/21/77   Protection Ratio

Pilot Tone On   Krohn-Hite 60 Hz, 10 kHz

Muting On

proponent's stereo
Noise level in [redacted] receiver
compared to 85% AM on channel

40
40
.8

Modulating Sig.		540	550	560		570	580		590	600
	mv/m	40	3.2	.8		, 1.25 40, 200	.8		3.2	40
	Freq,	540	550	560		570	580		590	600
				no filter	filter		no filter	filter		
4 tone signal AM modulated on channel, output set to .78 volts = 0 db reference		1.55 V 0 db	1.04V 0 db	.86 V 0 db		1.2V 0 db	0 db	.83 V	1.00V 0 db	1.52V 0 db
4 tones all combined into L+R, 85% AM		-44.8	-9.4	-2.5	-12.2	-28.9	-0.6	-9.5	-0.9	-45.0
4 tones all combined into L =-R (reverse phase of one channel as above)		-44.8	-10.2	-2.8	-13.4	-29.4	-1.2	-12.6	-5.0	-45.0
4 tones all combined into L only, 42.5% AM		-44.8	-13.0	-2.8	-15.6	-31.8	-1.05	-13.6	-5.4	-45.0
4 tones all combined into R only, 42.5% AM		-44.8	-12.3	-2.8	-15.6	-31.6	-1.0	-14.0	-4.8	-45.0
400 Hz and 9500 Hz combined into right channel for 45% AM, and 2500 Hz and 5500 Hz combined into left channel for 40% AM, 85% total AM		-44.6	-6.0	-2.4	-9.4	-25.0	-0.5	-7.4	+0.3	-44.6

NOISE FLOOR -45.0

aHC
Dwo

Proponent *Motorola* Test A.7

Date *7/20/77* Protection Ratio

Page 1

Noise Level in compatibility receiver
compared to 85% AM on channel

	mv/m	25	2	.5	25, 1.25	.5	2	25
Modulating Sig.	Freq,	540	550	560	570	580	590	600
4 tone signal AM modulated on channel, output set to .78 volts = 0 db reference		0 db	0 db	0 db	0 db	0 db	0 db	0 db
4 tones all combined into L+R, 85% AM		-46.2	-36.9	-15.7	-30.4	-16.6	-37.2	-47.6
4 tones all combined into L =-R (reverse phase of one channel as above)		-50.0	-31.3	-17.1	-31.4	-18.5	-31.4	-49.9
4 tones all combined into L only, 42.5% AM		-49.2	-36.5	-19.7	-33.5	-19.1	-36.5	-49.7
4 tones all combined into R only, 42.5% AM		-49.1	-35.8	-18.9	-33.4	-19.3	-36.4	-49.6
400 Hz and 9500 Hz combined into right channel for 45% AM, and 2500 Hz and 5500 Hz combined into left channel for 40% AM, 85% total AM		-46.3	-26.1	-13.2	-27.6	-13.9	-27.4	-48.0

Radio Tuned with 400 Hz, 400 Hz deviation FM signal for minimum output.

Noise Floor -49.9

Proponent Belar

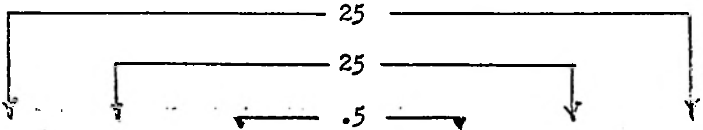
Date 7/21/77

Test A.7

Protection Ratio

Krohn-Hite, 80Hz, 10kHz

noise level in [illegible] proponent's stereo receiver
compared to 85% AM on channel



	mv/m	25	2	.5	25, 1.25	.5	2	25
Modulating Sig.	Freq,	540	550	560	570	580	590	600
4 tone signal AM modulated on channel, output set to [illegible] volts = 0 db reference		.225V 0 db	.22V 0 db	.225V 0 db	.32V 0 db	.225V 0 db	.22V 0 db	.225V 0 db
4 tones all combined into L+R, 85% AM		-27.1 Dmo aHC [illegible]	+8.0	+7.3	-29.7	+10.9	+12.1	-33.2
4 tones all combined into L =-R (reverse phase of one channel as above)		-27.5 Dmo aHC [illegible]	+3.7	+4.6	-23.8	+1.0	+5.0	-34.8
4 tones all combined into L only, 42.5% AM		-27.6 Dmo aHC [illegible]	0.0	+4.6 aHC [illegible]	-29.0	+4.0	+11.7	-34.3
4 tones all combined into R only, 42.5% AM		-27.6 Dmo aHC [illegible]	+5.9	+4.8	-26.8	+4.0	+5.3	-34.4
400 Hz and 9500 Hz combined into right channel for 45% AM, and 2500 Hz and 5500 Hz combined into left channel for 40% AM, 85% total AM		-27.1	+9.7	+7.8	-22.0	+10.5	+10.3	-33.1

aHC Dmo

Noise Floor -47.0 dB

Proponent Belar

Date 7/20/77

Page 2

Test A.7

Protection Ratio

Noise Level in compatibility receiver compared to 85% AM on channel

25 (540 ↔ 600)

25 (550 ↔ 590)

.5 (560 ↔ 580)

	mv/m	25	2	.5	25, 1.25	.5	2	25
Modulating Sig.	Freq,	540	550	560	570	580	590	600
4 tone signal AM modulated on channel, output set to .78 volts = 0 db reference		0 db	0 db	0 db	0 db	0 db	0 db	0 db
4 tones all combined into L+R, 85% AM		-45.8	-36.7	-16.7	-30.4 Dwo ahe [redacted]	-17.2	-37.2	-47.2
4 tones all combined into L =-R (reverse phase of one channel as above)		-49.7	-33.4	-20.1	-21.6 Dwo ahe [redacted]	-21.6	-34.1	-49.5
4 tones all combined into L only, 42.5% AM		-48.7	-35.1	-19.5	-26.0	-23.0	-36.5	-49.2
4 tones all combined into R only, 42.5% AM		-48.6	-35.8	-22.3	-26.1	-19.9	-35.3	-49.1
400 Hz and 9500 Hz combined into right channel for 45% AM, and 2500 Hz and 5500 Hz combined into left channel for 40% AM, 85% total AM		-46.1	-27.6	-18.0	-21.2	-15.2	-25.8	-47.6

Radio Tuned with 400 Hz, 400 Hz deviation FM signal for minimum output.

ahe Dwo Noise Floor -49.5 ahe Dwo [redacted]

jl

B.1

Over-the-Air Tests - WGMS

A low frequency station was chosen for detailed groundwave propagation tests in order to examine the effects of transmitting and receiving antenna systems and RF circuitry. WGMS is 5 kw day and 1 kw night with different directional pattern day and night. The operating frequency is 570 kHz. Such a low frequency and a directional transmitting antenna would probably place considerable impedance and bandwidth limitations on the transmissions. Also a typical superhetrodyne receiver would also probably have additional bandwidth and Rf - IF bandpass symmetry limitations on such a low frequency.

The transmitting facilities consisted of a main and alternate main Harris MW-5 pulse duration modulation 5 kw transmitters.

Each proponent made two connections to the transmitter. One to the normal audio input, and the other to a low level RF stage. The RF connection was installed by the Harris company and was simply a toggle switch and a BNC connector which permitted the drive to the transmitter to be taken from the normal crystal oscillator board or externally through the BNC connector.

Each proponent was required to provide the L + R audio balanced, 600 ohms for directly driving the audio input. Also each proponent provided sufficient RF drive on 570 kHz with the appropriate L - R RM or PM type modulation on it to drive the RF stages of the transmitter. These connections in interfacing were accomplished with no more difficulty than wiring up the proper connectors.

The WGMS tests were all made with the pattern on Day at 5 kw.

The transmitting site test arrangement is shown in the block diagram.

It is generally the same as test A.1 except the Harris transmitter is driven by the proponent's stereo adaptor, and the modulation monitor sample from the transmitter is used to drive the proponents "ideal detector." The test equipment and procedure is basically the same as test A.1.

At the receiving site, which was located about 5 miles from the transmitter, each of the proponent's receivers was connected to its respective antenna. In the case of Magnavox, the receiver incorporated a built-in ferrite loop antenna. The audio output of the receiver was connected to an RCA BA-43 line amplifier and then to either the BKF-10 automatic distortion meter or the Crown intermodulation meter as required. The two chart recorders were identical, and the frequency coordinate axis was driven at a fixed rate via motors synchronous with the A.C. line. By simply starting the two chart recorders in accordance with an instruction over the telephone, the two recorders would operate very satisfactorily in synchronism.

The stereo systems were also tested with programming. A special test tape was prepared which contained a variety of musical selections.

The selections were chosen to represent a cross section of music played over radio stations today and an additional selection which had very obvious stereophonic information. The tape was played on an Ampex AG-440-2 tape machine into a special Thomson-CSF AM stereo limiting arrangement, which in turn drove the proponent's left and right audio inputs.

Modulation was set so that peaks of approximately 95% negative and over 120% positive were achieved. At the receiving site, stereo recordings were made on an Ampex 602-2 tape machine from the proponent's receiver. The test arrangement is shown in the block diagram. In addition, a monaural recording was made from a middle grade consumer-type receiver. These tape recordings will be made available to the Federal Communications Commission.

Observation of Distortion

In Nulls of WGMS

Tests made on Tuesday August 9, 1977 in the early AM

The test tape was played at the WGMS transmitter through the audio processing equipment provided by the committee into each proponent's encoding equipment. The test tape was played two times, once with the L-R circuitry disabled so that the transmission was actually standard AM, and then in full stereo.

At the receiving location, in the parking lot of the Church of Latter Day Saints, at the corner of Falls Rd. and Glen Rd, Potomac, Md., observations were made in an automobile radio by Norm Parker and Frank Hilbert of Motorola, and on a Panasonic compatibility receiver by Chris Payne and Dennis Overstreet. For each test of AM and AM Stereo, the automobile was driven around an identical path and the receiver carried across the front border of the parking lot and observations were made of distortion. Generally in both cases the amount of distortion was the same for all proponents in both AM and AM Stereo.

Norm Parker

Norm Parker

Chris Payne

Chris Payne

Frank H. Hilbert

Frank Hilbert

Dennis M. Overstreet

Dennis Overstreet

B.1

Over - the - Air Tests

WTOP

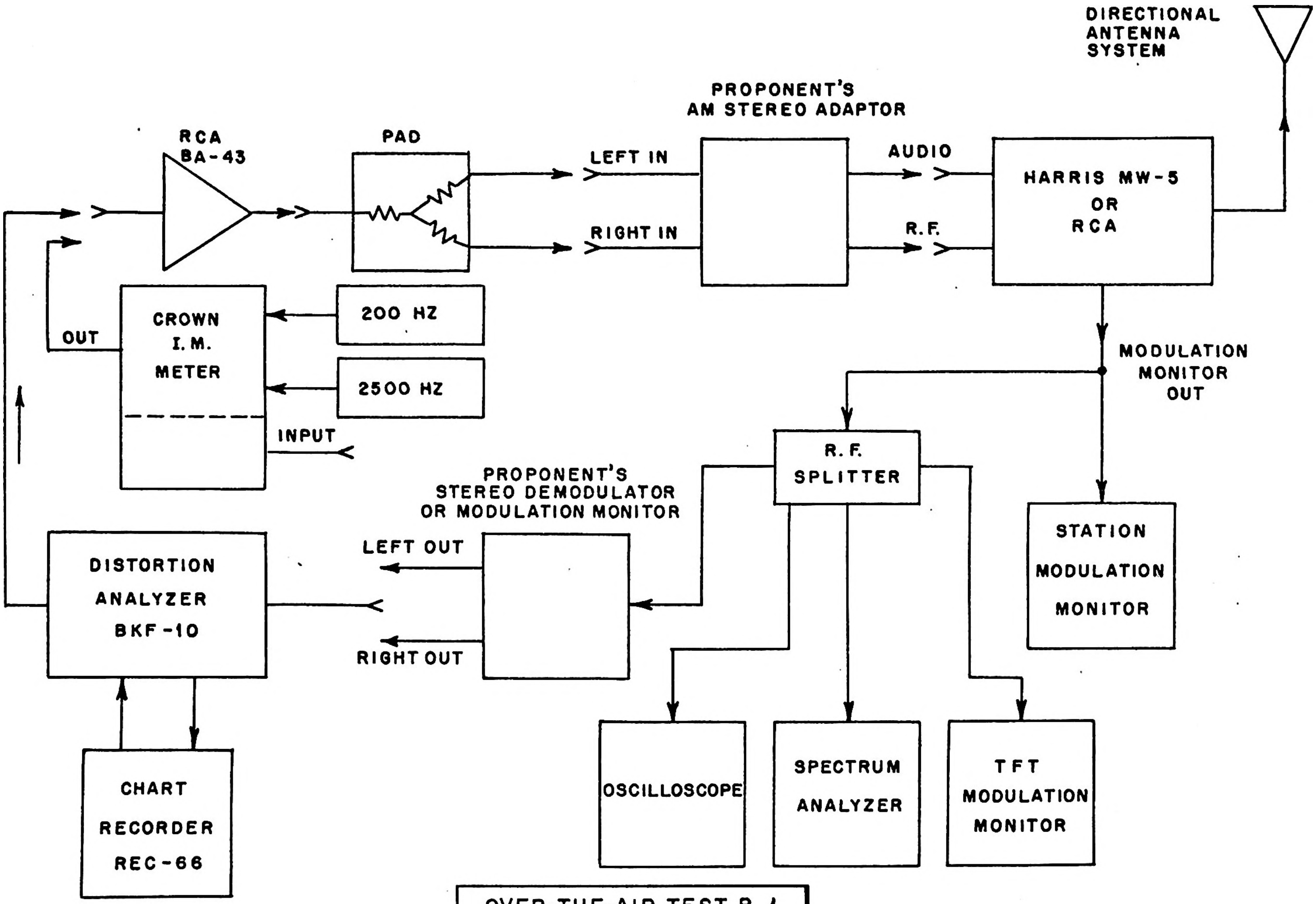
The test arrangement for the WTOP tests were essentially identical with those at WGMS. The 10 kw auxiliary plate modulated transmitter was used for the stereo tests because the performance and modulating system was more representative of transmitters presently used in service today. The interfacing between the transmitter and the proponent's equipment was the same as with WGMS. The RF input connection was taken from a low level RF stage and the L + R audio connected to the normal audio input to the transmitter. The station was operated in its pattern. The modulation levels were adjusted for approximately 85% negative and over 100% positive on programming and as indicated for the tone measurements. A complete set of technical measurements was take at WTOP both at the transmitter site from the proponents stereo demodulator and at the receiving location from the stereo receiver.

B.1

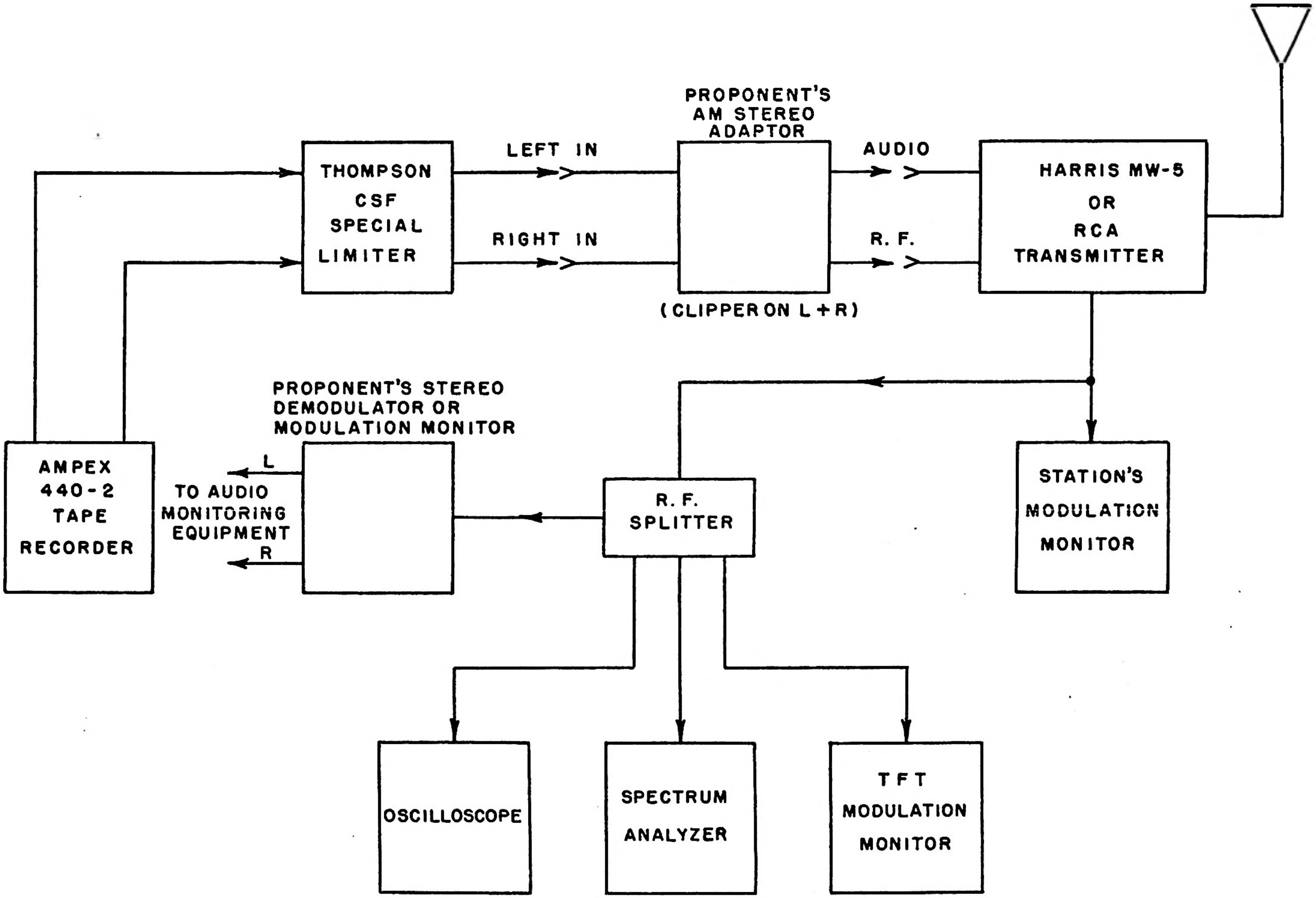
Over-the Air Tests

WBT (Skywave)

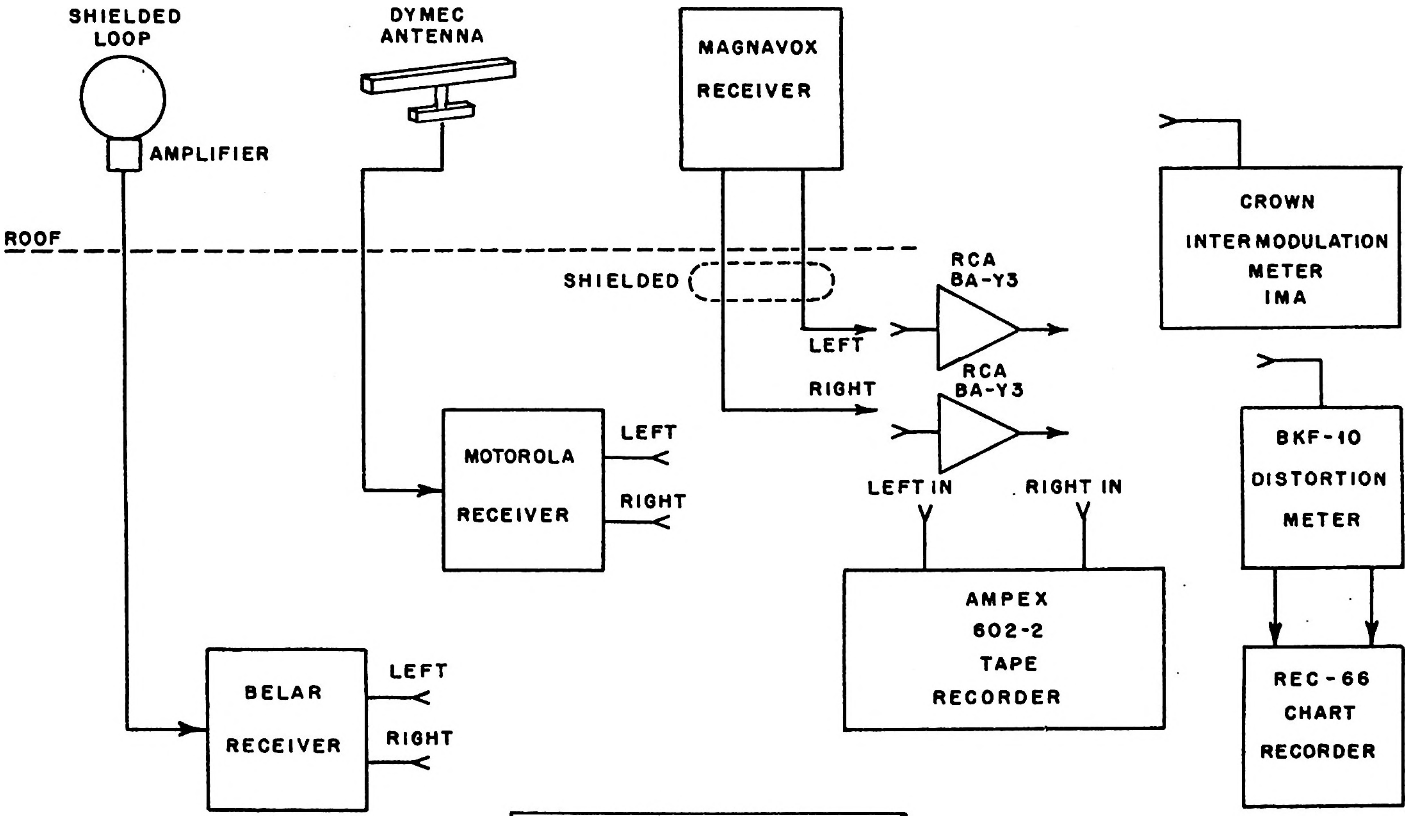
All three proponents brought their stereo encoding equipment to the transmitter site of WBT in Charlotte, N.C. A switching system was devised so that the stereo encoding equipment could be quickly switched between proponents. The NAMSRC test tape was transmitted one selection at a time using each propenent's transmitting equipment. At the receiving site in Bethesda, Md., tape recordings were made of the stereo transmissions on each of the respective stereo receivers and of the middle grade compatibility receiver. In addition, a chart recording of relative fields intensity was made from the AVC of a Collins communications receiver. The tape recordings and other pertinent data will be made available to the FCC. Comments on the skywave tests will be made by the proponents in their individual filings with the FCC.



OVER-THE-AIR TEST B.1
WGMS OR WTOP
TRANSMITTING SITE
(TONE TESTS)



OVER-THE-AIR TEST B.1
WGMS-WTOP-WBT
TEST TAPE TRANSMISSION



OVER THE AIR TEST B.1
WGMS OR WTOP
RECEIVING SITE

WGMS

Over-the-Air Test B.1

Measurements taken at Transmitter

Proponent Magnavox No Krohn-Hite

Date August 7, 1977 10 uSec Delay in L-R Channel

"[illegible]" BW
Normal aHe

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R Special Run L+R Output	L	33T	18 aHe dB	-34 dB	33T	.94 %
		R					

100 uSec. Deemphasis not used on tests below

		Output Channel	Response Chart #	Reference Level	Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.2	Mono, L=R	L	27T	11	-25.5	27T	2.8
		R	28T	11	-25	28T	0.97
a.3	Stereo, L=-R	L	30T	11	-25.5	30T	0.48
		R	29T	11	-25	29T	0.53
a.4a	Left Only	L	31T	aHe 11	-26	31T	1.55
a.4b	Left Separation L Modulated	R	31T				
a.5a	Right Only	R	32T	11	-25	32T	2.45
a.5b	Right Separation R Modulated	L	32T				

			Signal Level	Harmonic Distor.
a.6	L /-45, R /+45	L	dB	%
		R		

aHe
AMM JAH RDS

W6MS

Over-the-Air Test B.1

Measurements taken at Transmitter

Proponent Magnavox   No Krohn-Hite

Date August 7, 1977   10 uSec Delay in L-R Channel

"~~[illegible]~~" BW aHC
Fidelity

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R Special Run L+R Output	L	40T	18 dB	-34 dB	40T	0.99 %
		R					
	100 uSec. Deemphasis used on tests below						
a.2	Mono, L=R	L	34T	11	-26	34T	2.85
		R	35T	11	-25	35T	0.99
a.3	Stereo, L=-R	L	37T	11	-24	37T	0.51
		R	36T	11	-25	36T	0.50
a.4a	Left Only	L	38T	11	-25.5	38T	1.55
a.4b	Left Separation L Modulated	R	38T				
a.5a	Right Only	R	39T	11.5	-25	39T	2.50
a.5b	Right Separation R Modulated	L	~~[illegible]~~ aHC 39T				

			Signal Level	Harmonic Distor.
a.6	L /-45, R /+45	L	dB	%
		R		

aHC
AMM JHH RDS

W6MS

Over-the-Air Test B.1

Measurements taken at Receiver

Note: All tests done with ~~25 mV~~/M (or equivalent input level)

NARROW BANDWIDTH

Proponent MAGNAVOX

Date 8-7-77

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement: Reference Level	Noise Measurement: Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.1	Mono, L=R	L	027R	0.6	-33.1 dB	027R	2.7 %
		R	028R	5.0 dB	-29.3 dB	028R	11.0 %
	(100uS Deemphasis NOT used on the tests below)						
A.2	Mono, L=R RCVR IN MONO	L	033R	1.0 dB	-42.5 dB	033R	4.9 %
		R		dB	dB		%
A.3	Stereo, L=-R	L	030R	0.8 dB	-33.2 dB	030R	~~2.6~~ 3.5%
		R	029R	5.2 dB	-29.2 dB	029R	2.6 %
A.4a	Left Only	L	031R	0.8 dB	-33.5 dB	031R	3.4 %
		R		dB	dB		%
A.4b	Left Separation L Modulated	R	031R				
A.5a	Right Only	R	032R	+5.2 dB	-29.2 dB	032R	2.3 %
A.5b	Right Separation R Modulated	L	032R				

No.	Input Signal		Signal Level	Harmonic Distortion
A.6	L/ -45°, R/+ 45°	L	dB	%
		R	dB	%

Notes: disabled stereo Tone stereo light went out on RCVR

Technicians

Witness Y. Sakai
A.S.K.

Over-the-Air Test B.1

WGMS

Measurements taken at Receiver

MAGNAVOX

Proponent ~~Bel Air~~

Date 8-7-77

Note: All tests done with ~~25 uV/M~~ (or equivalent input level)

Wide BANDWIDTH

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.1	Mono, L=R	L	034R	-0.8	-33.6 dB	034R	23.5 %
		R	035R	+5.8 dB	-29.0 dB	035R	21.5 %
	(100uS Deemphasis NOT used on the tests below)						
A.2	Mono, L=R RCVR IN MONO	L	040R	+1.2 dB	-42 dB	040R	2.6 %
		R		dB	dB		%
A.3	Stereo, L=-R	L	037R	7.2 dB	-33.2 dB	037R	3.1 %
		R	036R	+5.8 dB	-29.2 dB	036R	2.4 %
A.4a	Left Only	L	038R	+0.9 dB	-33.7 dB	038R	3.1 %
		R		dB	dB		%
A.4b	Left Separation L Modulated	R	038R				
A.5a	Right Only	R	039R	+6.0 dB	-29.1 dB	039R	5.8 %
A.5b	Right Separation R Modulated	L	039R				

No.	Input Signal		Signal Level	Harmonic Distortion
A.6	L/ -45°, R/+ 45°	L	dB	%
		R	dB	%

Notes: WITH FLOURESENT LIGHTS ON THERE WAS A ONE (1) db INCREASE. DATA RAN WITH LIGHTS OFF FOR BOTH NARROW + WIDE BANDWIDTHS

Technicians Dano

Witness Y. Sakai

a.s.k.

WGMS

Over-the Air Test B.1

Measurements taken at Transmitter

Proponent Motorola

Date August 7, 1977

Krohn-Hite 70 Hz, 20 kHz
Pilot Tone On
4 uSec Delay in L-R Channel

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R Special Run Envelope Output	L	26T	21 dB	-32.5 dB	26T	1.55 %
		R					

100 uSec. Deemphasis not used on tests below

a.2	Mono, L=R	L	20T	21	-17	20T	3.6
		R	21T	21	-17	21T	1.35
a.3	Stereo, L=-R	L	23T	21	-17	23T	7.0
		R	22T	21	-17	22T	6.9
a.4a	Left Only	L	24T	21	-17	24T	4.4
a.4b	Left Separation L Modulated	R	24T				
a.5a	Right Only	R	25T	21	-17	25T	4.5
a.5b	Right Separation R Modulated	L	25T				

			Signal Level	Harmonic Distor.
a.6	L /-45, R /+45	L	dB	%
		R		

AMM RDS

WGMS

Over-the-Air Test B.1

Measurements taken at Transmitter

Proponent Motorola

Date 8/8/77 Pilot Tone On

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R Special Run Envelope Output	L		dB	dB		1.65%
		R					

100 uSec. Deemphasis not used on tests below

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.2	Mono, L=R	L					3.7%
		R					1.3%
a.3	Stereo, L=-R	L					3.6%
		R					3.5%
a.4a	Left Only	L					2.05%
a.4b	Left Separation L Modulated	R					
a.5a	Right Only	R					3.7%
a.5b	Right Separation R Modulated	L					

			Signal Level	Harmonic Distor.
a.6	L /-45, R /+45	L	dB	%
		R		

aHC

Station AM Monitor Disconnected

WGMS

Over-the-Air Test B.1

84.5% Mod

Measurements taken at Receiver

Note: All tests done with ~~25~~ .575 mV/~~M~~ (or equivalent input level)

KROHN-HITE 60 Hz + 10 KHz

Proponent MOTOROLA

Date 8-27-77

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.1	Mono, L=R	L	020R	15.6 dB	-23.6 dB	020R	2.9 %
		R	021R	19.0 dB	-20.8 dB	021R	4.0 %

(100uS Deemphasis NOT used on the tests below)

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.2	Mono, L=R, envelope detector only RCVR in Mono	L	026R	15.8 dB	-39.2 dB	026R	2.0 %
		R		dB	dB		%
A.3	Stereo, L=-R	L	023R	15.4 dB	-23.5 dB	023R	2.9 %
		R	022R	18.8 dB	-20.8 dB	022R	2.8 %
A.4a	Left Only	L	024R	16.0 dB	-23.6 dB	024R	3.2 %
		R		dB	dB		%
A.4b	Left Separation L Modulated	R	024R				
A.5a	Right Only	R	025R	19.2 dB	-20.8 dB	025R	2.7 %
A.5b	Right Separation R Modulated	L	025R				

No.	Input Signal		Signal Level	Harmonic Distortion
A.6	L/ -45°, R/+ 45°	L	dB	%
		R	dB	%

Notes:

Technicians DmO

J.S.K.

Witness Y. S.

A.S.K.

WGMS

Over-the-Air Test B.1

Measurements taken at Transmitter

Proponent Belar Nokrohn-Hite ,

Date August 7, 1977 19 uSec Delay in L-R Channel

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R Special Run L-R Detector Out	L	47T	12 dB	-40 dB	47T	1.25%
		R					

100 uSec. Deemphasis not used on tests below

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.2	Mono, L=R	L	41T	12	-31	41T	2.00
		R	42T	13	-33	42T	2.45
a.3	Stereo, L=-R	L	44T	12	-30	44T	0.75
		R	43T	13	-33	43T	1.35
a.4a	Left Only	L	45T	12	-30.5	45T	1.10
a.4b	Left Separation L Modulated	R	45T				
a.5a	Right Only	R	46T	13	-32	46T	2.40
a.5b	Right Separation R Modulated	L	46T				

			Signal Level	Harmonic Distor.
a.6	L /-45, R /+45	L	dB	%
		R		

AHC
AMM JHH RDS

WGMS

Over-the-Air Test B.1

Measurements taken at Receiver

Note: All tests done with ~~25~~ 19.2 mV/~~M~~ (or equivalent input level)

Proponent BeLAR

Date 8-7-77

KROHN HiTe 80 Hz + 10 KHz

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.1	Mono, L=R	L	041R	4.1	-37.1 dB	041R	5.8 %
		R	092R	+6.5 dB	-31.7 dB	092R	8.7 %

(100uS Deemphasis NOT used on the tests below)

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.2	Mono, L=R L-R detector off	L	047R	2.6 dB	-41.5 dB	047R	6.2 %
		R		dB	dB		%
A.3	Stereo, L=-R	L	044R	2.8 dB	-32.5 dB	044R	1.9 %
		R	043R	6.4 dB	-31.6 dB	043R	.65 %
A.4a	Left Only	L	045R	+2.0 dB	-36.5 dB	045R	2.5 %
		R		dB	dB		%
A.4b	Left Separation L Modulated	R	045R				
A.5a	Right Only	R	046R	6.9 dB	-31.8 dB	046R	3.6 %
A.5b	Right Separation R Modulated	L	046R				

No.	Input Signal		Signal Level	Harmonic Distortion
A.6	L/ -45°, R/+ 45°	L	dB	%
		R	dB	%

Notes:

Technicians

Witness A.S.K., Y.S.

WTOP

Over-the-Air Test B.1

Measurements taken at Transmitter

Proponent MAGNAVOX

NORMAL BW

Date 8-11-77

100 uSec. Deemphasis NOT used on tests below (applies from row a.2 down)

		Output Channel	Response Chart #	Noise Measurement		Harmonic Distor. Chart #	Intermod. Distor.
				Reference Level	Residual Noise		
a.1	Mono, L=R	L	048T	+1.0 Dmo dB	-36.5 dB	048T	7.15%
		R	049T	+.8	-41.3	049T	3.1%
a.2	~~Mono, L=R~~ MONO	L	054T	+6.2	-56.0	054T	4.1%
		R					
a.3	Stereo, L=-R	L	051T	+1.0	-36.9	051T	3.2%
		R	050T	+1.0	-41.5	050T	3.2%
a.4a	Left Only	L	052T	+.5	-36.5	052T	2.05%
a.4b	Left Separation L Modulated	R	052T				
a.5a	Right Only	R	053T	+.8	-41.3	053T	2.05%
a.5b	Right Separation R Modulated	L	053T				

			Signal Level	Harmonic Distor.
a.6	L /-45, R /+45	L	dB	%
		R		

C.M. DDS

WTOP

Over-the-Air Test B.1

Measurements taken at Transmitter

Proponent MAGNAVOX

Date AUG 12, 1977

Fidelity BW

				Noise Measurement			
		Output Channel	Response Chart #	Reference Level	Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R	L	069T	+1.0 dB	-35.9 dB	069T	.82 %
		R	070T	+1.1	-42.3	070T	3.5%

100 uSec. Deemphasis NOT used on tests below

a.2	Mono,	L	075T	+7.0	-53.9	075T	3.95%
		R					
a.3	Stereo, L=-R	L	072T	+.5	-36.1	072T	2.8%
		R	071T	+1.0	-42.1	071T	2.7%
a.4a	Left Only	L	073T	+0.8	-36.1	073T	1.55
a.4b	Left Separation L Modulated	R	073T				
a.5a	Right Only	R	074T	+1.0	-41.0	074T	2.55%
a.5b	Right Separation R Modulated	L	074T				

			Signal Level	Harmonic Distor.
a.6	L /-45, R /+45	L	dB	%
		R		

e.m.

RDS

Over-the Air Test H.1 WTOP

"Normal" BW Measurements taken at Receiver

Note: All tests done with 25 mV/M (or equivalent input level)

No Krohn-Hite

Proponent Magnavox

Date 8/10/77

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.1	Mono, L=R Special Run Receiver in Mono	L	54R	+8.5	-38 dB	54R	6.8 %
		R		dB	dB		%

(100uS NOT Deemphasis used on the tests below)

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.2	Mono, L=R	L	(48R	+8.5 dB	-30 dB	48R	4.0 %
		R	49R	+6 dB	-32 dB	49R	13.0 %
A.3	Stereo, L=-R	L	51R	+7 dB	-30 dB	51R	3.0 %
		R	50R	+6 dB	-32 dB	50R	1.8 %
A.4a	Left Only	L	52R	+8.5 dB	-30 dB	52R	2.7 %
		~~R~~		~~dB~~	~~dB~~		~~%~~
A.4b	Left Separation L Modulated	R	52R				
A.5a	Right Only	R	53R	+6 dB	-33 dB	53R	1.7 %
A.5b	Right Separation R Modulated	L	53R				

↑ minimum IM Values

No.	Input Signal		Signal Level	Harmonic Distortion
A.6	L/ -45°, R/+ 45°	L	dB	%
		R	dB	%

Notes:

Technicians aHC

Witness Y. Sahai AMM

G. P. [illegible]

Over-theAir Test B.1

WTOP

"Fidelity" BW

Measurements taken at Receiver

Note: All tests done with 25 mV/M (or equivalent input level)

Proponent Magnavox

Date 8/12/77

No Krohn-Hite

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.1	Mono, L=R Special Run Receiver in Mono	L	75R	+7.5	-36 dB	75R	5.2 %
		R		dB	dB		%
	(100uS Deemphasis used on the tests below)						
A.2	Mono, L=R Cables reversed at receiver ∴	R	69R	+8.5 dB	-29.5 dB	69R	9.0 %
		L	70R	+3 dB	-34 dB	70R	16.0 %
A.3	Stereo, L=-R R Out in Black, L Out in Red	R	72R	+9.5 dB	-30 dB	72R	2.8 %
		L	71R	+5 dB	-33 dB	71R	2.4 %
A.4a	Left Only	L	73R	+7 dB	~~[illegible]~~ -30 a9te dB	73R	1.5 %
		~~R~~		~~dB~~	~~dB~~		~~%~~
A.4b	Left Separation L Modulated	R	~~[illegible]~~ 73R				
A.5a	Right Only	R	74R	~~[illegible]~~ +6.5 a9te dB	~~[illegible]~~ -33 a9te dB	74R	4.8 %
A.5b	Right Separation R Modulated	L	74R				

Minimum Value of IM Read

No.			Signal Level	Harmonic Distortion
A.6	L/ -45°, R/+ 45°	L	dB	%
		R	dB	%

Notes:

Technicians a9te.

Witness Y. Sakai AMA

Over-the-Air Test B.1

WTOP

Measurements taken at Transmitter

Proponent MOTOROLA

Date 8-11-77

PILOT TONE ON
KROHN HITE - 70 Hz + 20 KHz

		Output Channel	Response Chart #	Noise Measurement		Harmonic Distor. Chart #	Intermod. Distor.
				Reference Level	Residual Noise		
a.1	Mono, L=R	L	055T	+10.0 dB	-48.5 dB	055T	5.6 %
		R	056T	+9.5	-49.0	056T	6.2

100 uSec. Deemphasis NOT used on tests below

		Output Channel	Response Chart #	Reference Level	Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.2	Mono, L=R MONO	L	061T	+9.6	-54.5	061T	5.0%
		R					
a.3	Stereo, L=-R	L	058T	+10.0	-49.3	058T	3.25
		R	057T	+10.1	-48.8	057T	4.15
a.4a	Left Only	L	059T	+10.0	-48.2	059T	2.99
a.4b	Left Separation L Modulated	R	059T				
a.5a	Right Only	R	060T	-9.8	-49.0	060T	5.5%
a.5b	Right Separation R Modulated	L	060T				

			Signal Level	Harmonic Distor.
a.6	L ∠-45, R ∠+45	L	dB	%
		R		

RDS

C. Mw

WTOP

Over-the-Air Test B.1

Measurements taken at Transmitter

Proponent Belar

Date 8-12-77
Dmo

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.1	Mono, L=R	L	062T	+.9 dB	-39.0 dB	062T	2.7 %
		R	063T	+1.5	-39.0	063T	4.5

100 uSec. Deemphasis not used on tests below

		Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Distor.
a.2	Mono, L=R MONO	L	068T	+.7	-56.0	068T	3.2%
		R					
a.3	Stereo, L=-R	L	065T	0.0	-40.1	065T	0.97%
		R	064T	0.0db	-39.5	064T	1.4%
a.4a	Left Only	L	066T	0.0	-39.5	066T	1.9%
a.4b	Left Separation L Modulated	R	066T				
a.5a	Right Only	R	067T	+.5	-39.0	067T	0.93
a.5b	Right Separation R Modulated	L	067T				

		Output Channel	Signal Level	Harmonic Distor.
a.6	L /-45, R /+45	L	dB	%
		R		

Dmo
RDS
C. M.

WTOP

Over-the-Air Test B.1

Measurements Taken at Receiver

Proponent Motorola

Date 8/10/77

Note: All tests done with 25 mV/M (or equivalent input level)

Krohn-Hite 60 Hz, 10 kHz

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.1	Mono, L=R	L	61R	+22	-27 dB	61 R	2.6 %
		R		dB	dB		%
	(100uS Deemphasis NOT used on the tests below)						
A.2	Mono, L=R	L	55R	+22 dB	-21 dB	55R	3.2 %
		R	56R	+19.5 dB	-25.5 dB	56R	2.8 %
A.3	Stereo, L=-R	L	58R	+22 dB	-22.5 dB	58R	2.2 %
		R	57R	+19 dB	-26 dB	57R	6.3 %
A.4a	Left Only	L	59R	+22 dB	-21 dB	59R	2.9 %
		~~R~~		~~dB~~	~~dB~~		~~%~~
A.4b	Left Separation L Modulated	R	59R				
A.5a	Right Only	R	60R	+19 dB	-26 dB	60R	4.0 %
A.5b	Right Separation R Modulated	L	60R				

↑ Minimum IM Value Read

No.	Input Signal	Output Channel	Signal Level	Harmonic Distortion
A.6	L/ -45°, R/+ 45°	L	dB	%
		R	dB	%

10 kHz Whistle Filter In

Notes:

Technicians AHC

Witness Y. Sakai AMM

WTOP

Over-the-Air Test B.1

Measurements taken at Receiver

Note: All tests done with 25 mV/M (or equivalent input level)

Proponent Belar

Date 8/12/77

Krohn-Hite 80Hz, 10kHz

No.	Input Signal	Output Channel	Response Chart #	Noise Measurement Reference Level	Noise Measurement Residual Noise	Harmonic Distor. Chart #	Intermod. Dist.
A.1	Mono, L=R	L	68R	+9	-35.5 dB	68R	5.6 %
	Special Run Receiver in Mono	R		dB	dB		%
	(100uS Deemphasis Not used on the tests below)						
A.2	Mono, L=R	L	62R	+9.5 dB	-28 dB	62R	5.0 %
		R	63R	+6.5 dB	-30 dB	63R	8.5 %
A.3	Stereo, L=-R	L	65R	+6.5 dB	-29 dB	65R	1.45 %
		R	64R	+5 dB	-30.5 dB	64R	4.0 %
A.4a	Left Only	L	66R	+7 dB	-29 dB	66R	3.4 %
		~~R~~		~~dB~~	~~dB~~		~~%~~
A.4b	Left Separation L Modulated	R	66R				
A.5a	Right Only	R	67R	+5.5 dB	-30 dB	67R	0.9 %
A.5b	Right Separation R Modulated	L	67R				

Minimum IM Value Read

No.	Input Signal		Signal Level	Harmonic Distortion
A.6	L/ -45°, R/+ 45°	L	dB	%
		R	dB	%

Notes:

Technicians

Witness Y. Schnie AMM

GUIDE TO AUDIO PERFORMANCE CHARTS

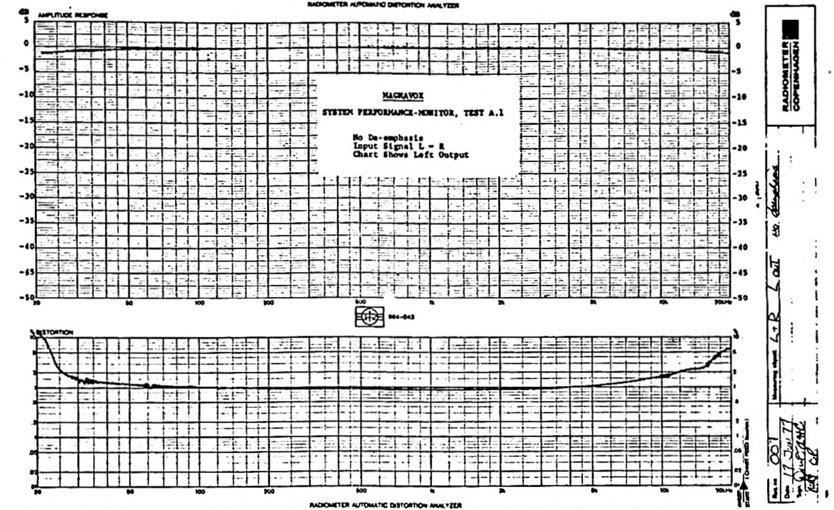
Page No.	Test	Input Condition	Graph Shows	Individual Chart Numbers		
				Top Mag.	Middle Mot.	Bottom Belar
1	(A.1 Monitor	L+R	L	007	093	141
2	No De-emphasis)	L+R	R	008	094	142
3		L=-R	L	013	096	144
4		L=-R	R	014	095	043
5		L only	L out	015	097	145
6		R only	R out	017	098	146
7	(A.1 Monitor	L+R	L	009	100	150
8	100 us De-emphasis)	L+R	R	010	099	149
9		L=-R	L	011	101	154
10		L=-R	R	012	102	153
11		L only	L	016	103	155
12		R only	R	018	104	156
13	(A.1 Monitor	L+R	L	057	118	157
14	No De-emphasis	L+R	R	058	117	158
	Thru Bandpass Filter)					
15	(A.1 Monitor	L+R	L	060	124	166
16	100 us De-emphasis	L+R	R	059	123	165
17	Thru Bandpass Filter)	L-R	L	061	125	170
18		L-R	R	062	126	169
19		L only	L	064	127	171
20		R only	R	063	128	172
21	(A.2 Receiver	L+R	L	031	130	177
22	No De-emphasis)	L+R	R	032	129	176
23		L-R	L	036	131	178
24		L-R	R	037	132	179
25		L only	L	040	133	181
26		R only	R	041	134	180
27		L=R	L	019		
		L=R	R		020	
	A.2 Magnavox Narrow Receiver No De-emphasis	L=-R	L			023
28		L=-R	R	024		
		L only	L		027	
		R only	R			029

Page No.	Test	Input Condition	Graph Shows	Individual Chart Numbers		
				Top Mag.	Middle Mot.	Bottom Belar
29	(A.2 Receiver	L+R	L	050	136	185
30	100 us De-emphasis)	L+R	R	049	135	184
31		L-R	L	051	137	186
32		L-R	R	052	138	187
33		L only	L	054	139	188
34		R only	R	053	140	189
35		L=R	L	043		
		L=R	R		044	
	A.2 Magnavox	L=-R	L			046
	Narrow Receiver					
36	100 us De-emphasis	L=-R	R	045		
		L only	L		047	
		R only	R			048
37	(B.1 WGMS	L+R	L	34T	20T	41T
38	Xmitter Data)	L+R	R	35T	21T	42T
39		L=-R	L	37T	23T	44T
40		L=-R	R	26T	22T	43T
41		L only	L	38T	24T	45T
42		R only	R	39T	25T	46T
43		Special Run AM only	AM Det.	40T	26T	47T
44	(B.1 WGMS	L+R	L	034R	020R	041R
45	Receiver Data)	L+R	R	035R	021R	042R
46		L=-R	L	037R	023R	044R
47		L=-R	R	036R	022R	043R
48		L only	L	038R	024R	045R
49		R only	R	039R	025R	046R
50		L+R (Mono.)	AM Det.	040R	026R	047R
51		L+R Trans.	AM Det.	33T		
		L=R	L		27R	
	B.1 Magnavox	L=R	R			28R
	WGMS Narrow					
52	Receiver	L=-R	L	30R		
		L=-R	R		29R	
		L only	L			31R
53		R only	R	032R		
		L=R Rec.	AM Det.		033R	
						Blank
54	(B.1 WTOP	L+R	L	069R	055T	062T
55	Xmitter Data)	L+R	R	070T	056T	063T
56		L=-R	L	072T	058T	065T
57		L=-R	R	071T	057T	064T
58		L only	L	073T	059T	066T
59		R only	R	074T	060T	067T
60		L+R (Mono.)	AM Det.	075T	061T	068T

Page No.	Test	Input Condition	Graph Shows	Individual Chart Numbers		
				Top Mag.	Middle Mot.	Bottom Belar
61	(B.1 WTOP	L+R	L	70R	55R	62R
62	Receiver Data)	L+R	R	69R	56R	63R
63		L=-R	L	71R	58R	65R
64		L=-R	R	72R	57R	64R
65		L only	L	73R	59R	66R
66		R only	R	74R	60R	67R
67		L+R (Mono.)	AM Det.	75R	61R	68R
68	B.1 Magnavox	L+R	L	48R		
	WTOP Narrow	L+R	R		49R	
	Receiver	L-R	L			51R
69		L-R	R	50R		
		L only	L		52R	
		R only	R			53R
70		L+R	AM Det.	54R		
					Blank	
						Blank
71		L=R	L	27T		
		L=R	R		28T	
	B.1 Magnavox	L=-R	L			30T
	WGMS Narrow					
72	Meas. at Trans.	L=-R	R	29T		
	No De-emphasis	L only	L		31T	
		R only	R			32T
73		L=R	L	048T		
		L=R	R		049T	
	B.1 Magnavox	L only	L			052T
	WTOP Narrow					
74	Meas. at Trans.	R only	R	053T		
		L+R	AM Det.		054T	
						Blank

Page No.	Test	Input Condition	Graph Shows	Individual Chart Numbers Top Mag.	 Middle Mot.	 Bottom Belar
75		L+R	L	078		
		L+R	R		077	
	A.1 Motorola	L-R	L			079
76	No De-emphasis No Pilot	L-R	R	080		
		L only	L		081	
		R only	R			082
77		L+R	L	084		
		L+R	R		083	
	A.1 Motorola	L-R	L			085
78	100 us De-emphasis No Pilot	L-R	R	086		
		L only	L		087	
		R only	R			088
79		L+R	L	105		
		L+R	R		106	
	A.1 Motorola	L-R	L			108
80	No Pilot Filter	L-R	R	107		
		L only	L		109	
		R only	R			110
81	A.1 Motorola	L=-R	L	119		
	No De-emphasis	L=-R	R		120	
	Pilot On	L only	L			121
82	A.1 Motorola	R only	R	122		
	100 us De-emphasis	L=R	L		111	
	Filter	L=R	R			112
83		L=-R	L	113		
		L=-R	R		114	
		L only	L			115
84		R only	R	116		
					Blank	
						Blank

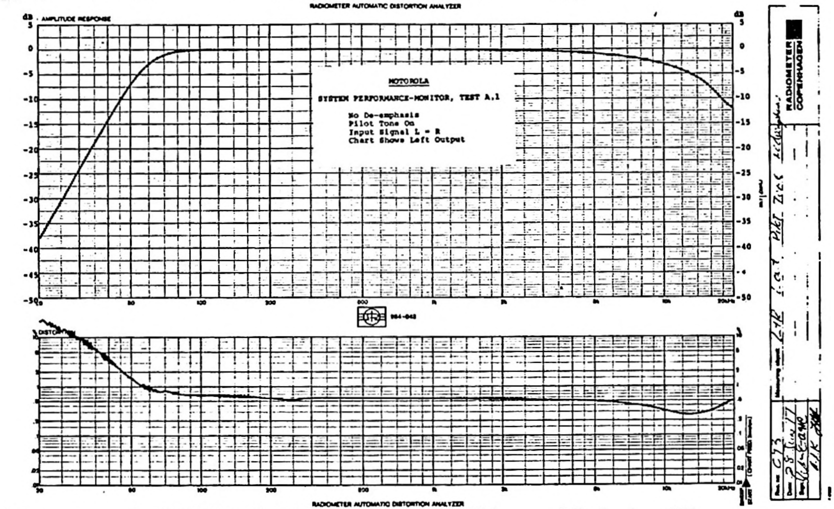
Page No.	Test	Input Condition		Graph Shows	Individual Chart Numbers		
					Top Mag.	Middle Mot.	Bottom Belar
85	Belar A.1	L=R	AM	L	147		
	No De-emphasis	L=R	Det. Off	R		148	
86	Belar A.1	L=R	" "	L			151
	De-emphasis	L=R	" "	R	152		
	Belar A.1 Filter	L=R	" "	L		160	
	No De-emphasis	L=R	AM Det. Off	R			159
87	Belar A.1 Filter	L=R	" "	L	168		
	De-emphasis			R		167	
	Belar A.1 Filter	L-R		L			161
	De-emphasis						
88	A.1 Belar	L=-R	AM	R	162		
	Filter No De-emphasis	L only	Det.	L		163	
		R only	Off	R			164
89	A.2 Belar Receiver) No De-emphasis	L=R	AM	L	174		
		L=R	Det. Off	R		175	
90	A.2 Belar Receiver) 100 us De-emphasis	L=R		L			182
		L=R	" "	R	183		
						Blank	
							Blank
91	BA-43 Left				091		
	BM-13 Right					092	
	Krohn Hite Filter #2903						090
92	Krohn Hite Filter #2904				089		
						173	



MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

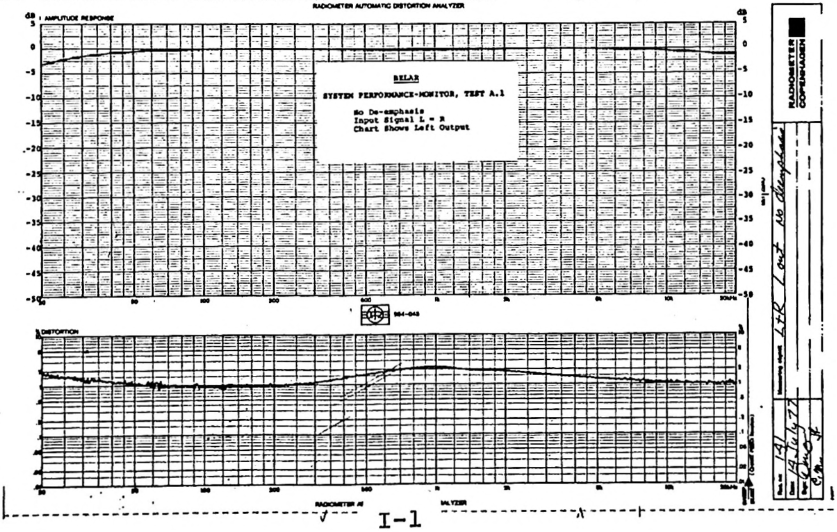
No De-emphasis
Input Signal L = R
Chart Shows Left Output



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

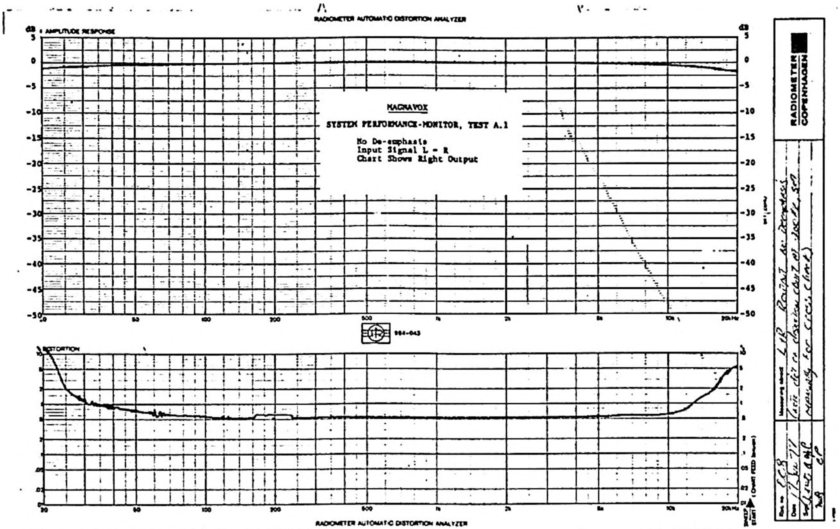
No De-emphasis
Pilot Tone On
Input Signal L = R
Chart Shows Left Output



BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

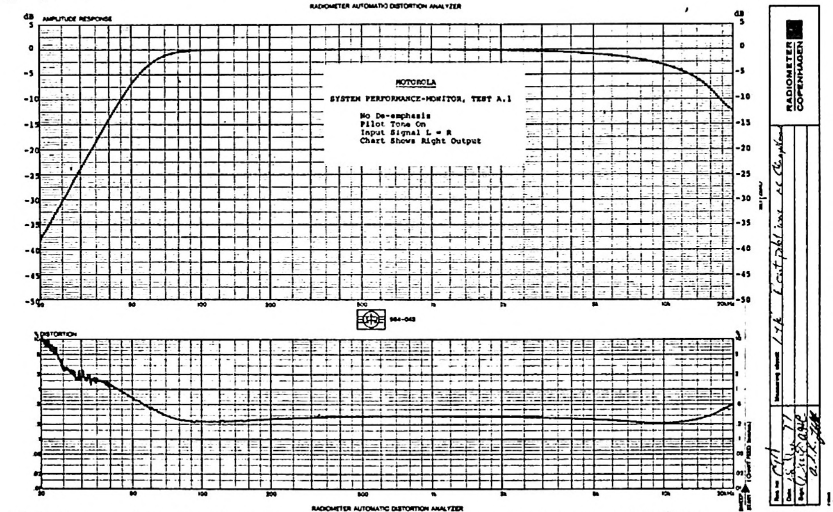
No De-emphasis
Input Signal L = R
Chart Shows Left Output



MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

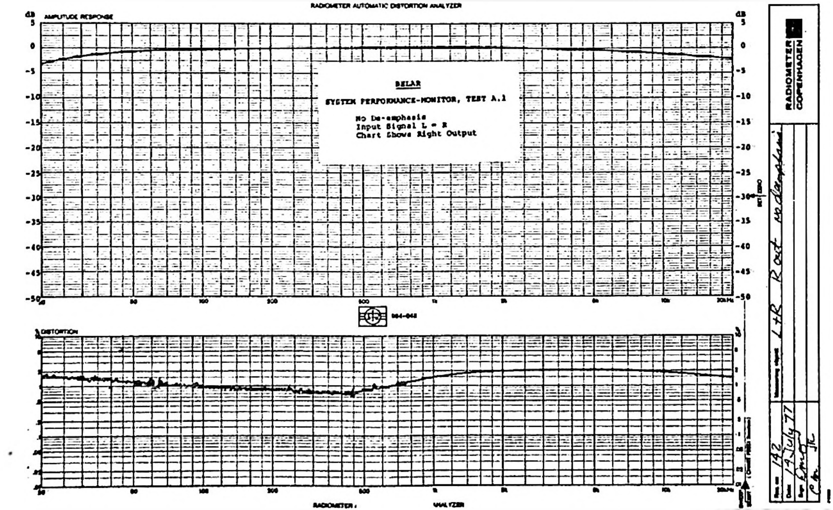
No De-emphasis
Input Signal L = R
Chart Shows Right Output



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

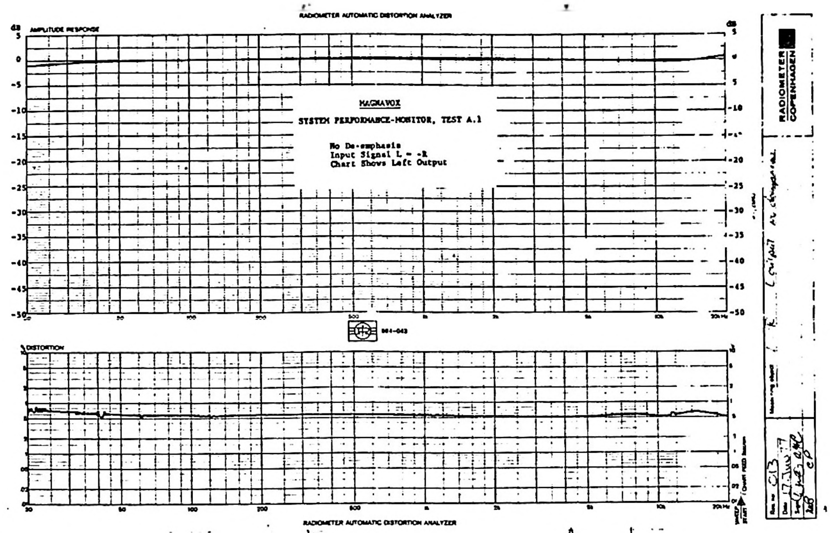
No De-emphasis
Pilot Tone On
Input Signal L = R
Chart Shows Right Output



BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

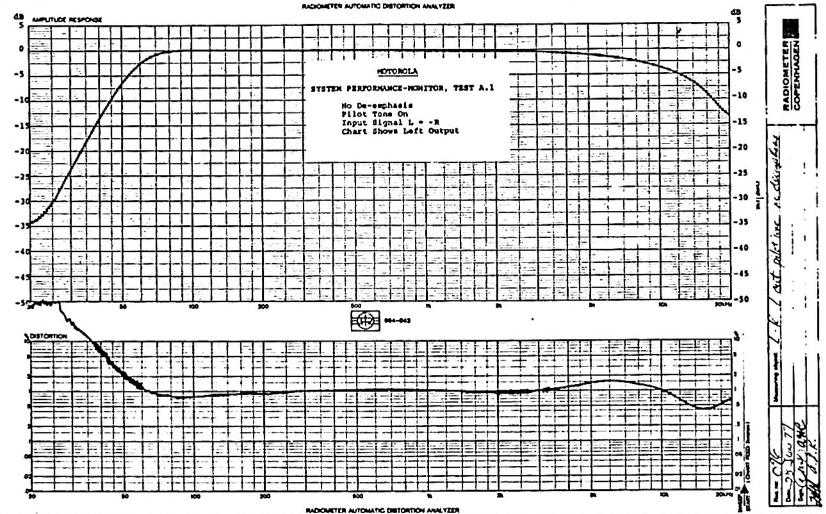
No De-emphasis
Input Signal L = R
Chart Shows Right Output



MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

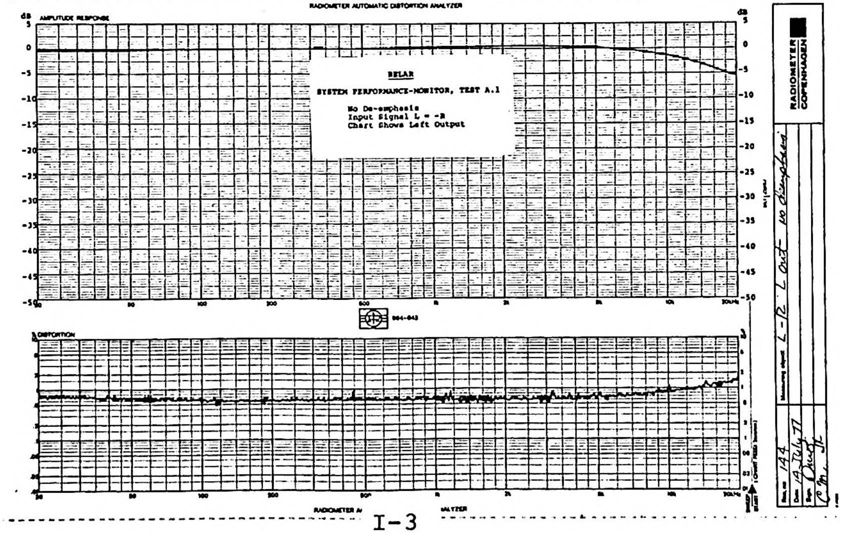
No De-emphasis
Input Signal L = -R
Chart Shows Left Output



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

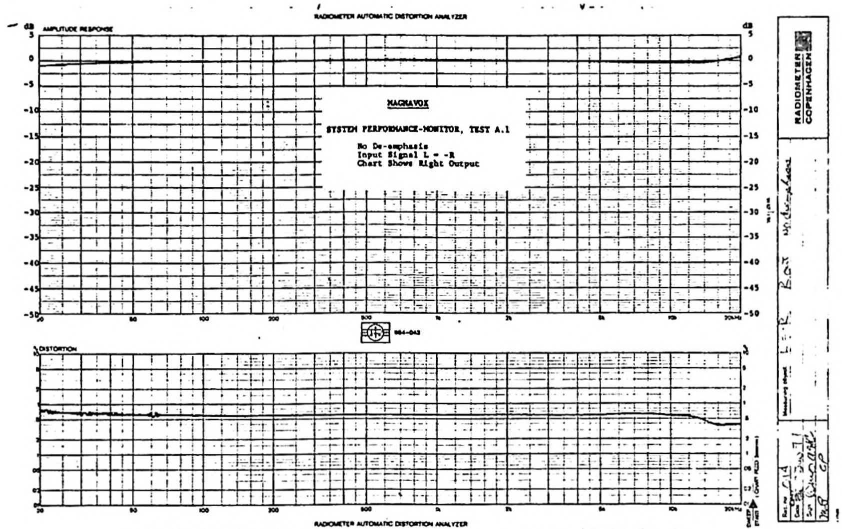
No De-emphasis
Pilot Tone On
Input Signal L = -R
Chart Shows Left Output



BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

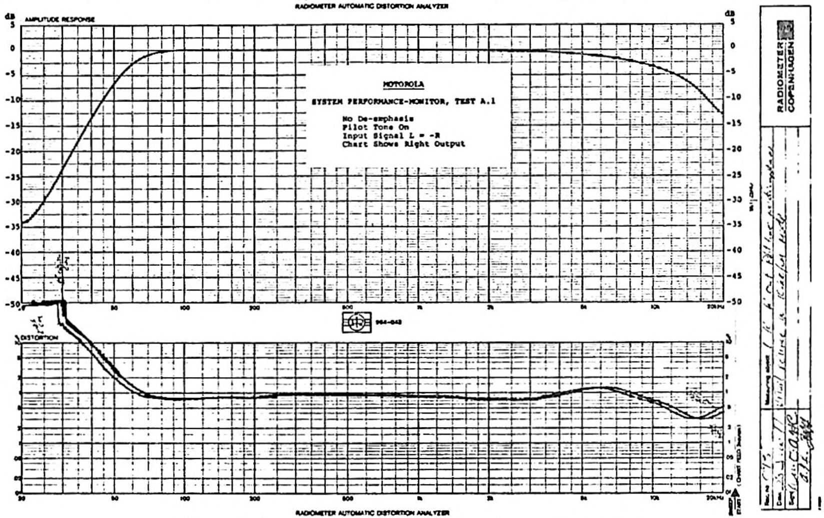
No De-emphasis
Input Signal L = -R
Chart Shows Left Output



MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

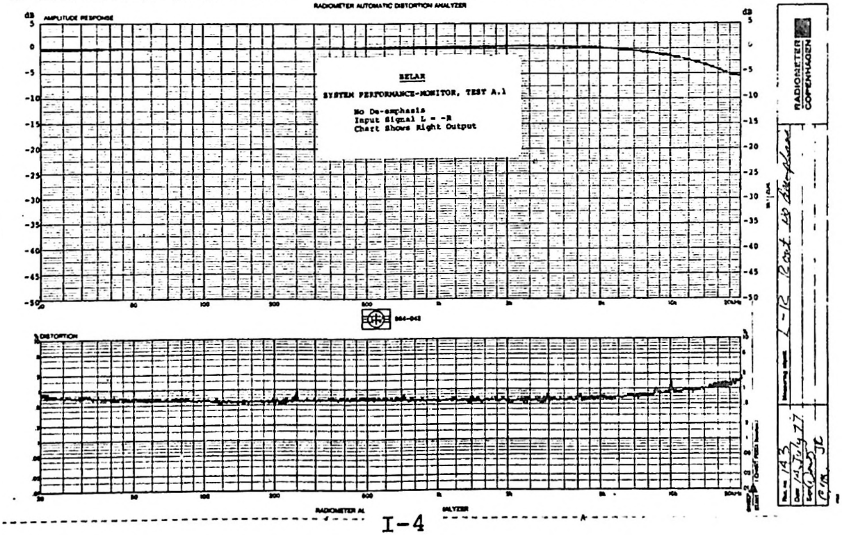
No De-emphasis
Input Signal L = -R
Chart Shows Right Output



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

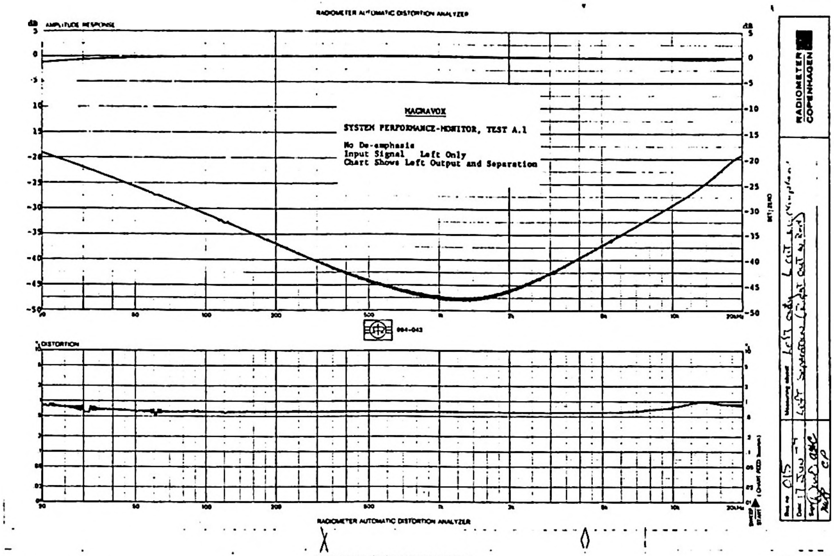
No De-emphasis
Pilot Tone On
Input Signal L = -R
Chart Shows Right Output



BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

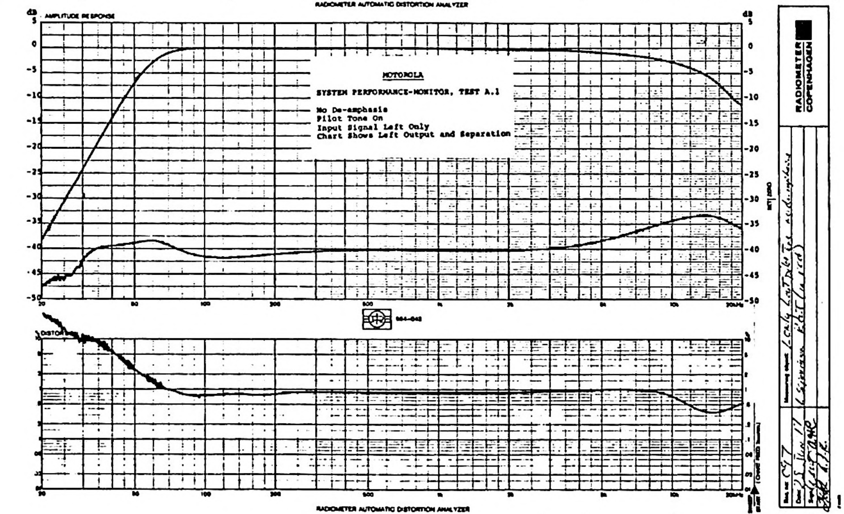
No De-emphasis
Input Signal L = -R
Chart Shows Right Output



MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

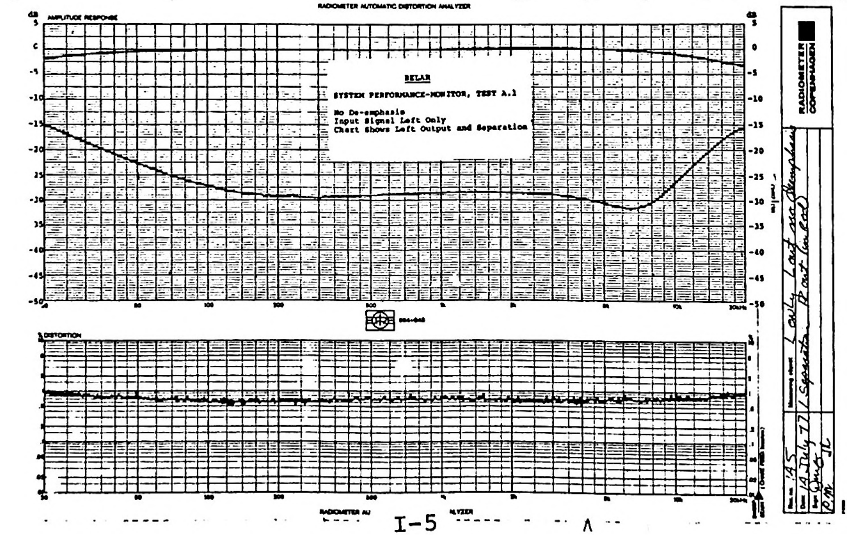
No De-emphasis
Input Signal Left Only
Chart Shows Left Output and Separation



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

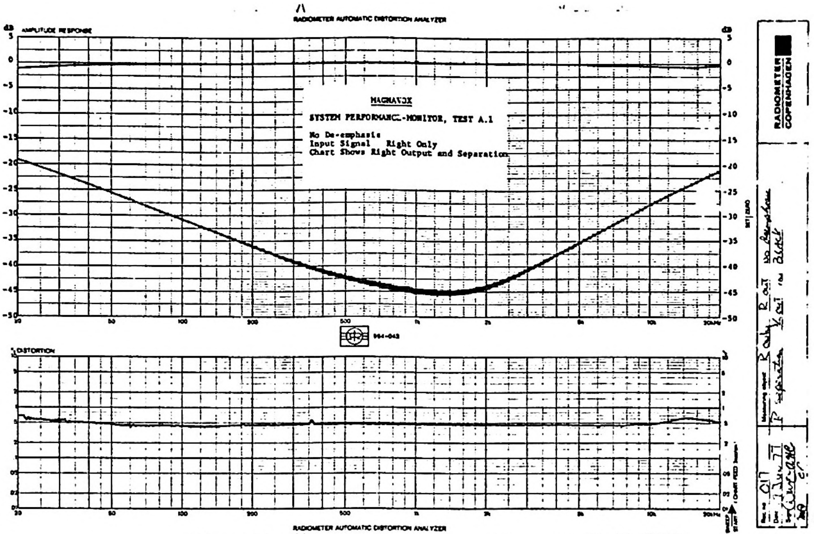
No De-emphasis
Pilot Tone On
Input Signal Left Only
Chart Shows Left Output and Separation



BELAR

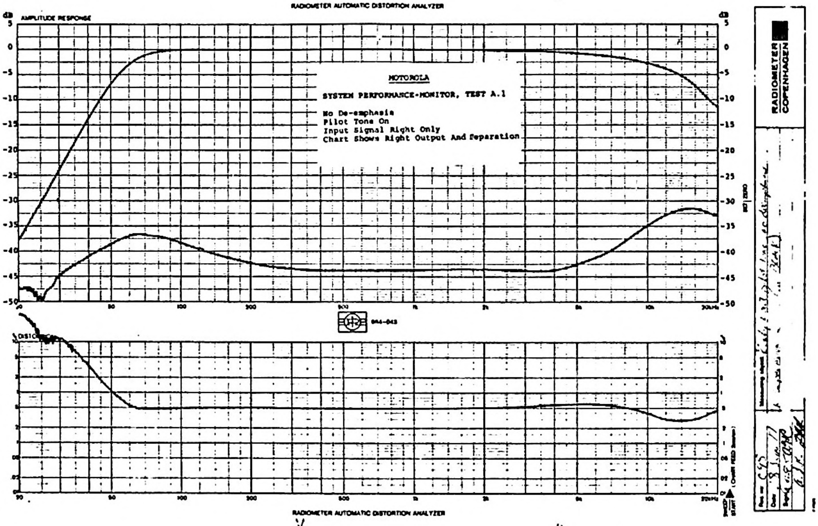
SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
Input Signal Left Only
Chart Shows Left Output and Separation


MAGNAVOX

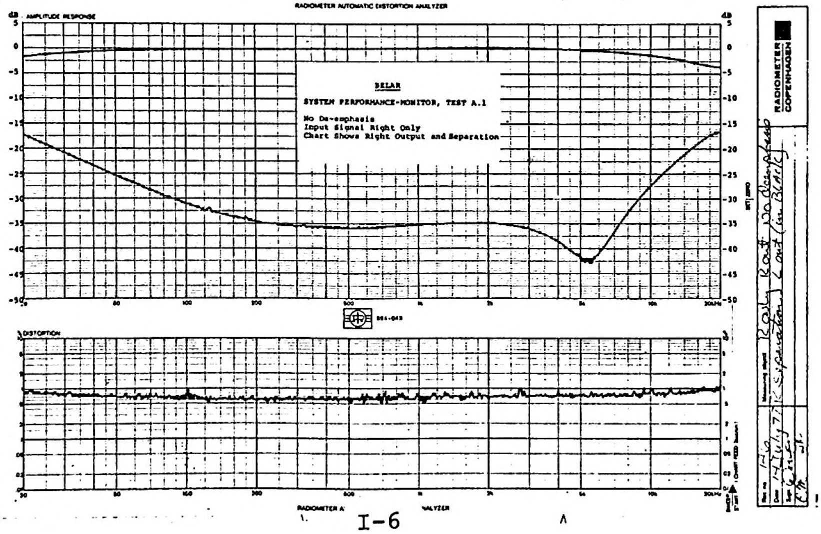
SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
Input Signal Right Only
Chart Shows Right Output and Separation


MOTOROLA

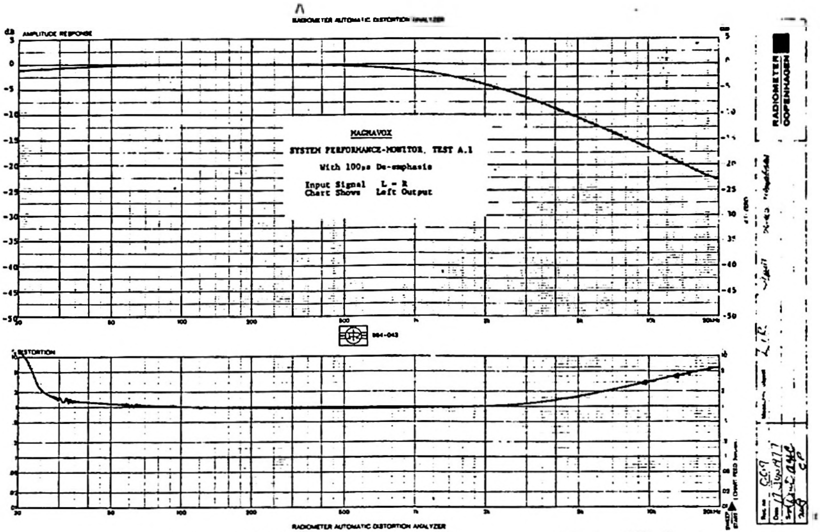
SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
Pilot Tone On
Input Signal Right Only
Chart Shows Right Output And Separation


BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
Input Signal Right Only
Chart Shows Right Output and Separation

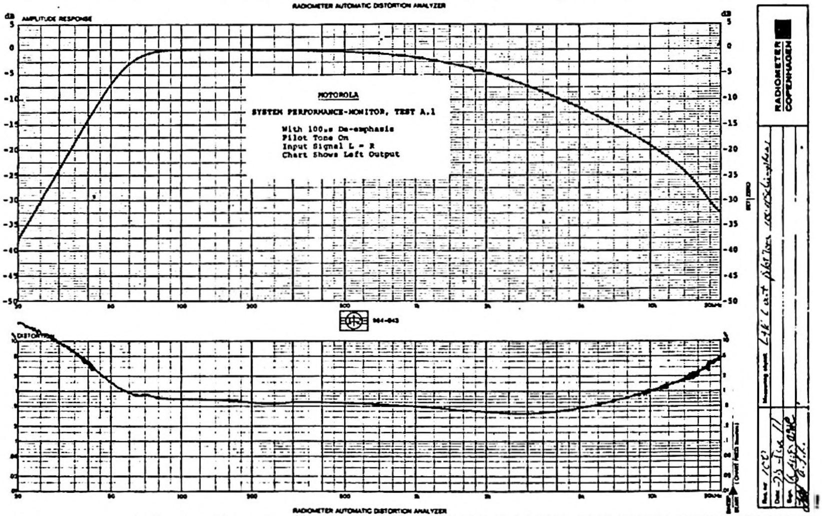


MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100μs De-emphasis

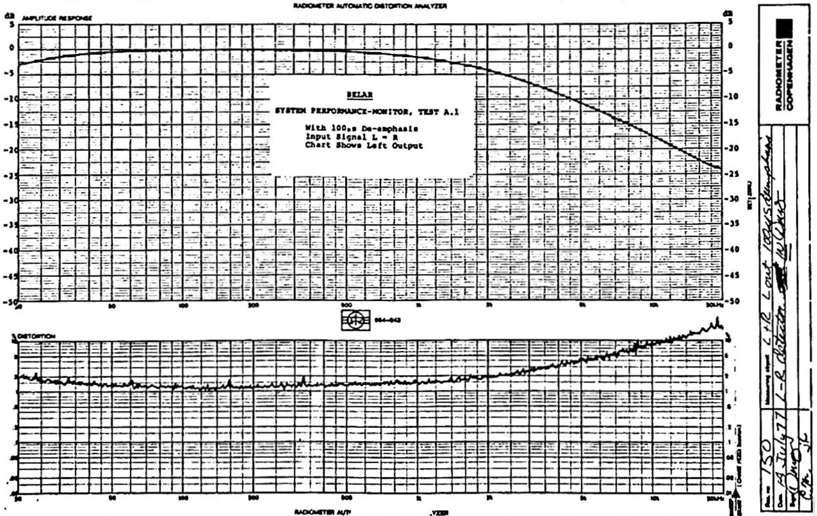
Input Signal L = R
Chart Shows Left Output



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

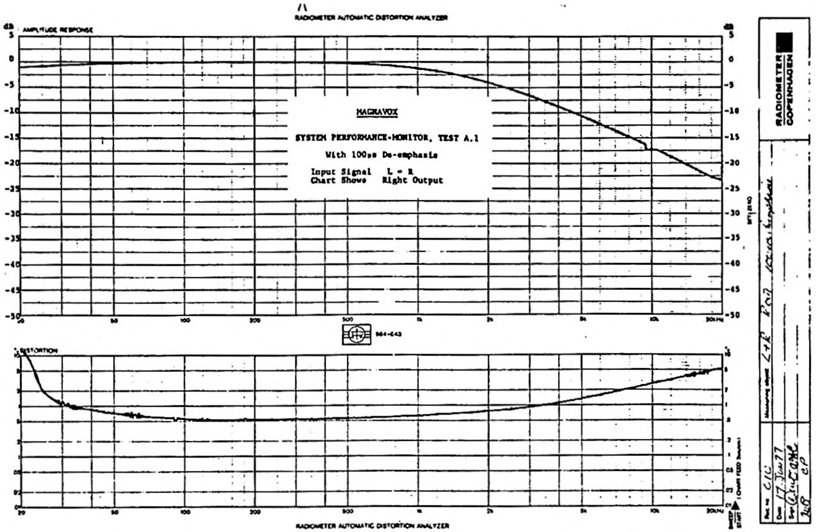
With 100μs De-emphasis
Pilot Tone On
Input Signal L = R
Chart Shows Left Output



BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100μs De-emphasis
Input Signal L = R
Chart Shows Left Output

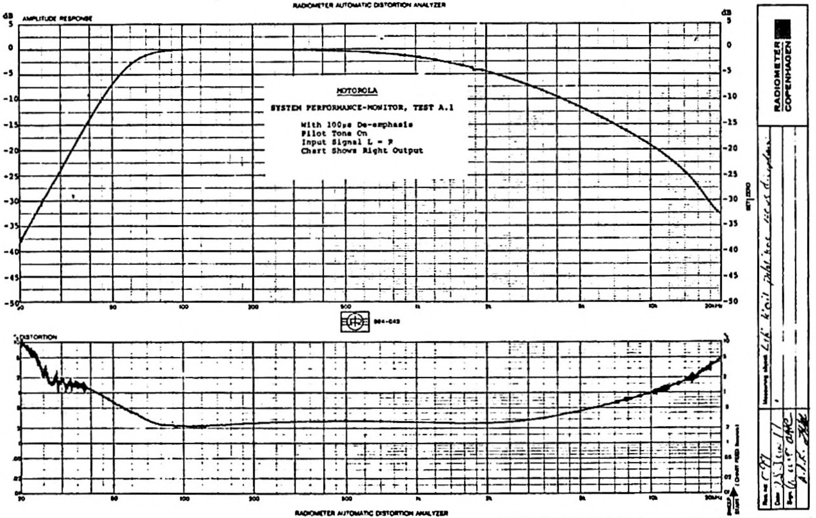


MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100μs De-emphasis

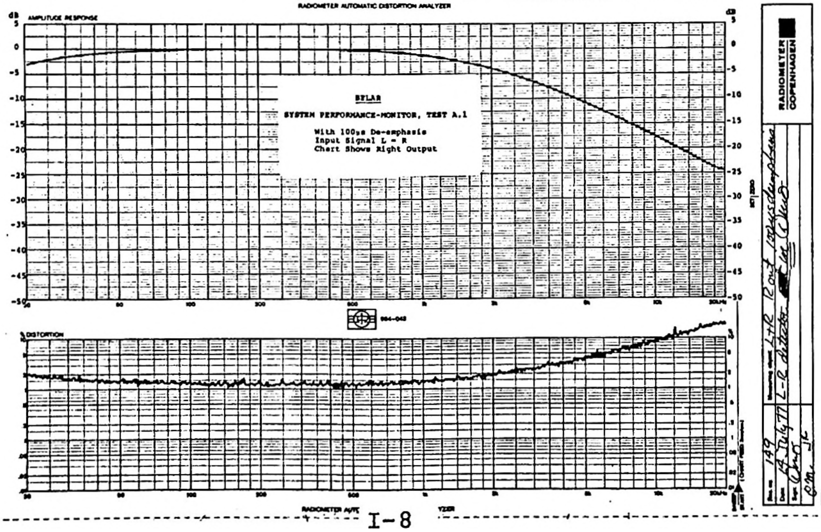
Input Signal L = R
Chart Shows Right Output



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

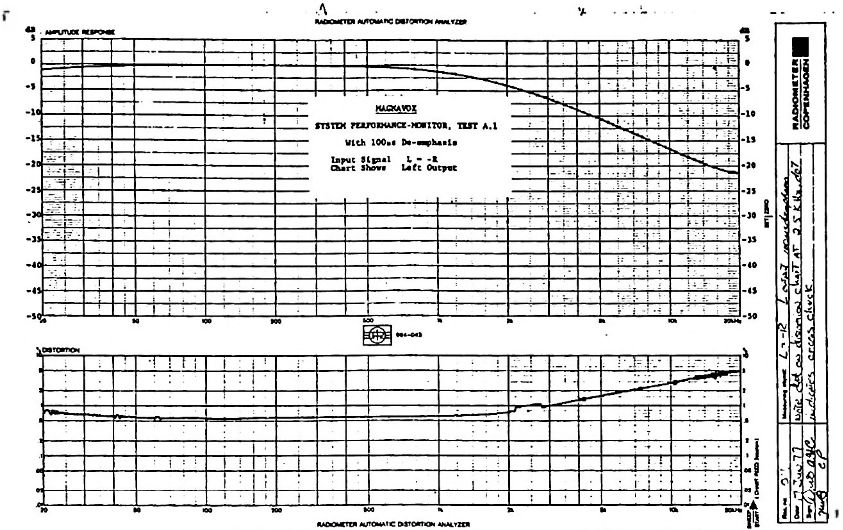
With 100μs De-emphasis
Pilot Tone On
Input Signal L = R
Chart Shows Right Output

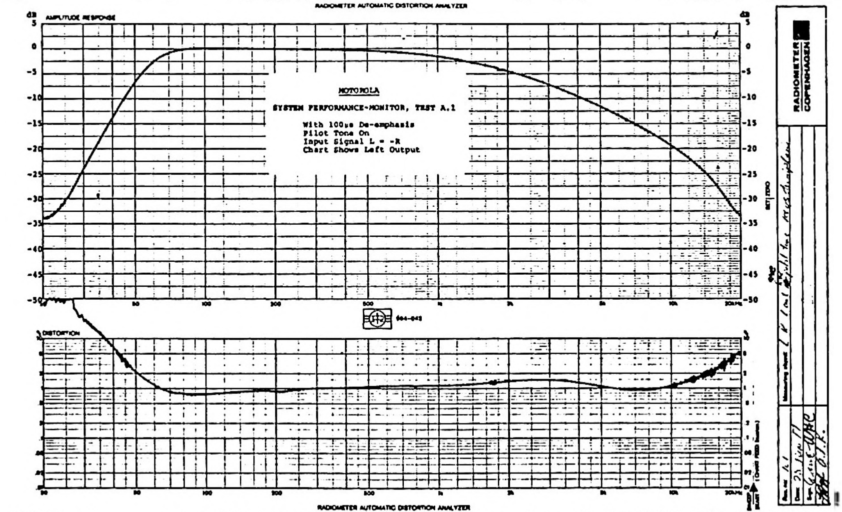


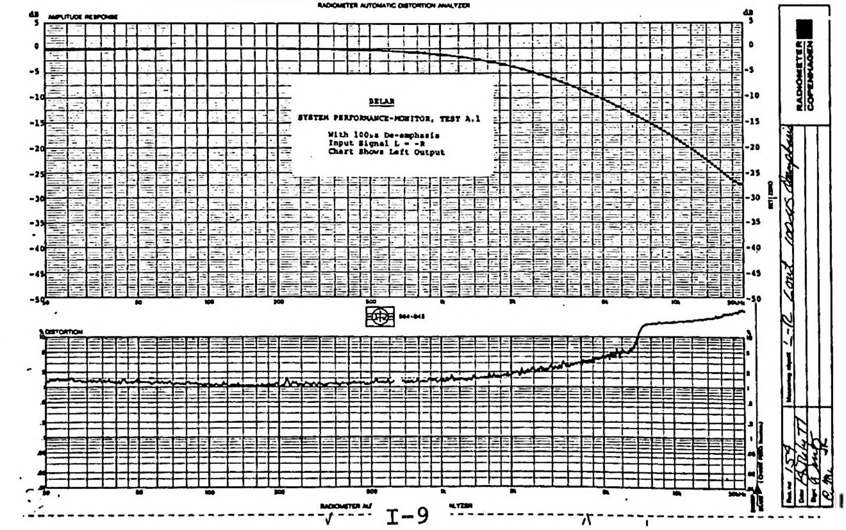
BYLAB

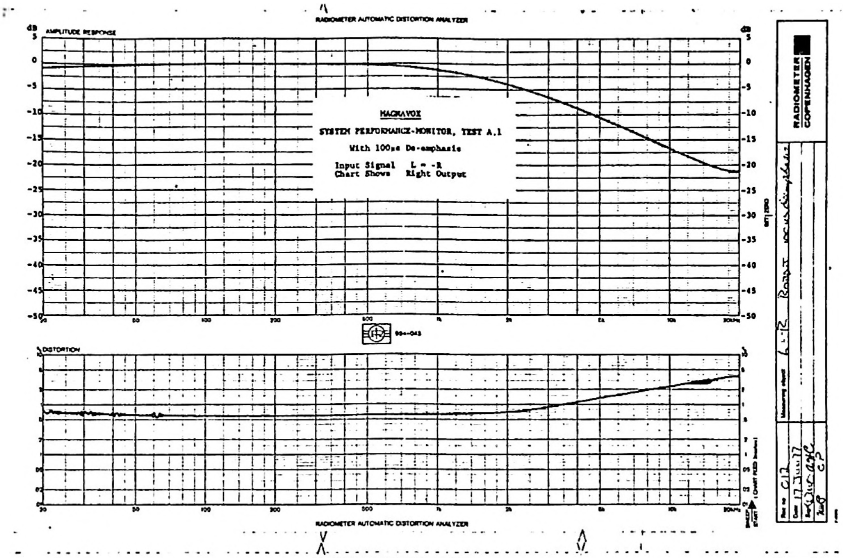
SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100μs De-emphasis
Input Signal L = R
Chart Shows Right Output


RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
MAGNAVOX
SYSTEM PERFORMANCE-MONITOR, TEST A.1
With 100µs De-emphasis
Input Signal L = -R
Chart Shows Left Output
DISTORTION
RADIOMETER COPENHAGEN
L = -R Lout
dot on distortion chart AT 2.5 KHz
indicates cross check
7 Jun 77
RADIOMETER AUTOMATIC DISTORTION ANALYZER


RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
MOTOROLA
SYSTEM PERFORMANCE-MONITOR, TEST A.1
With 100µs De-emphasis
Pilot Tone On
Input Signal L = -R
Chart Shows Left Output
DISTORTION
RADIOMETER COPENHAGEN
L R Lout pilot tone 100µS deemphasis
23 Jun 77
RADIOMETER AUTOMATIC DISTORTION ANALYZER


RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
BELAR
SYSTEM PERFORMANCE-MONITOR, TEST A.1
With 100µs De-emphasis
Input Signal L = -R
Chart Shows Left Output
DISTORTION
RADIOMETER COPENHAGEN
L=-R Lout 100µS deemphasis
154
RADIOMETER AUTOMATIC DISTORTION ANALYZER

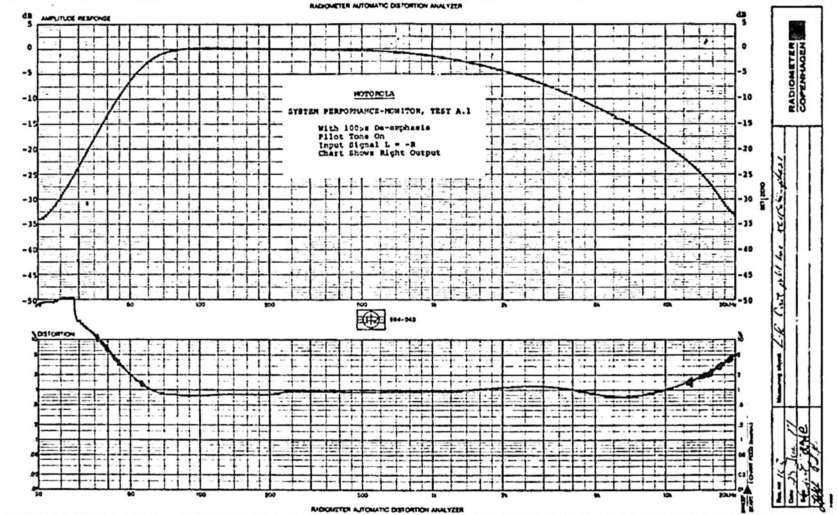


MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100μs De-emphasis

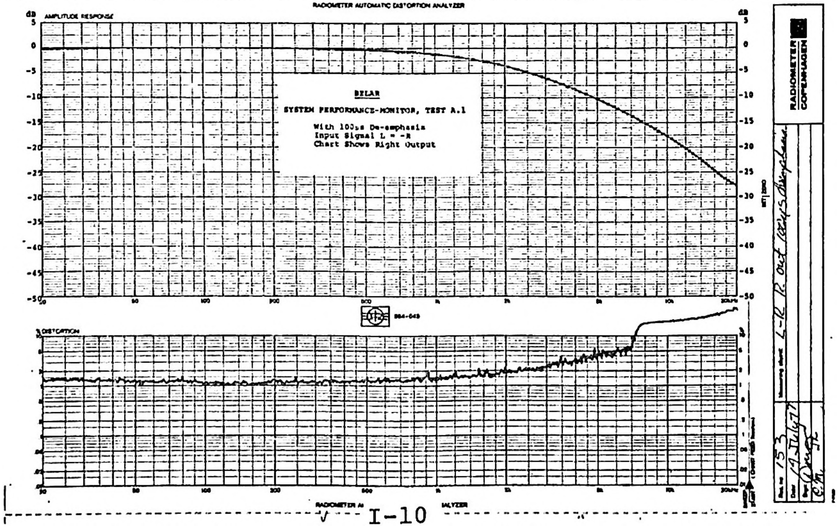
Input Signal   L = -R
Chart Shows   Right Output



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

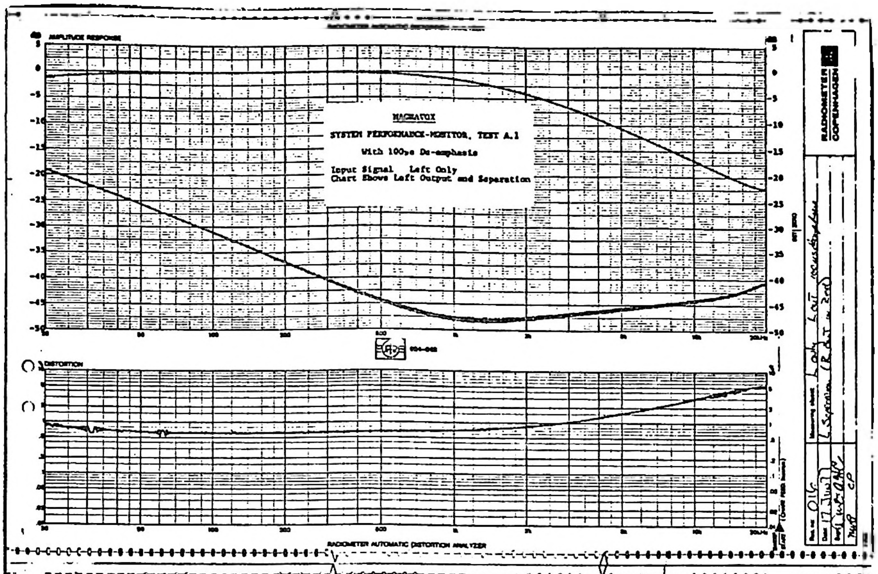
With 100μs De-emphasis
Pilot Tone On
Input Signal L = -R
Chart Shows Right Output



BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100μs De-emphasis
Input Signal L = -R
Chart Shows Right Output

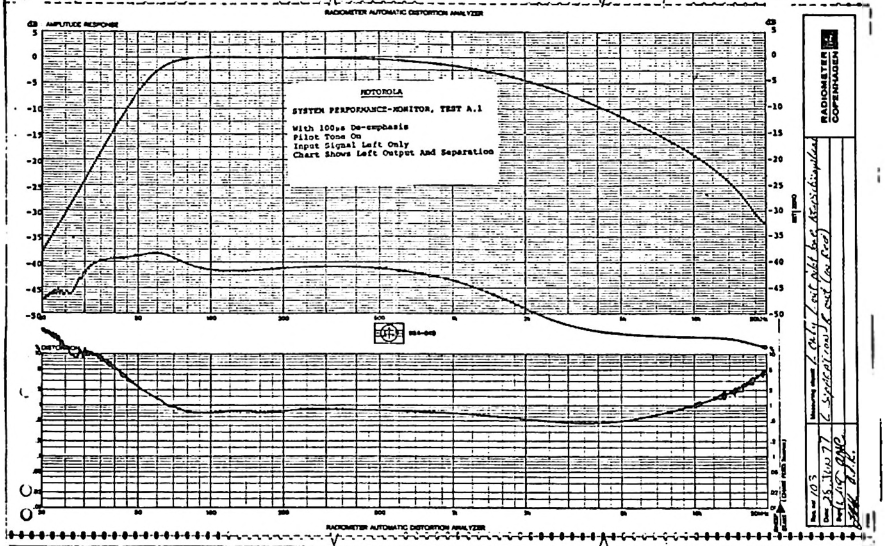


MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100µs De-emphasis

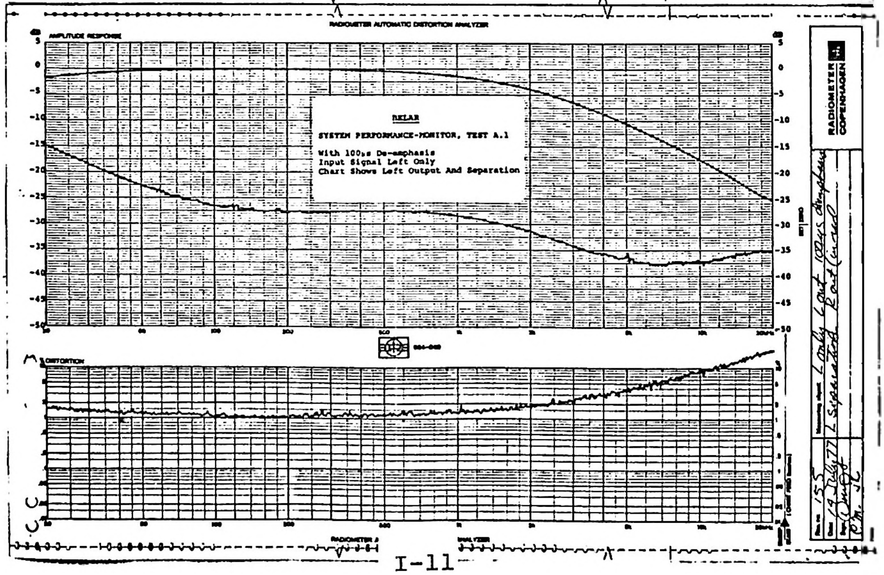
Input Signal Left Only
Chart Shows Left Output and Separation



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

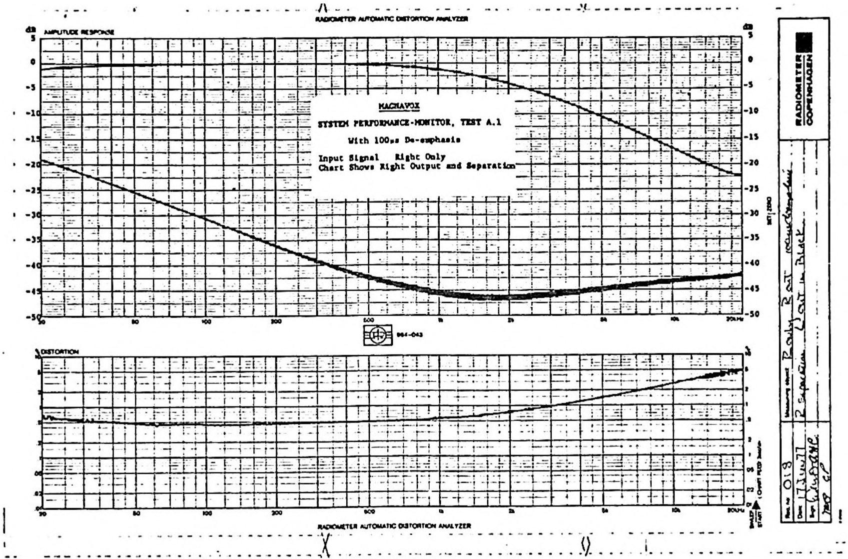
With 100µs De-emphasis
Pilot Tone On
Input Signal Left Only
Chart Shows Left Output And Separation



DELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100µs De-emphasis
Input Signal Left Only
Chart Shows Left Output And Separation



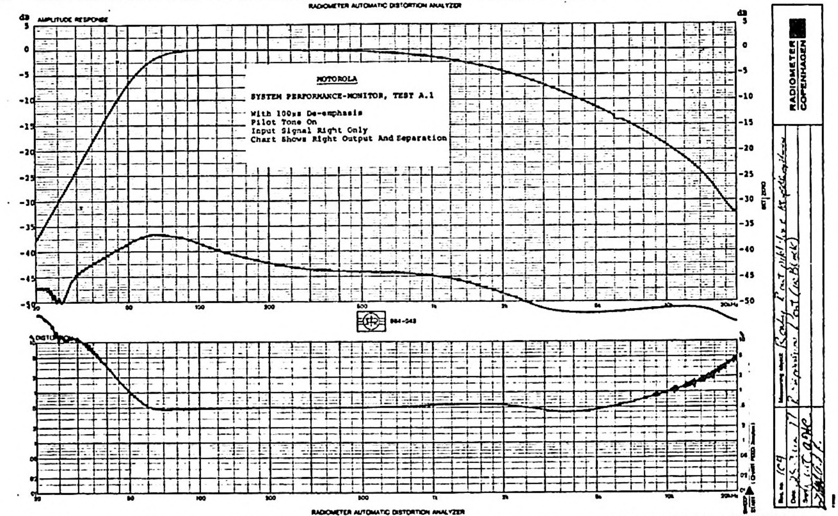
MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100µs De-emphasis

Input Signal Right Only
Chart Shows Right Output and Separation

Rec. no 018
Date 17 Jun 77
Measuring object R only R out 100µs deemphasis
R separation L out in Black

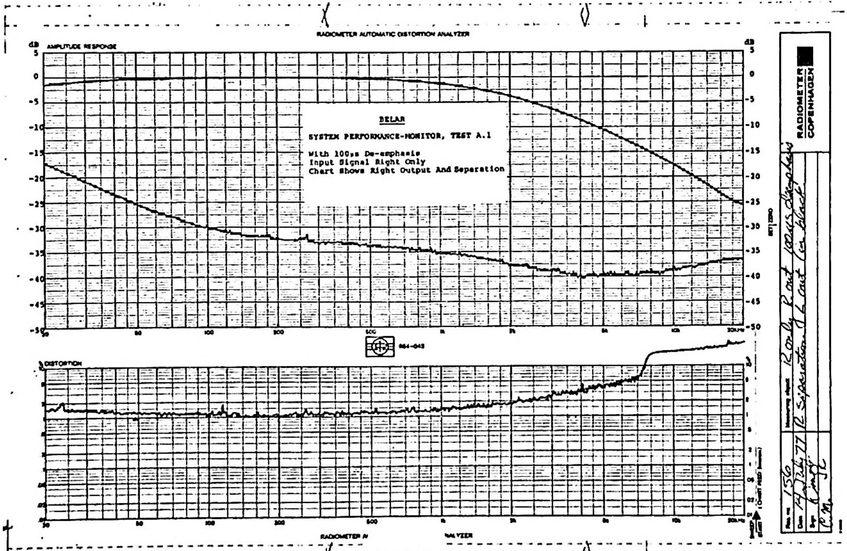


MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100µs De-emphasis
Pilot Tone On
Input Signal Right Only
Chart Shows Right Output And Separation

Rec. no 109
Date 25 Jun 77
Measuring object R only R out pilot tone [illegible]
R separation L out (in Black)

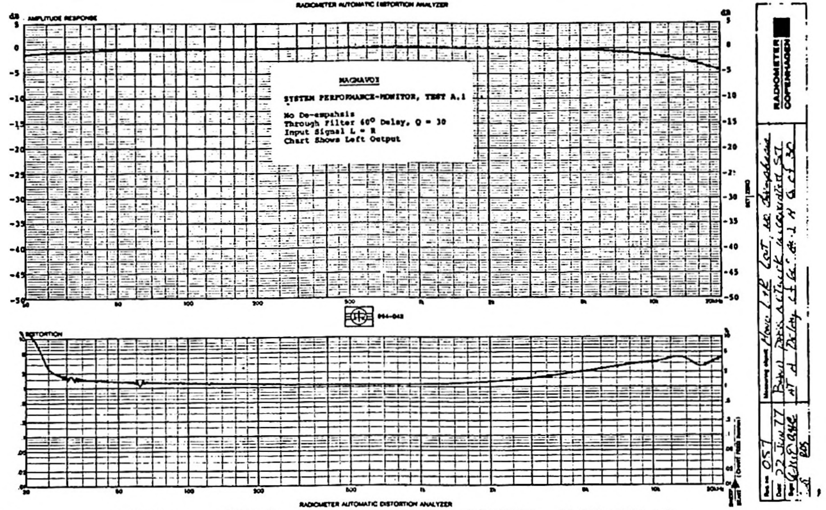


BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100µs De-emphasis
Input Signal Right Only
Chart Shows Right Output And Separation

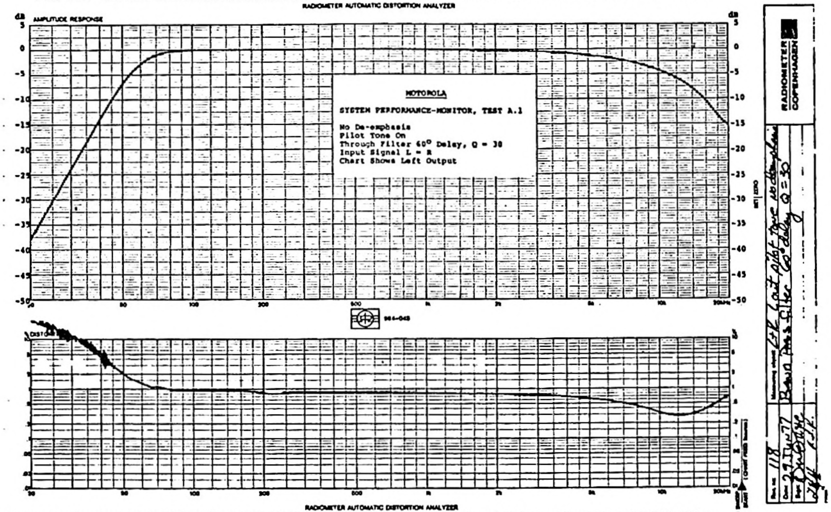
Rec. no 1560
Date 14 July 77
Measuring object R only R out 100µs deemphasis
R separation L out (in black)



MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

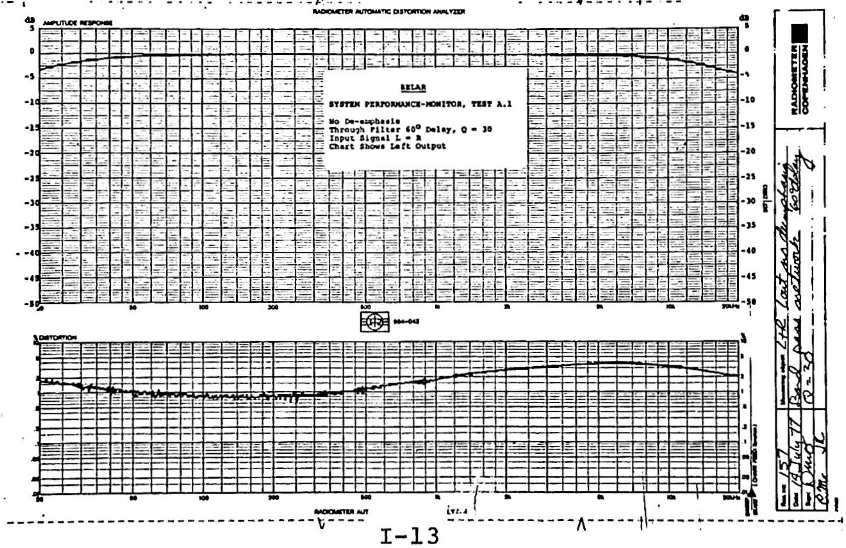
No De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal L = R
Chart Shows Left Output



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

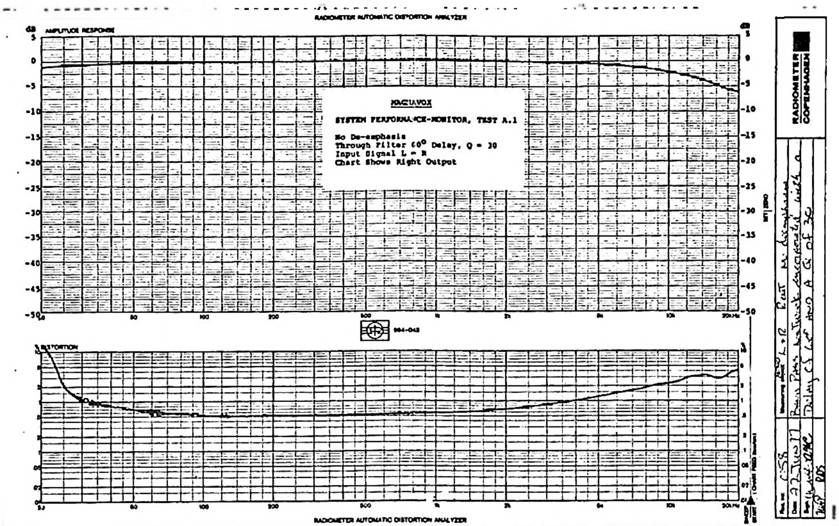
No De-emphasis
Pilot Tone On
Through Filter 60° Delay, Q = 30
Input Signal L = R
Chart Shows Left Output



BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal L = R
Chart Shows Left Output

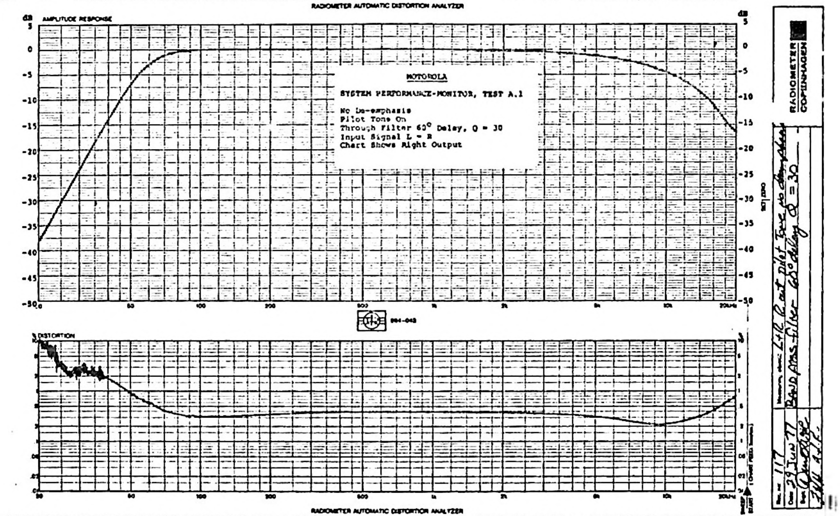


MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal L = R
Chart Shows Right Output

Rec. no. C58
Date 22 Jun 77
Measuring object L + R R out no deemphasis
Band Pass network connected with a
Delay of 60° and A Q of 30
RDS

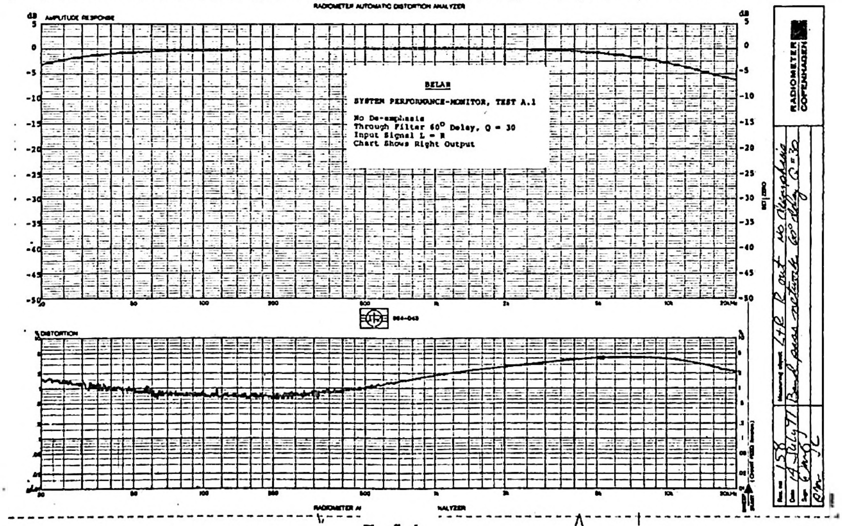


MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
Pilot Tone On
Through Filter 60° Delay, Q = 30
Input Signal L = R
Chart Shows Right Output

Rec. no. 117
Date 29 Jun 77
Measuring object L+R R out pilot Tone no deemphasis
Band pass filter 60° delay Q = 30

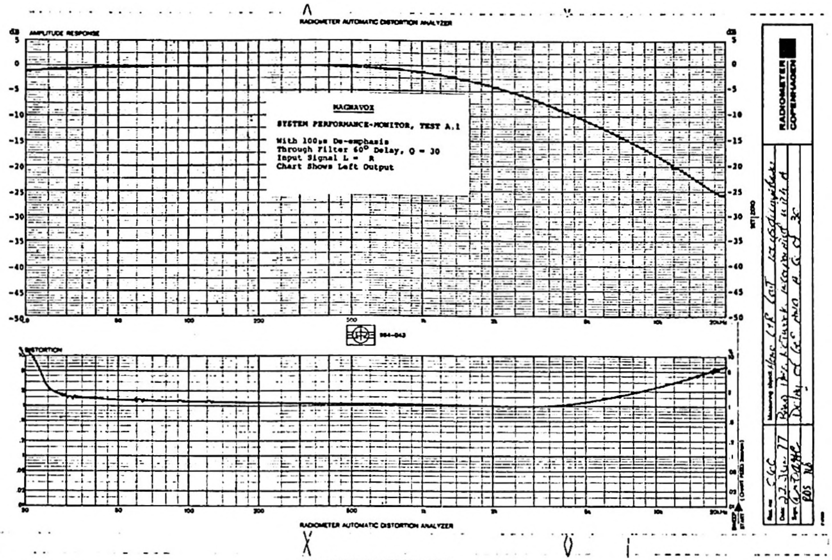


BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal L = R
Chart Shows Right Output

Rec. no. 158
Date 14 July 77
Measuring object L+R R out no deemphasis
Band pass network 60° delay Q = 30



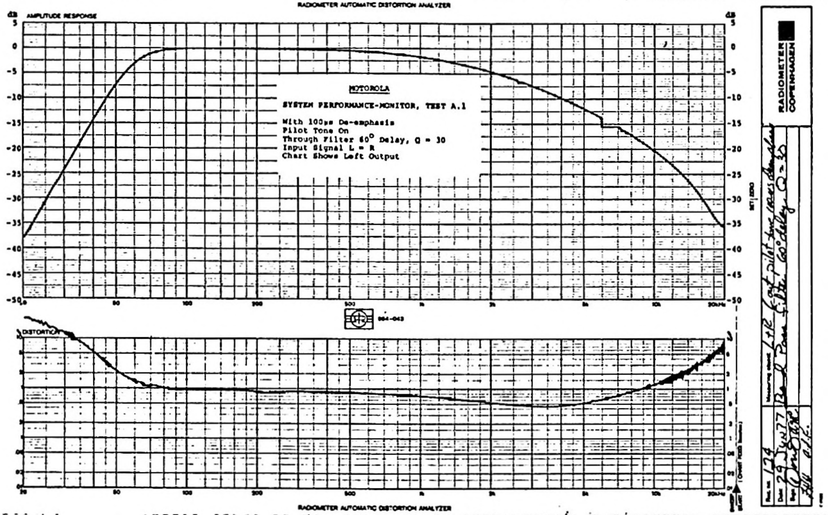
MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100µs De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal L = R
Chart Shows Left Output

Rec. no. 566
Date 22 Jun 77
RDS MB

Measuring object Mono L+R Lout 100µs deemphasis
Band Pass Network accompanied with a
Delay of 60° and a Q of 30



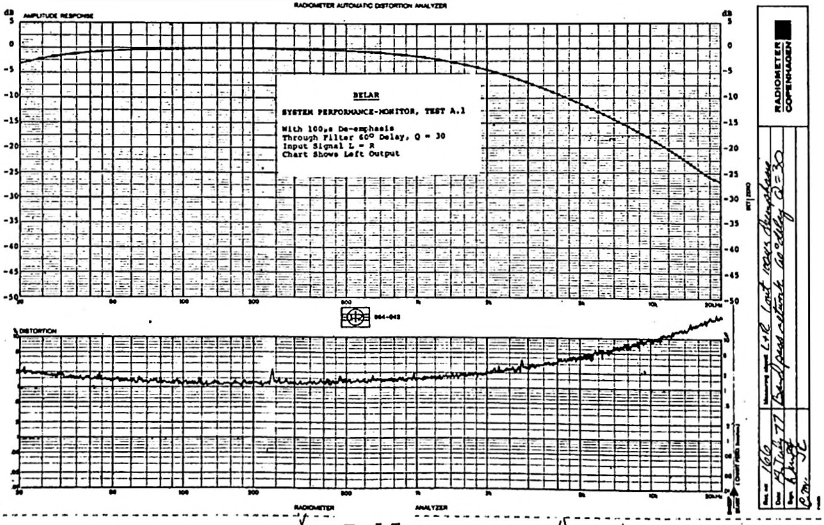
MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100µs De-emphasis
Pilot Tone On
Through Filter 60° Delay, Q = 30
Input Signal L = R
Chart Shows Left Output

Rec. no. 124
Date 29 JUN77
JHH e.l.f.

Measuring object L+R Lout pilot tone 100µs deemphasis
Band Pass filter 60° delay, Q = 30



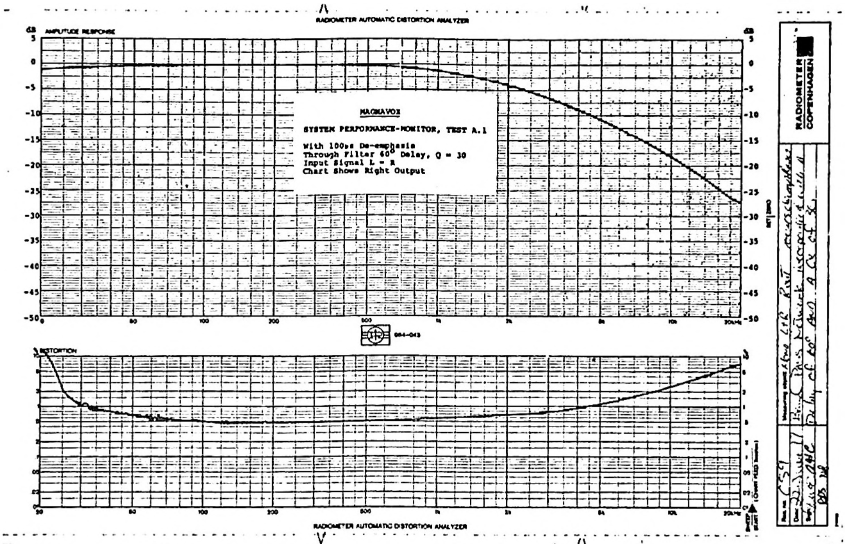
BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100µs De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal L = R
Chart Shows Left Output

Rec. no. 166
Date 14 July 77
C.M. JC

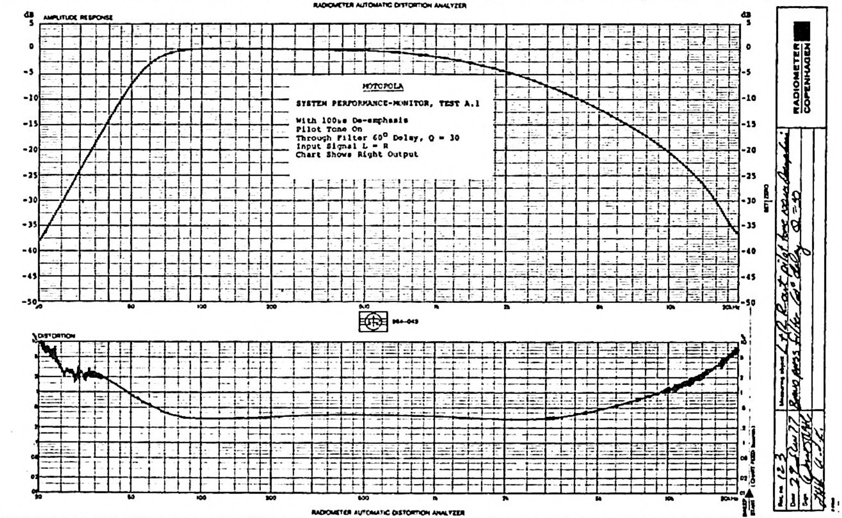
Measuring object L+R Lout 100µs deemphasis
Band pass network 60° delay Q=30



MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

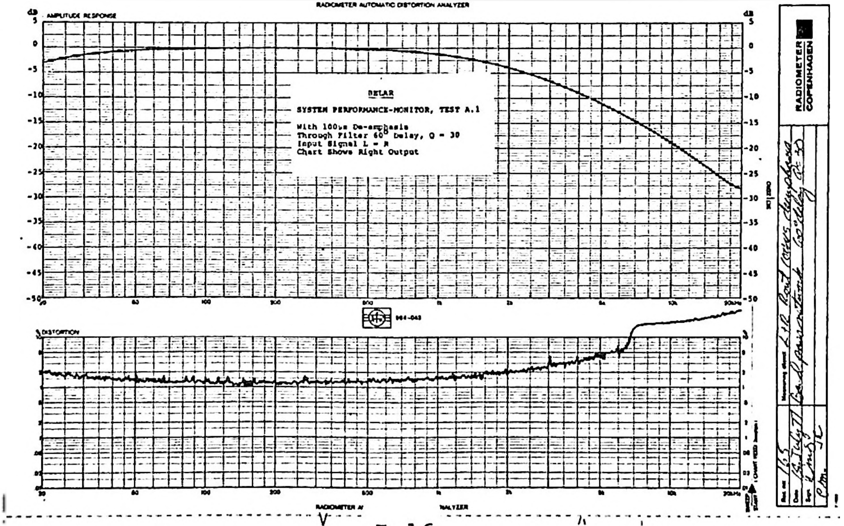
With 100μs De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal L = R
Chart Shows Right Output



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

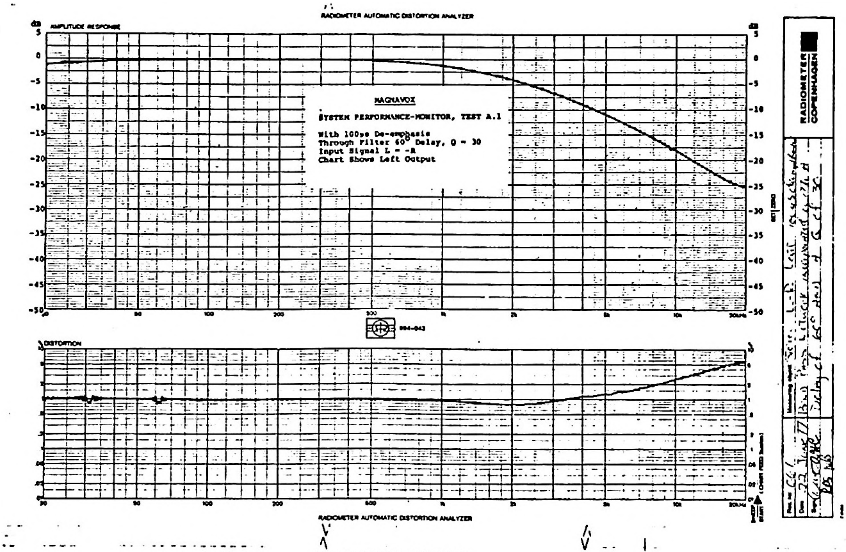
With 100μs De-emphasis
Pilot Tone On
Through Filter 60° Delay, Q = 30
Input Signal L = R
Chart Shows Right Output



BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100μs De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal L = R
Chart Shows Right Output

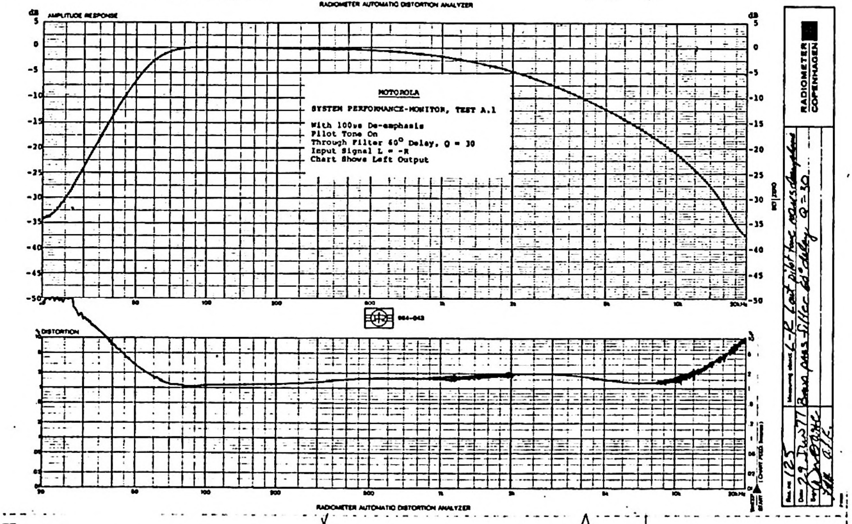


MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100μs De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal L = -R
Chart Shows Left Output

Rec. no. C4
Date 22 June 77
Measuring object: [illegible] L-R Left [illegible] de-emphasis
Band pass [illegible]
Delay of 60° deg & Q of 30

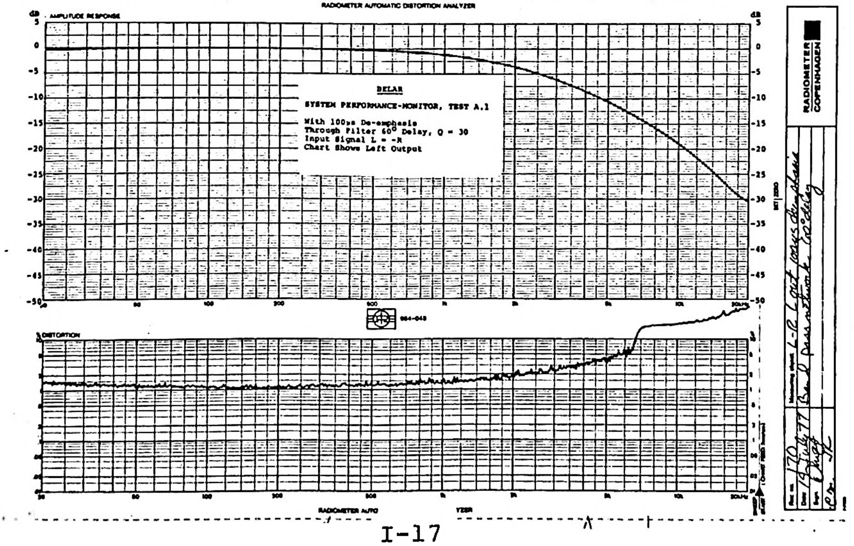


MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100μs De-emphasis
Pilot Tone On
Through Filter 60° Delay, Q = 30
Input Signal L = -R
Chart Shows Left Output

Rec. no. 125
Date 29 Jun 77
Measuring object: L-R Left pilot tone 100us de-emphasis
Band pass filter 60° delay Q = 30

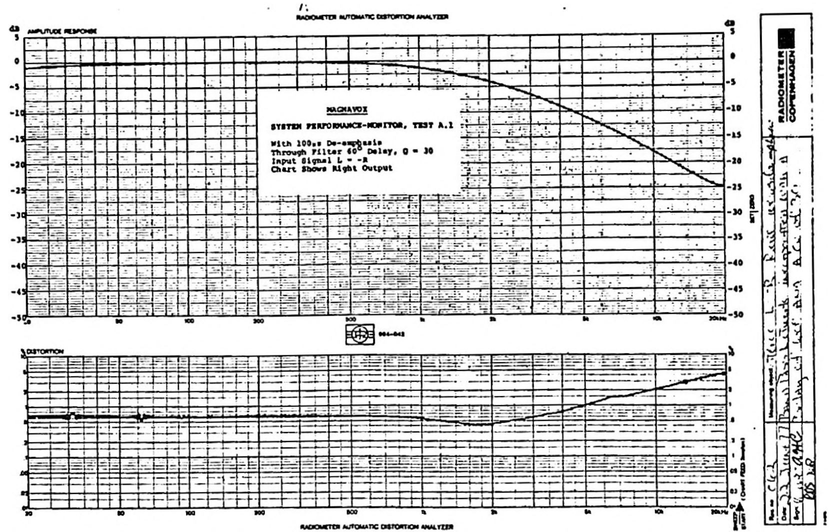


DELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100μs De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal L = -R
Chart Shows Left Output

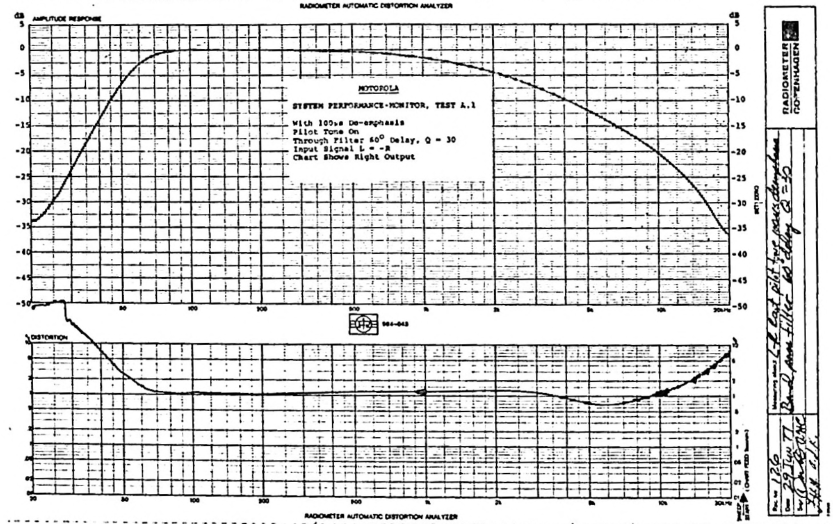
Rec. no. 170
Date 19 July 77
Measuring object: L-R Left out 100us de-emphasis
Band pass network 60° delay



MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

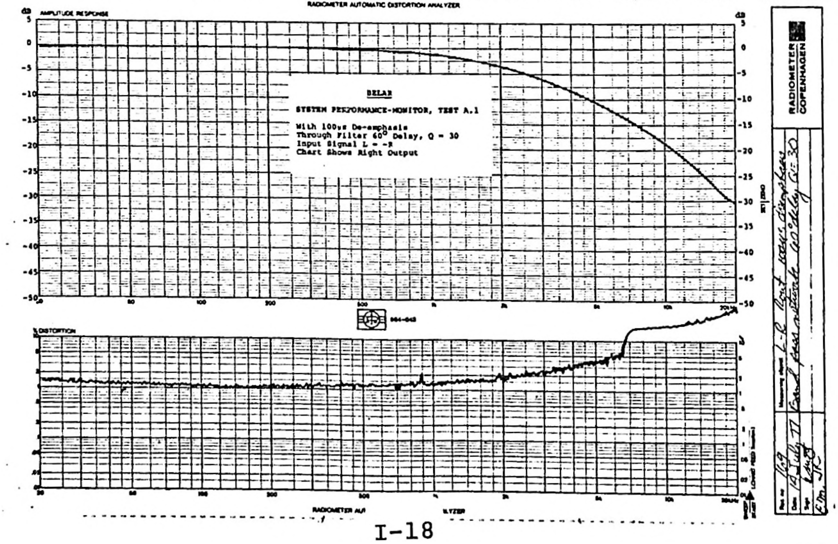
With 100µs De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal L = -R
Chart Shows Right Output



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

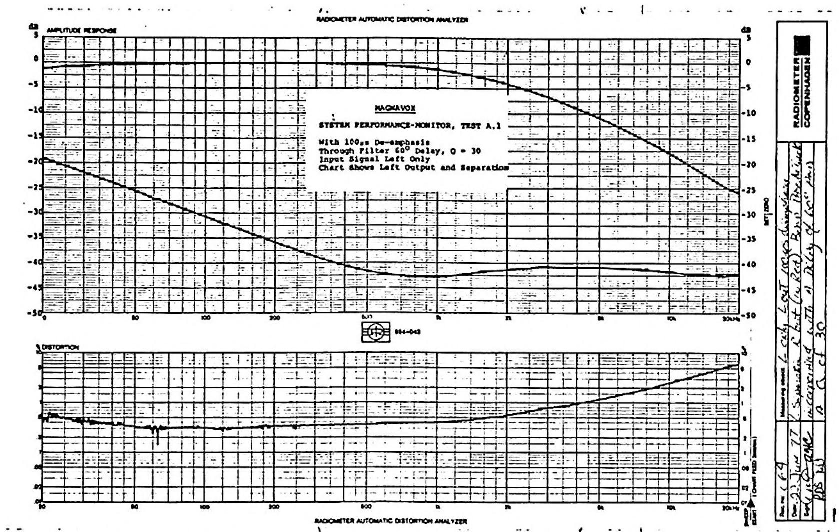
With 100µs De-emphasis
Pilot Tone On
Through Filter 60° Delay, Q = 30
Input Signal L = -R
Chart Shows Right Output



BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100µs De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal L = -R
Chart Shows Right Output

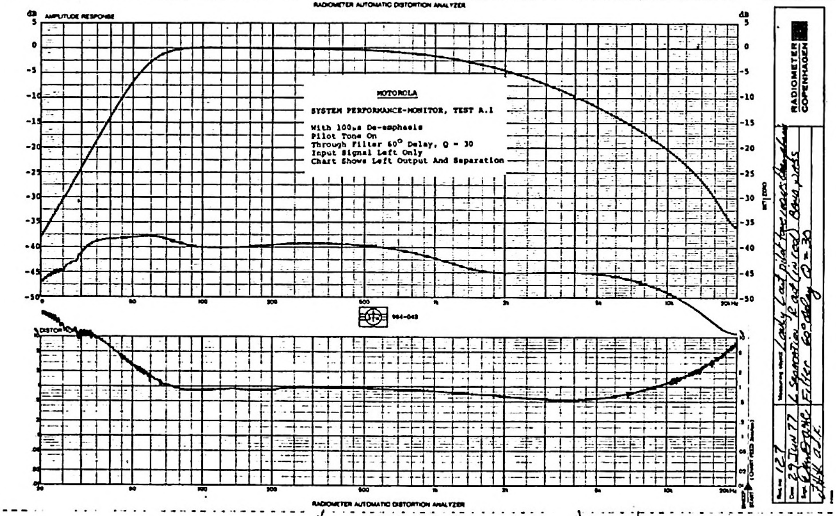


MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100μs De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal Left Only
Chart Shows Left Output and Separation

Run no. (6)4
Date 22 Jun 77
Measuring object: L only L out 100μs deemphasis
L separation R out (in Red) Base Band
incorporated with a Delay of 60° phase
a Q of 30

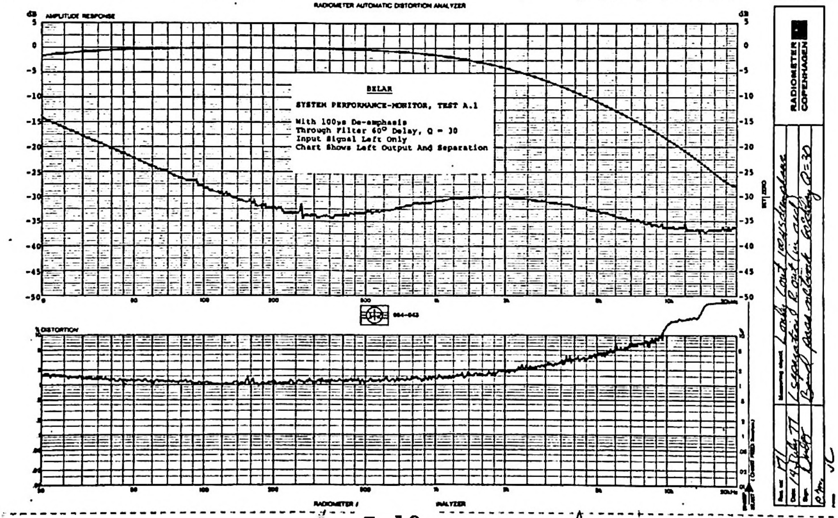


MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100μs De-emphasis
Pilot Tone On
Through Filter 60° Delay, Q = 30
Input Signal Left Only
Chart Shows Left Output And Separation

Run no. 127
Date 29 JUN 77
Measuring object: L only L out pilot tone 100μs deemphasis
L separation R out (in red) Base band with
Filter 60° delay Q = 30

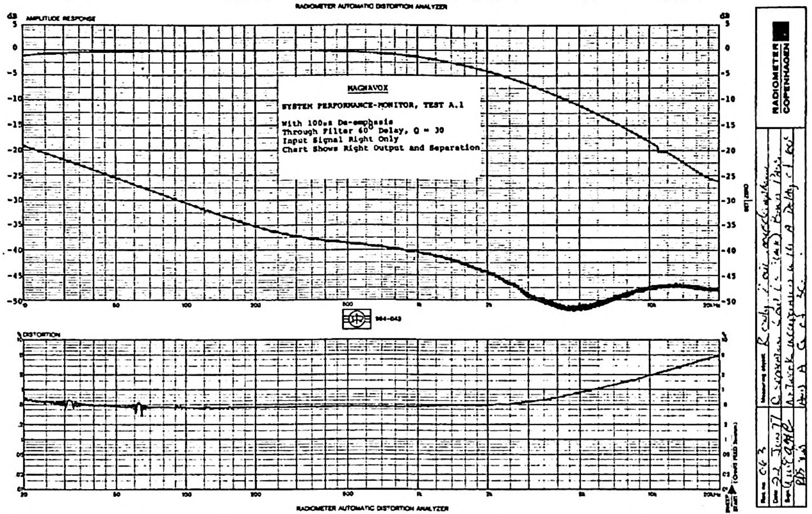


BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100μs De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal Left Only
Chart Shows Left Output And Separation

Run no. 71
Date 14 Jul 77
Measuring object: L only L out 100μs deemphasis
L separation R out (in red)
Band pass network 60° delay Q=30



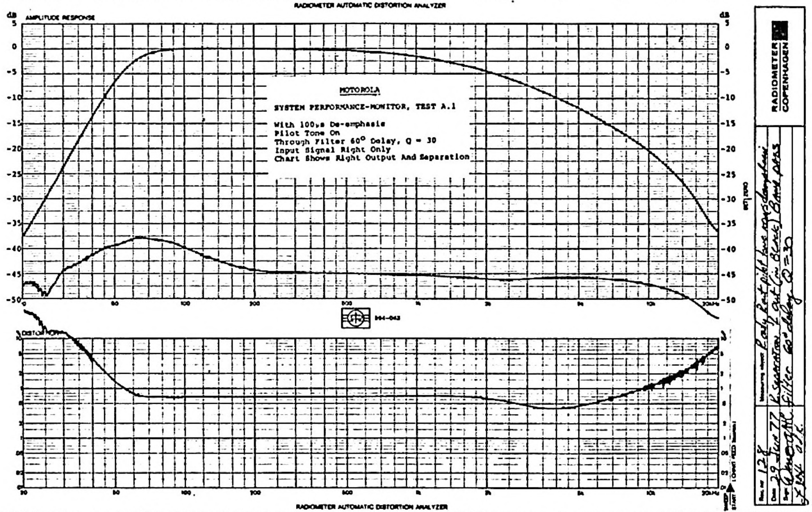
MAGNAVOX

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100µs De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal Right Only
Chart Shows Right Output and Separation

Rec. no 063
Date 22 Jun 77
Sign. [illegible]
RDS [illegible]

Measuring object R only in out [illegible]
L separation L out (in black) Band Pass
network [illegible] with A Delay of 60°
and A Q of 30.



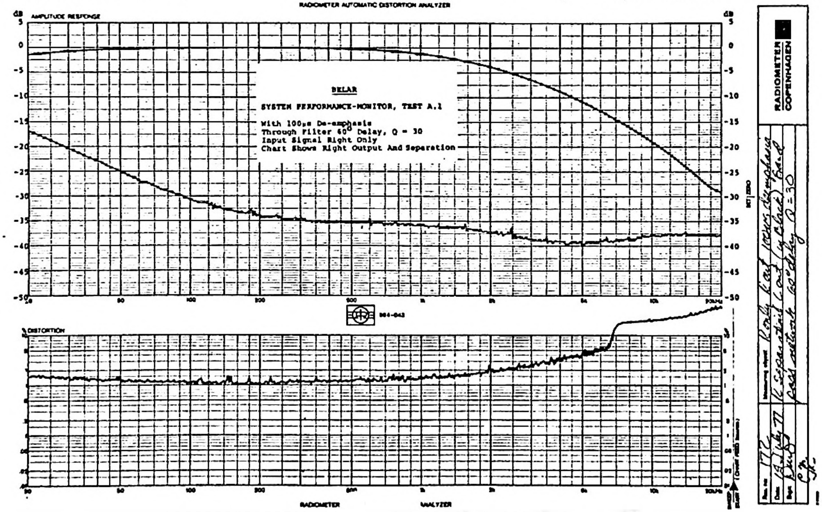
MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100µs De-emphasis
Pilot Tone On
Through Filter 60° Delay, Q = 30
Input Signal Right Only
Chart Shows Right Output And Separation

Rec. no 128
Date 29 Jun 77
Sign. [illegible]
[illegible] O.K.

Measuring object R only R out pilot tone on, de-emphasis
R separation L out (in Black) Band pass
filter 60° delay Q=30



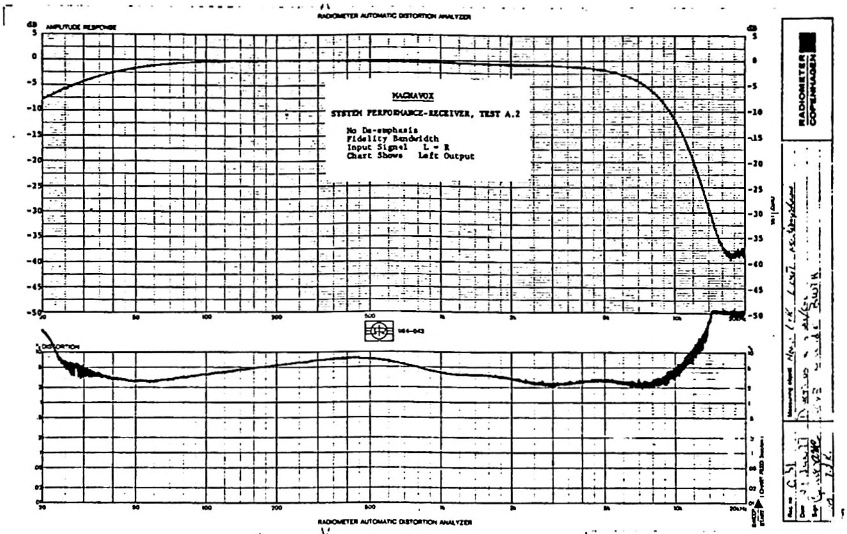
DELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100µs De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal Right Only
Chart Shows Right Output And Separation

Rec. no 172
Date 13 July 77
Sign. [illegible]
C.R.

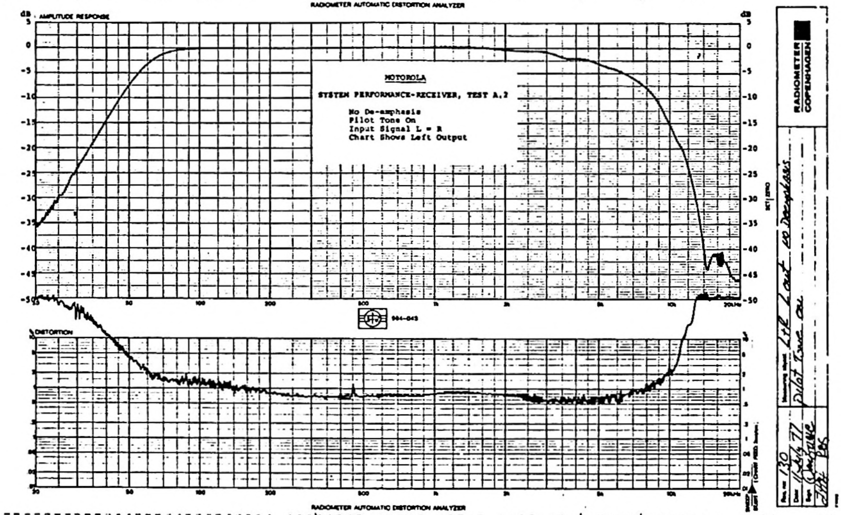
Measuring object R only R out 100µs de-emphasis
R Separation L out (in Black) Band
pass network 60° delay Q=30



MAGNAVOX

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

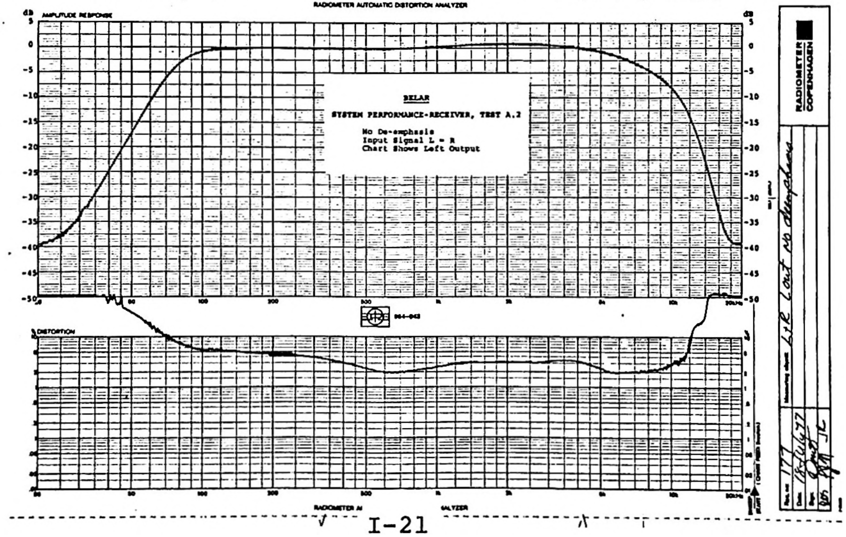
No De-emphasis
Fidelity Bandwidth
Input Signal L = R
Chart Shows Left Output



MOTOROLA

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

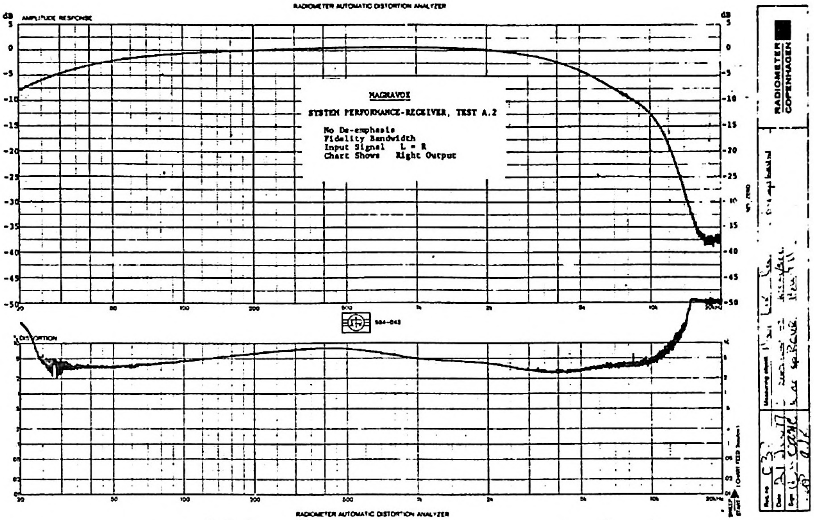
No De-emphasis
Pilot Tone On
Input Signal L = R
Chart Shows Left Output



BELAR

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

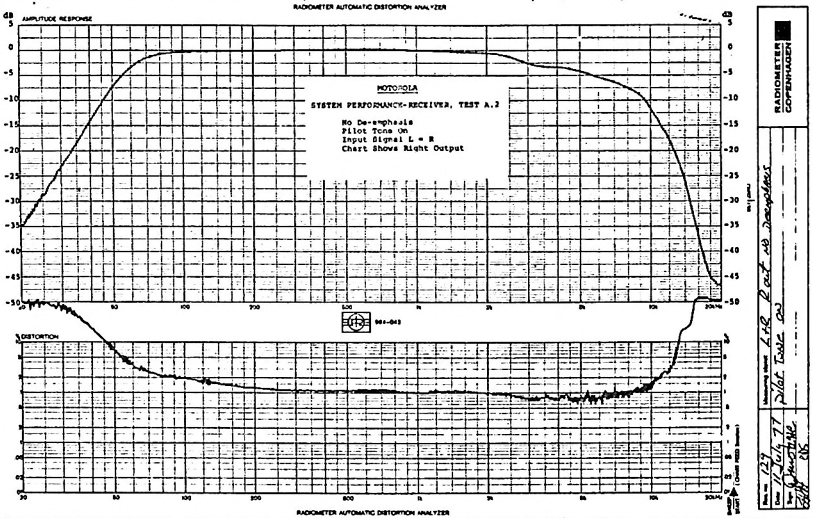
No De-emphasis
Input Signal L = R
Chart Shows Left Output



MAGNAVOX

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

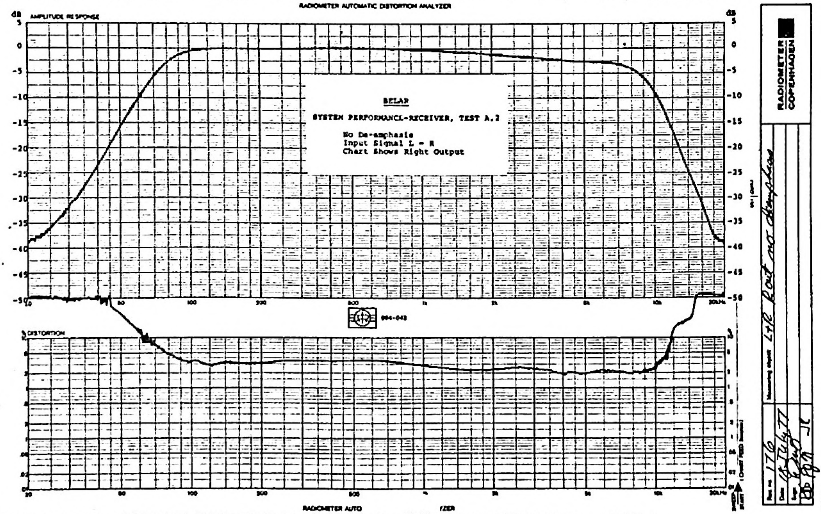
No De-emphasis
Fidelity Bandwidth
Input Signal   L = R
Chart Shows   Right Output



MOTOROLA

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

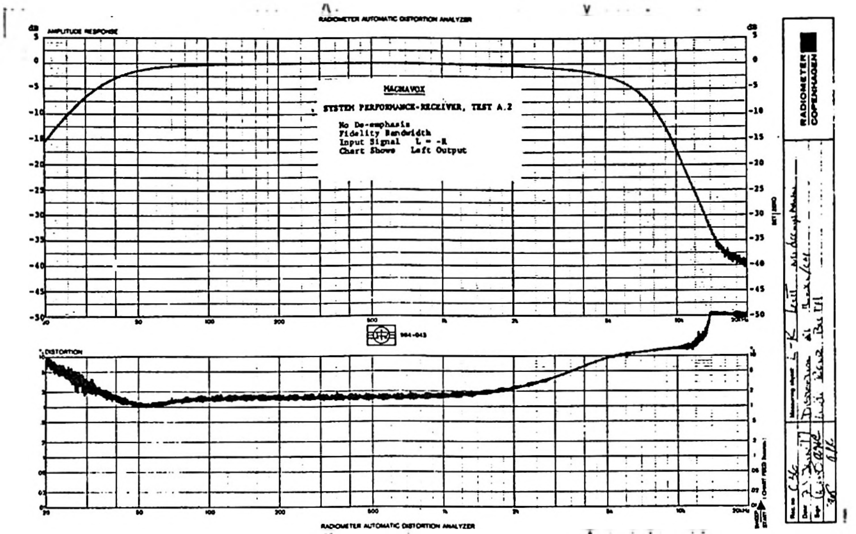
No De-emphasis
Pilot Tone On
Input Signal L = R
Chart Shows Right Output



BELAR

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

No De-emphasis
Input Signal L = R
Chart Shows Right Output

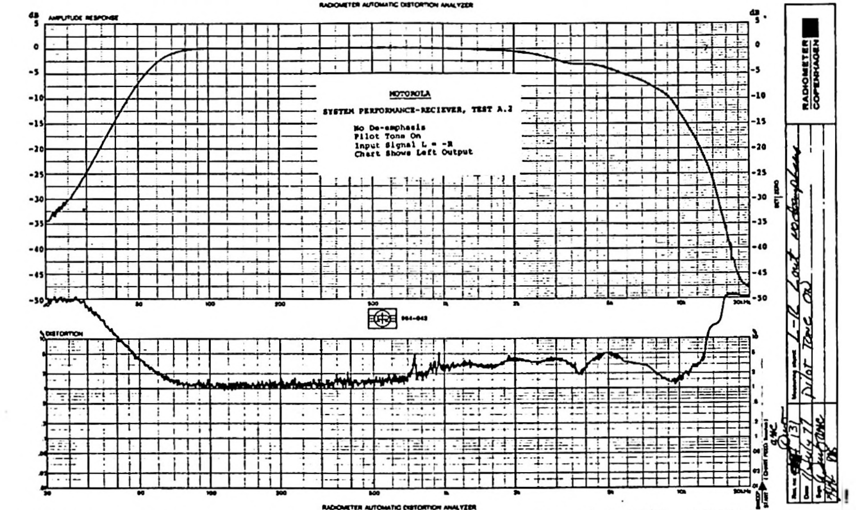


MAGNAVOX

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

No De-emphasis
Fidelity Bandwidth
Input Signal L = -R
Chart Shows Left Output

Rec. no C46
Date 21 Jun 77
Sign [illegible]
Measuring object L-R Lout no deemphasis
Distortion at [illegible]

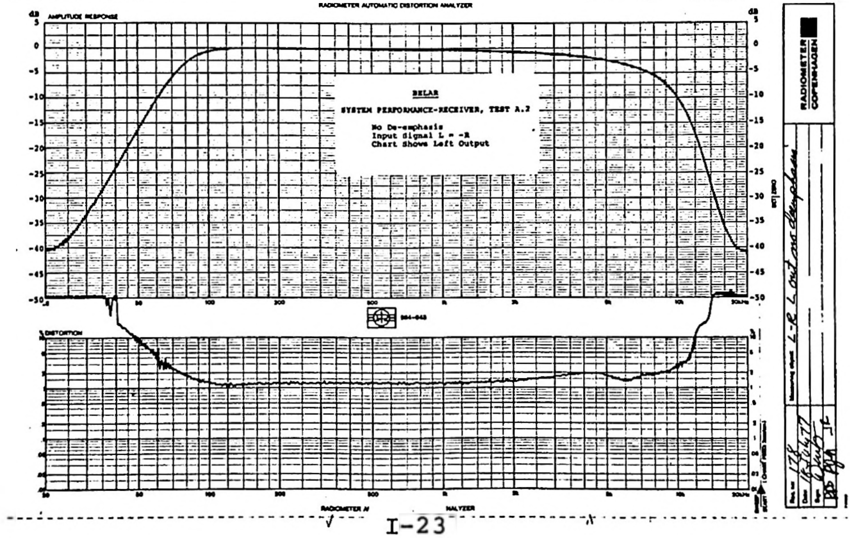


MOTOROLA

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

No De-emphasis
Pilot Tone On
Input Signal L = -R
Chart Shows Left Output

Rec. no 131
Date 7 July 77
Sign [illegible]
Measuring object L-R Lout no deemphasis
Pilot Tone On

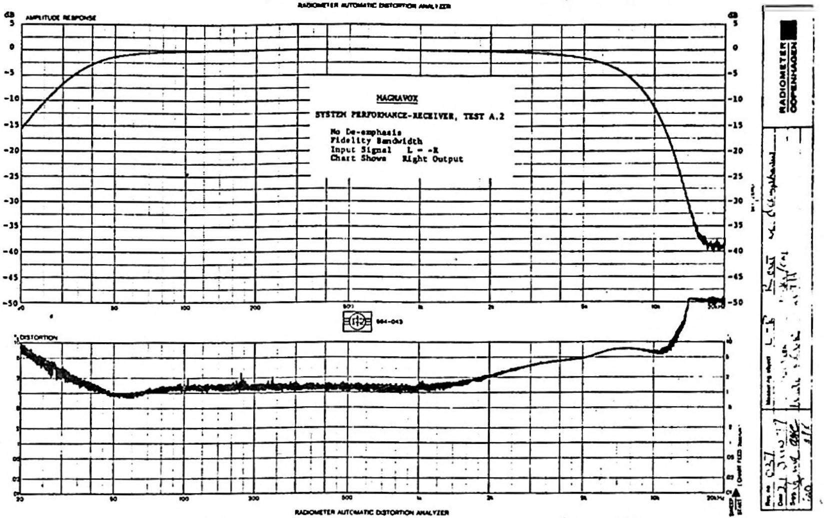


BELAR

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

No De-emphasis
Input Signal L = -R
Chart Shows Left Output

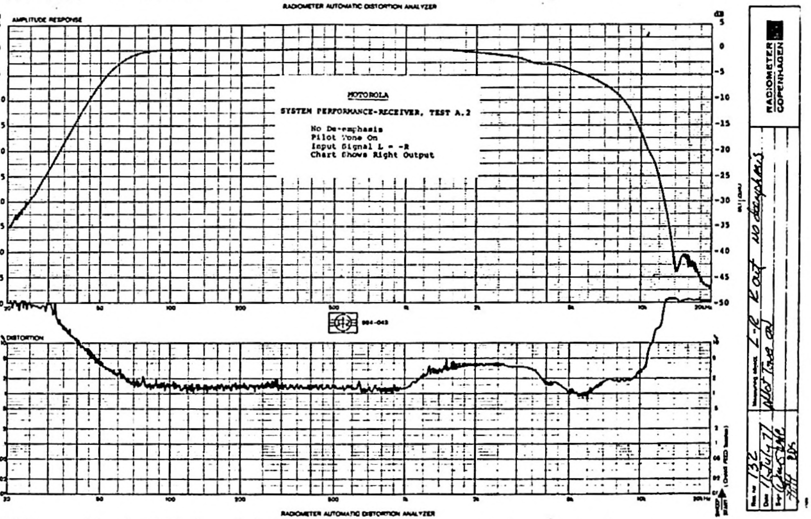
Rec. no 178
Date 18 July 77
Sign [illegible]
Measuring object L-R L out no deemphasis



MAGNAVOX

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

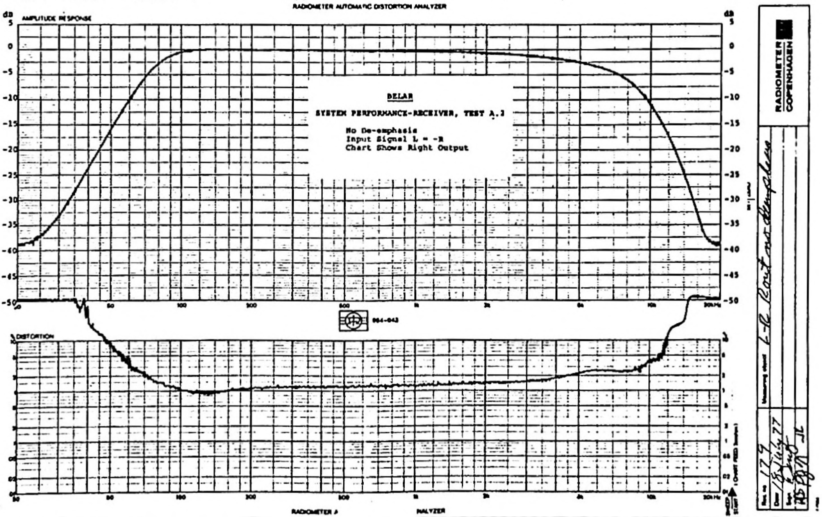
No De-emphasis
Fidelity Bandwidth
Input Signal L = -R
Chart Shows Right Output



MOTOROLA

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

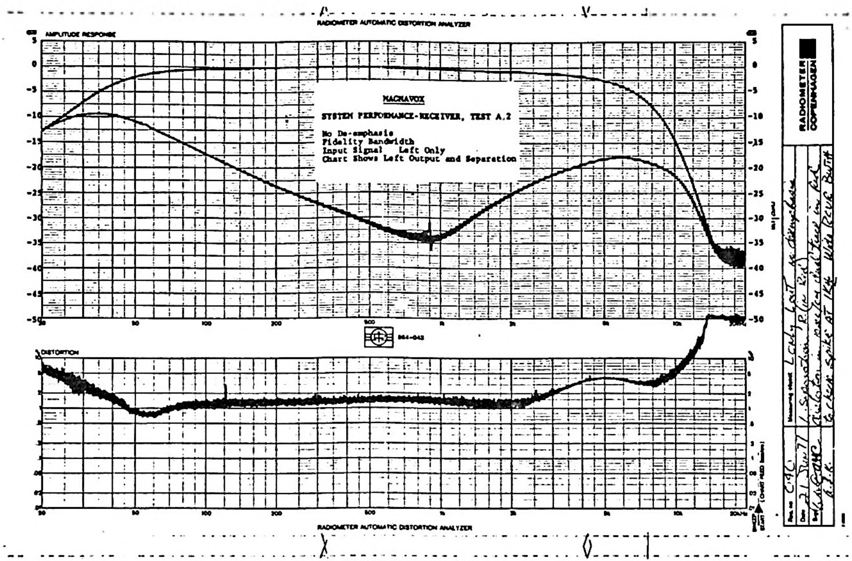
No De-emphasis
Pilot Tone On
Input Signal L = -R
Chart Shows Right Output



BELAR

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

No De-emphasis
Input Signal L = -R
Chart Shows Right Output



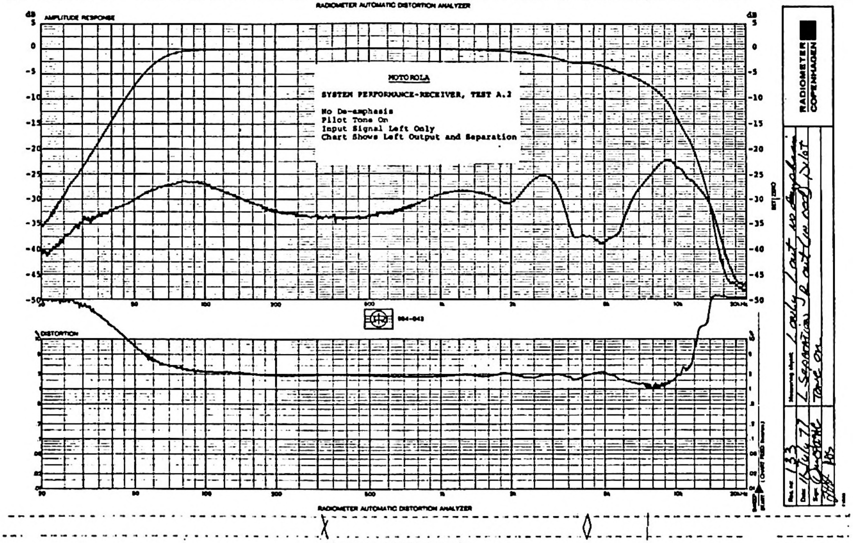
MAGNAVOX

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

No De-emphasis
Fidelity Bandwidth
Input Signal Left Only
Chart Shows Left Output and Separation

Rec. no C4C
Date 21 Jun 77
Sign
A.J.K.

Measuring object L only L out no de-emphasis
L Separation R (in Red)
Distortion in pen/on dual trace in Red
to check spike AT 1KHz Wide RCVR BWTH



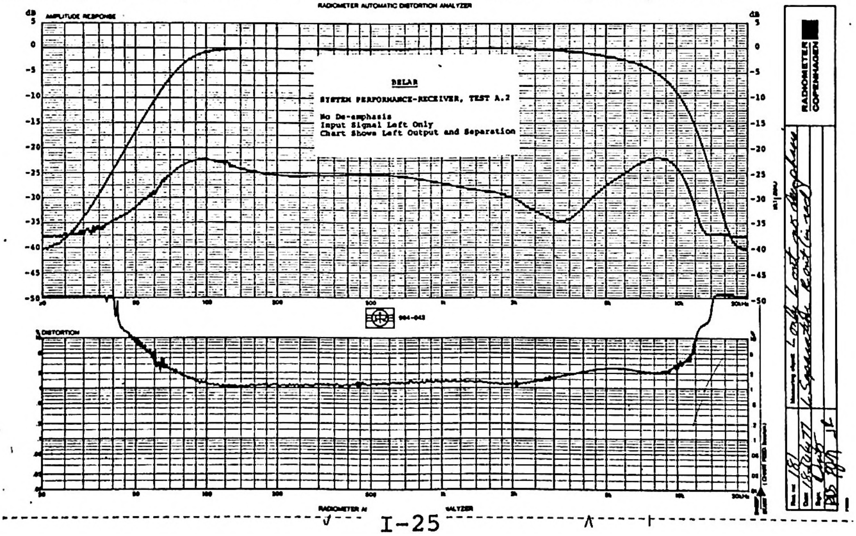
MOTOROLA

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

No De-emphasis
Pilot Tone On
Input Signal Left Only
Chart Shows Left Output and Separation

Rec. no 133
Date 11 July 77
Sign

Measuring object L only L out no de-emphasis
L Separation R out (in red) Pilot
Tone on



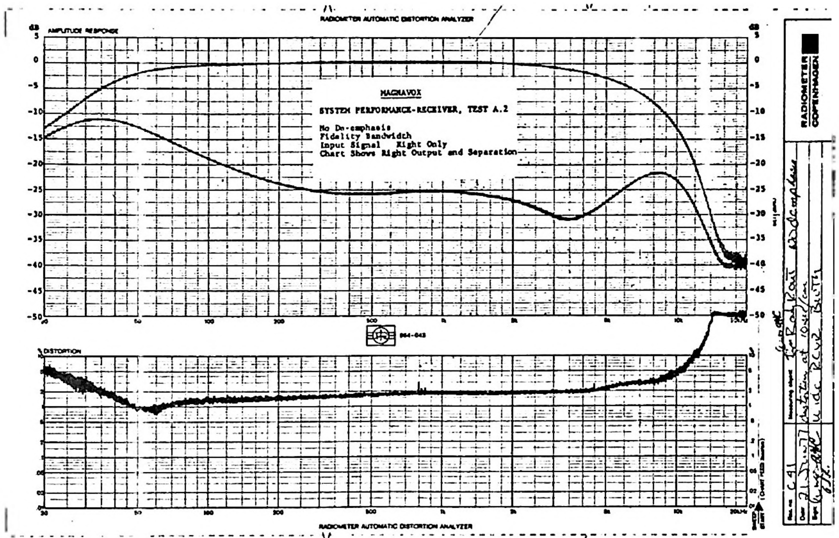
BELAR

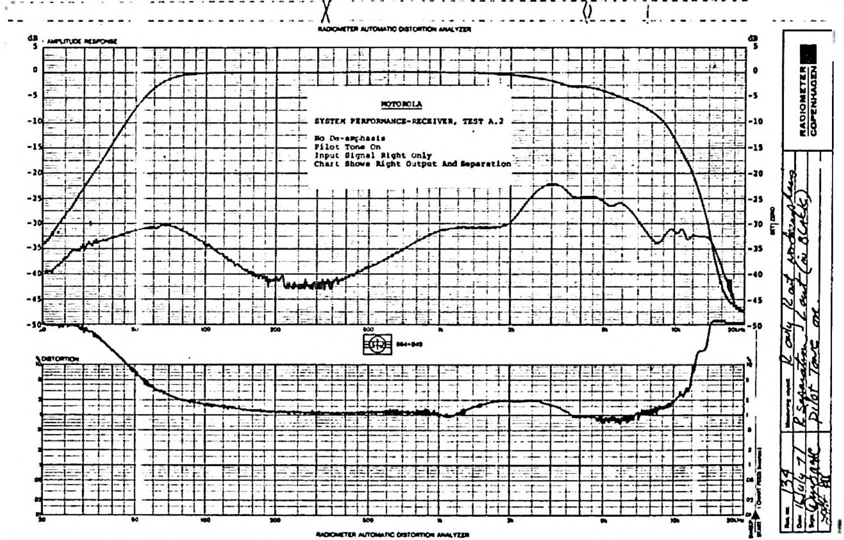
SYSTEM PERFORMANCE-RECEIVER, TEST A.2

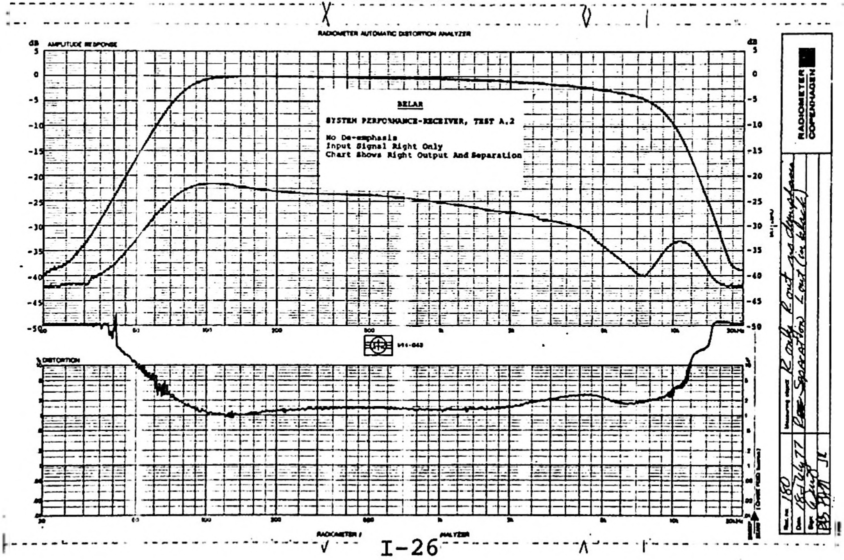
No De-emphasis
Input Signal Left Only
Chart Shows Left Output and Separation

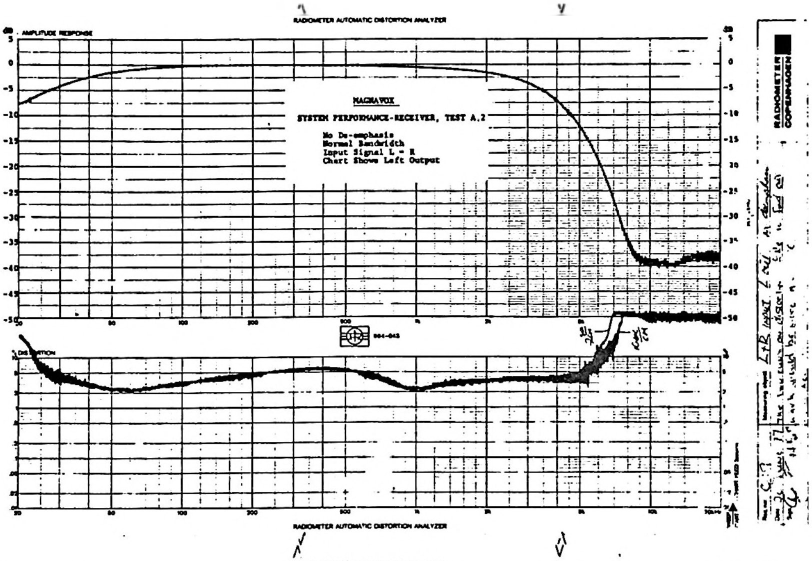
Rec. no 181
Date 18 July 77
Sign
BDS

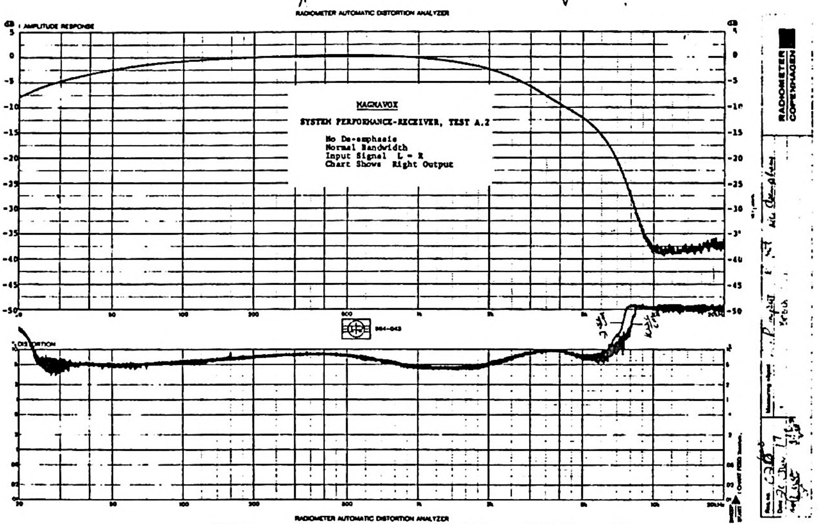
Measuring object L only L out no de-emphasis
L Separation R out (in red)

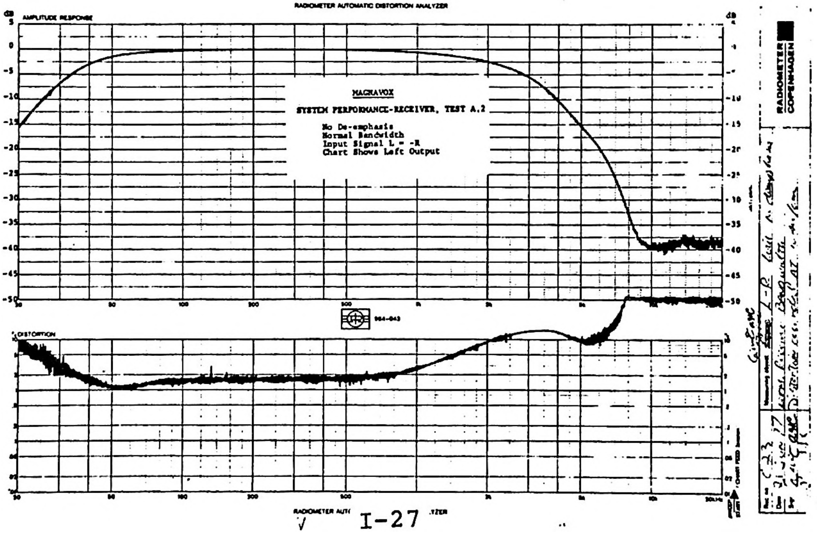

RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
MAGNAVOX
SYSTEM PERFORMANCE-RECEIVER, TEST A.2
No De-emphasis
Fidelity Bandwidth
Input Signal Right Only
Chart Shows Right Output and Separation
20
50
100
200
500
1k
2k
5k
10k
20kHz
DISTORTION
RADIOMETER COPENHAGEN
C 41
21 JUN 77
R out L out no de-emphasis
distortion at 10%/cm
wide RCVR BW
RADIOMETER AUTOMATIC DISTORTION ANALYZER

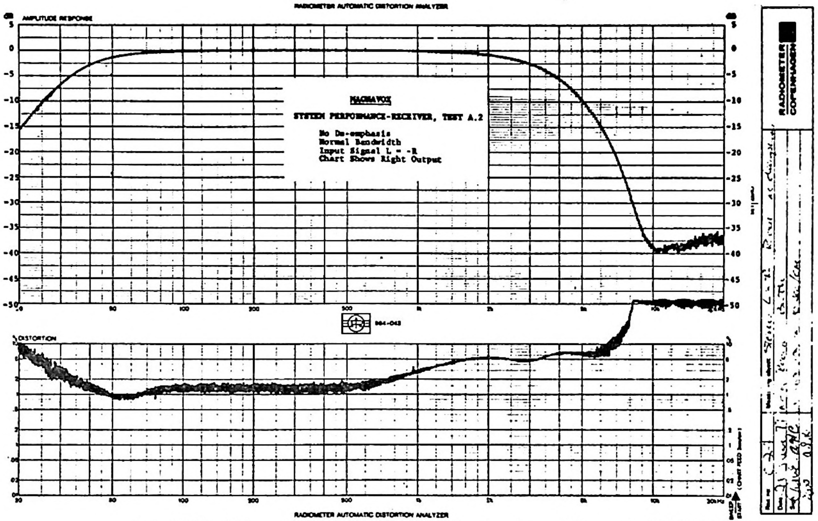

RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
MOTOROLA
SYSTEM PERFORMANCE-RECEIVER, TEST A.2
No De-emphasis
Pilot Tone On
Input Signal Right Only
Chart Shows Right Output And Separation
20
50
100
200
500
1k
2k
5k
10k
20kHz
DISTORTION
RADIOMETER COPENHAGEN
134
1 July 77
R only R out no de-emphasis
R Separation L out (in black)
Pilot Tone on
RADIOMETER AUTOMATIC DISTORTION ANALYZER

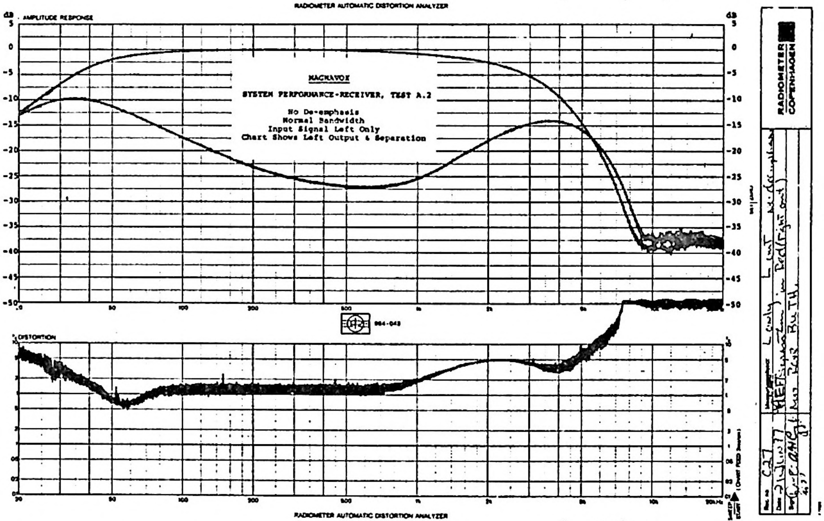

RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
BELAR
SYSTEM PERFORMANCE-RECEIVER, TEST A.2
No De-emphasis
Input Signal Right Only
Chart Shows Right Output And Separation
20
50
100
200
500
1k
2k
5k
10k
20kHz
DISTORTION
RADIOMETER COPENHAGEN
180
15 July 77
R only R out no de-emphasis
Separation L out (in black)
RADIOMETER AUTOMATIC DISTORTION ANALYZER

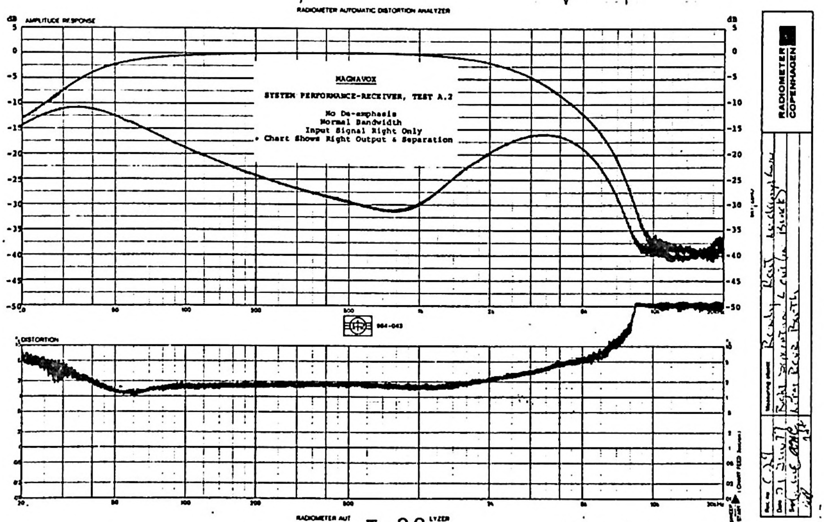

RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
MAGNAVOX
SYSTEM PERFORMANCE-RECEIVER, TEST A.2
No De-emphasis
Normal Bandwidth
Input Signal L = R
Chart Shows Left Output
964-043
% DISTORTION
20
50
100
200
500
1k
2k
5k
10k
20kHz
RADIOMETER
COPENHAGEN
L+R input

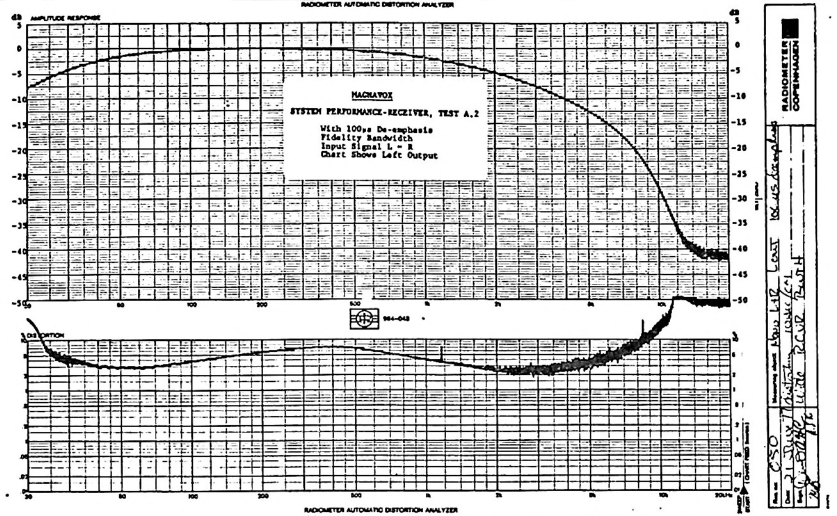

RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
MAGNAVOX
SYSTEM PERFORMANCE-RECEIVER, TEST A.2
No De-emphasis
Normal Bandwidth
Input Signal L = R
Chart Shows Right Output
964-043
% DISTORTION
20
50
100
200
500
1k
2k
5k
10k
20kHz
RADIOMETER
COPENHAGEN


RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
MAGNAVOX
SYSTEM PERFORMANCE-RECEIVER, TEST A.2
No De-emphasis
Normal Bandwidth
Input Signal L = -R
Chart Shows Left Output
964-043
% DISTORTION
20
50
100
200
500
1k
2k
5k
10k
20kHz
RADIOMETER
COPENHAGEN
L-R


RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
MAGNAVOX
SYSTEM PERFORMANCE-RECEIVER, TEST A.2
No De-emphasis
Normal Bandwidth
Input Signal L = -R
Chart Shows Right Output
964-043
DISTORTION
20
50
100
200
500
1k
2k
5k
10k
20k Hz
RADIOMETER COPENHAGEN
C 21
21 June 77
Stereo L = -R
AHC


RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
MAGNAVOX
SYSTEM PERFORMANCE-RECEIVER, TEST A.2
No De-emphasis
Normal Bandwidth
Input Signal Left Only
Chart Shows Left Output & Separation
964-043
DISTORTION
20
50
100
200
500
1k
2k
5k
10k
20k Hz
RADIOMETER COPENHAGEN
C27
21 June 77
L only L out
AHC

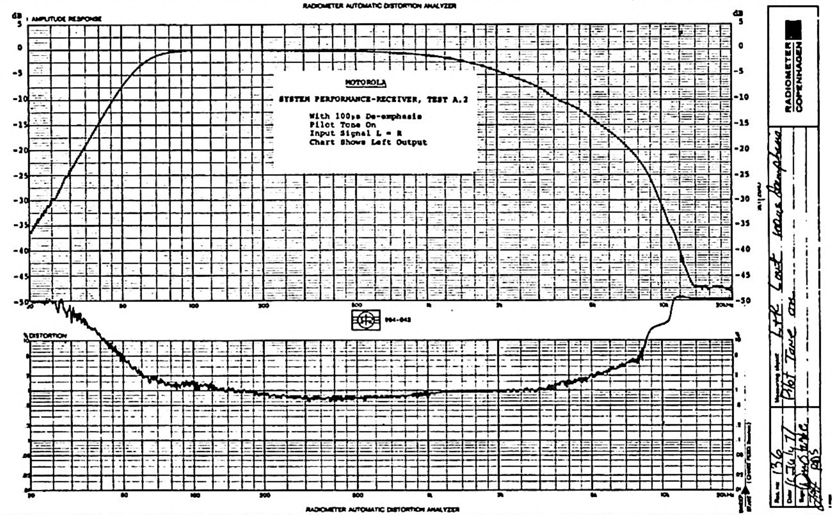

RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
MAGNAVOX
SYSTEM PERFORMANCE-RECEIVER, TEST A.2
No De-emphasis
Normal Bandwidth
Input Signal Right Only
Chart Shows Right Output & Separation
964-043
DISTORTION
20
50
100
200
500
1k
2k
5k
10k
20k Hz
RADIOMETER COPENHAGEN
C 28
21 June 77
R only R out
AHC



MAGNAVOX

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

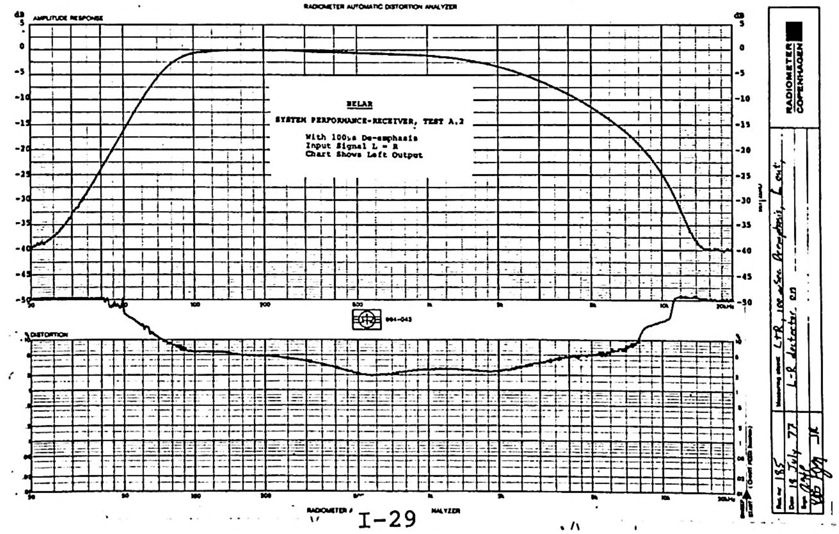
With 100μs De-emphasis
Fidelity Bandwidth
Input Signal L = R
Chart Shows Left Output



MOTOROLA

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

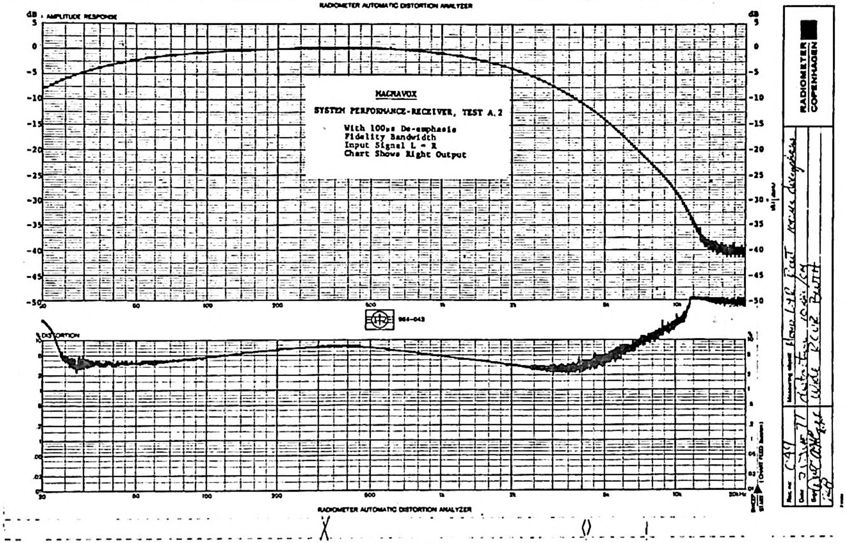
With 100μs De-emphasis
Pilot Tone On
Input Signal L = R
Chart Shows Left Output



BELAR

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

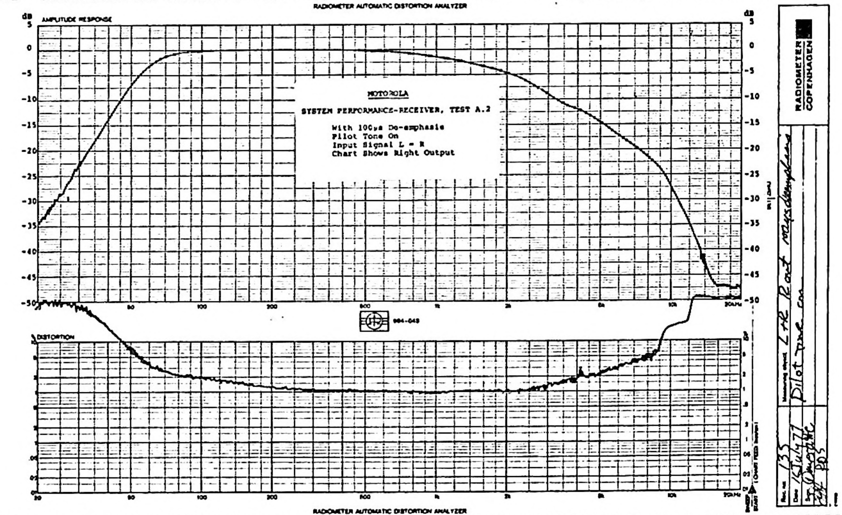
With 100μs De-emphasis
Input Signal L = R
Chart Shows Left Output



MAGNAVOX

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

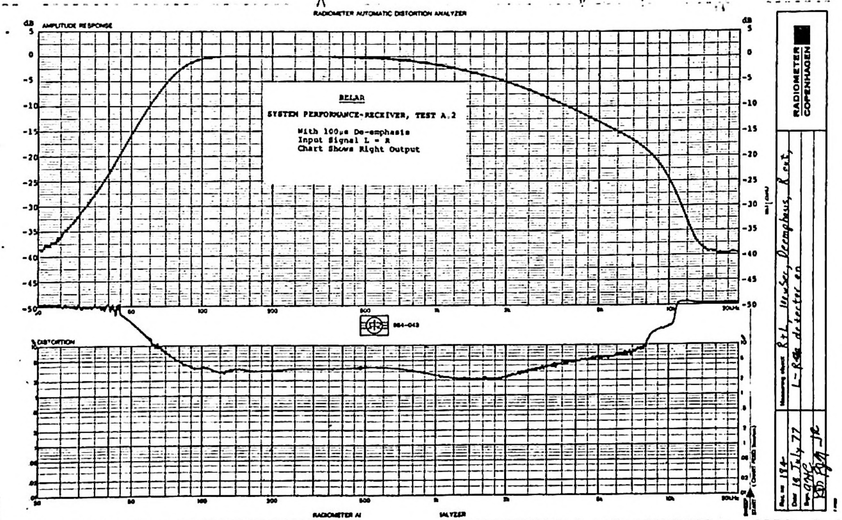
With 100μs De-emphasis
Fidelity Bandwidth
Input Signal L = R
Chart Shows Right Output



MOTOROLA

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

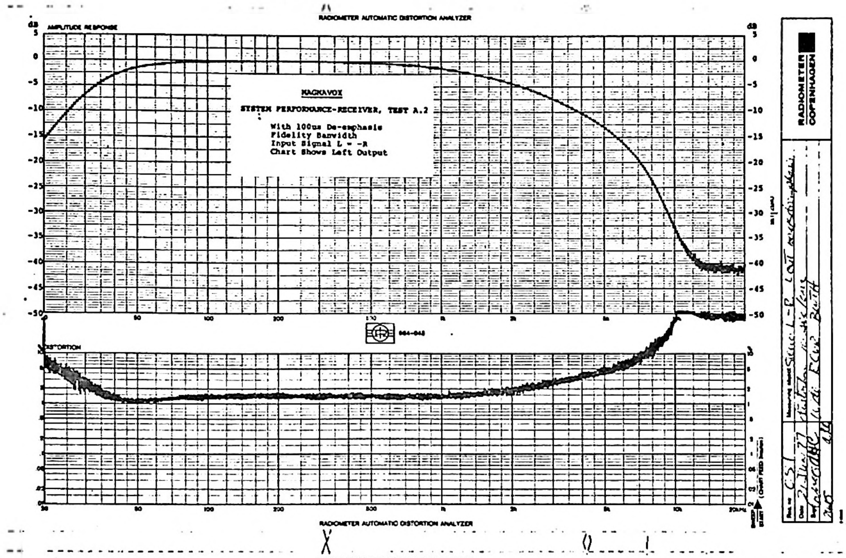
With 100μs De-emphasis
Pilot Tone On
Input Signal L = R
Chart Shows Right Output



BELAR

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

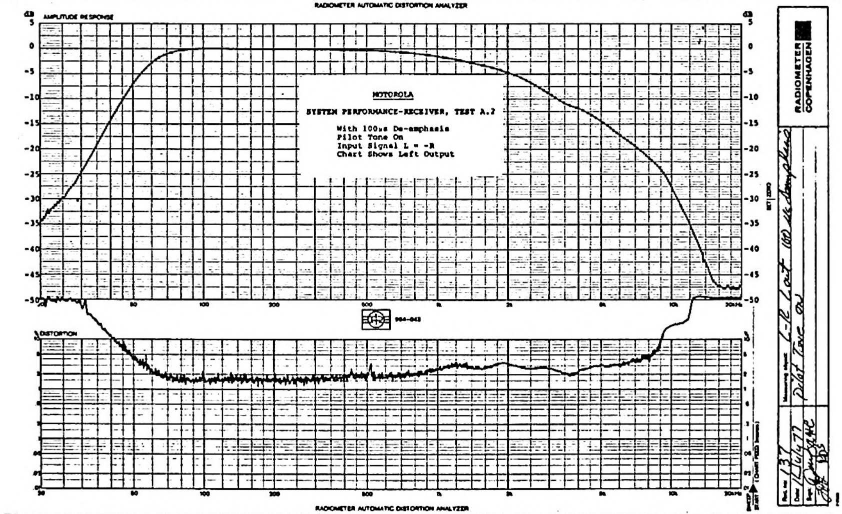
With 100μs De-emphasis
Input Signal L = R
Chart Shows Right Output



MAGNAVOX

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

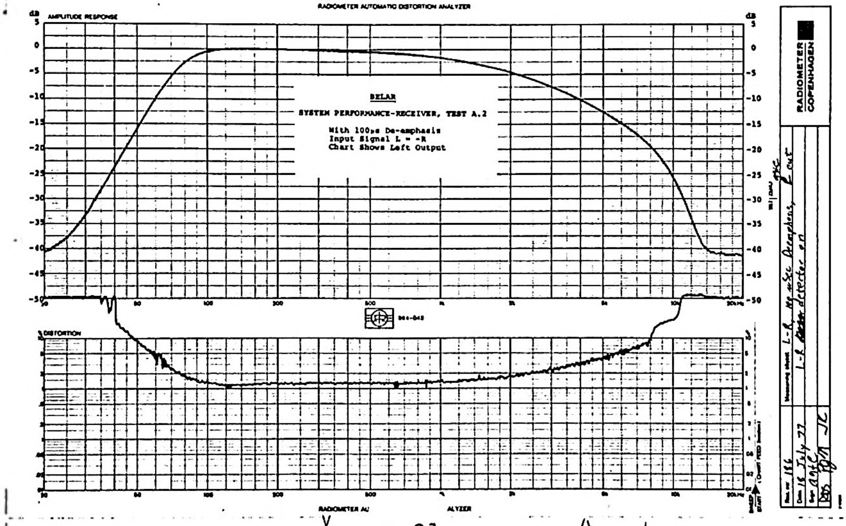
With 100us De-emphasis
Fidelity Banwidth
Input Signal L = -R
Chart Shows Left Output



MOTOROLA

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

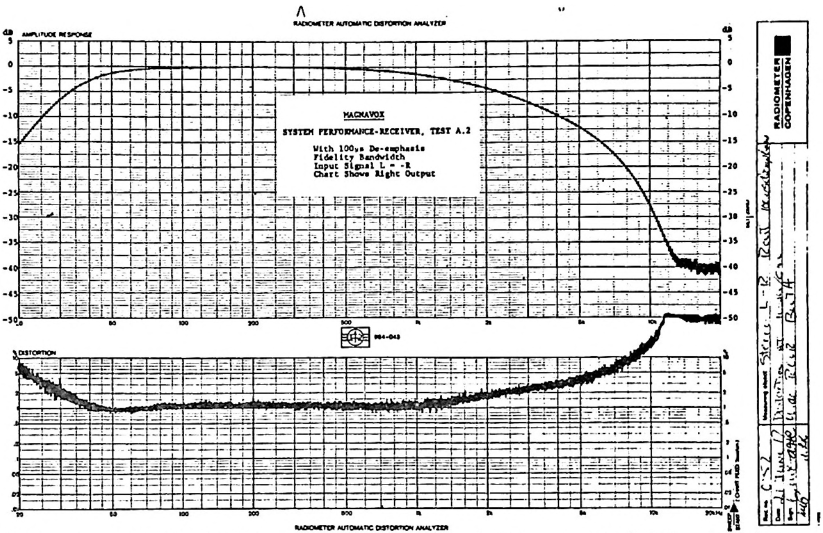
With 100us De-emphasis
Pilot Tone On
Input Signal L = -R
Chart Shows Left Output



BELAR

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

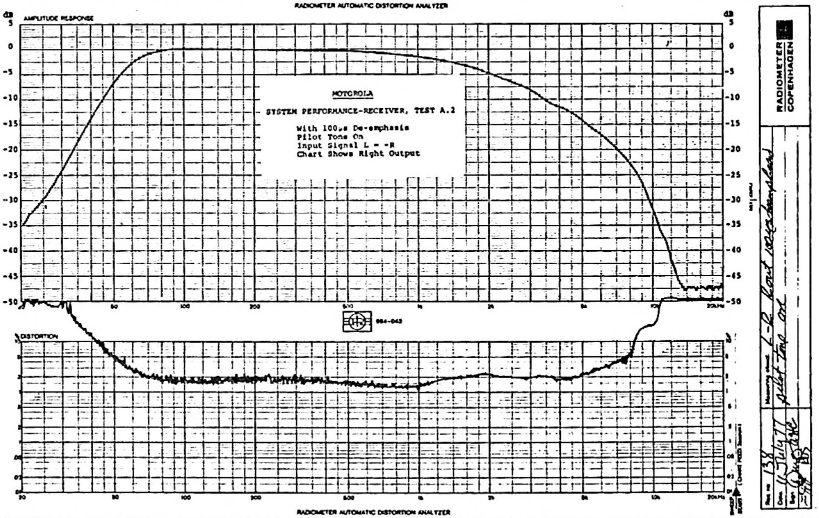
With 100us De-emphasis
Input Signal L = -R
Chart Shows Left Output



MAGNAVOX

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

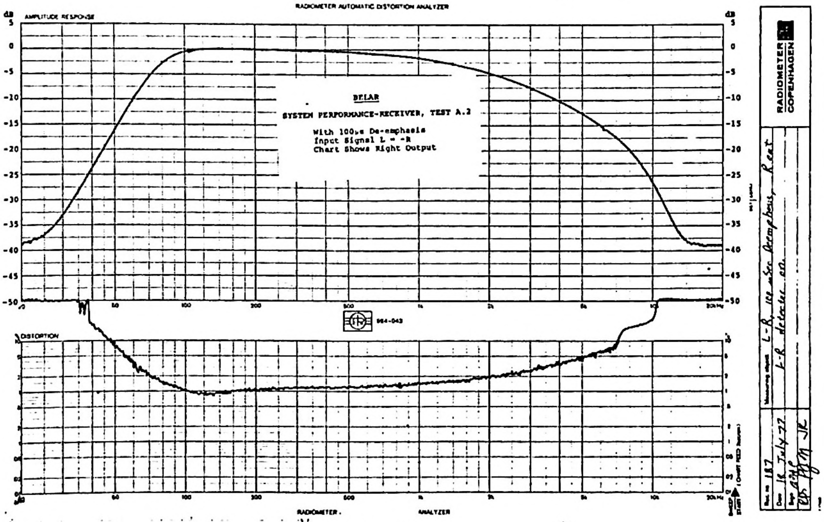
With 100μs De-emphasis
Fidelity Bandwidth
Input Signal L = -R
Chart Shows Right Output



MOTOROLA

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

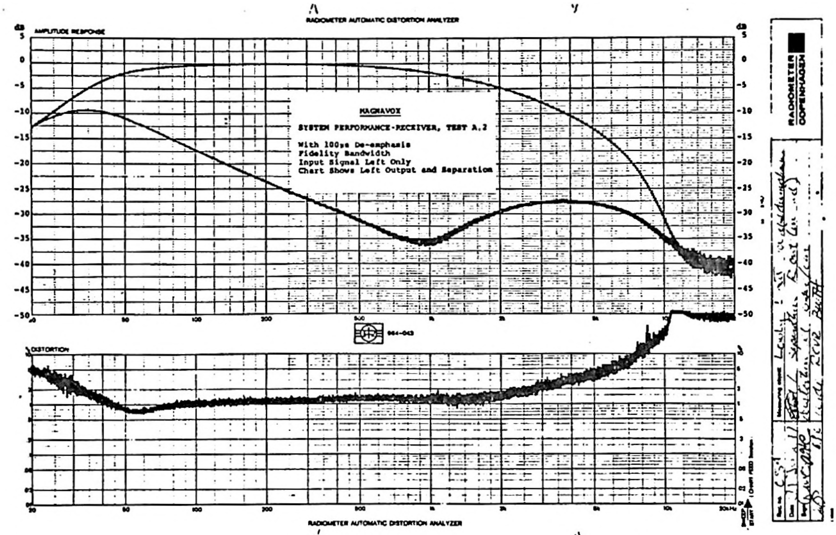
With 100μs De-emphasis
Pilot Tone On
Input Signal L = -R
Chart Shows Right Output

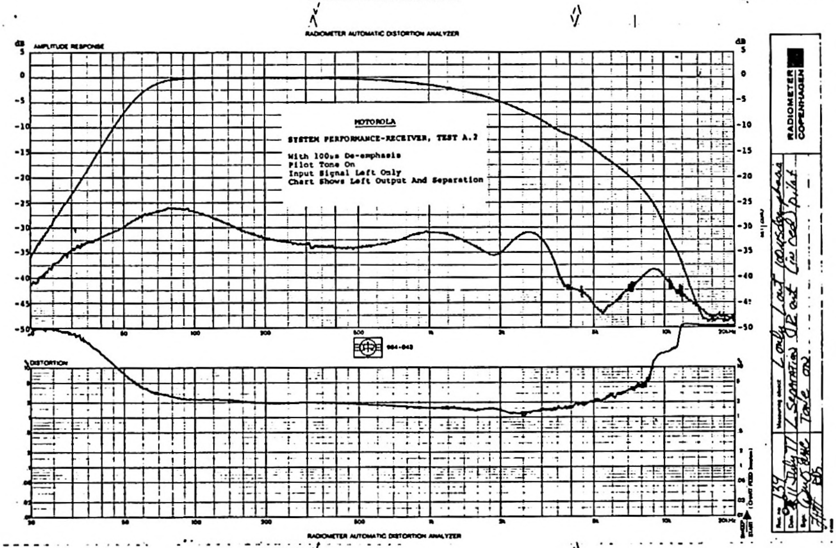


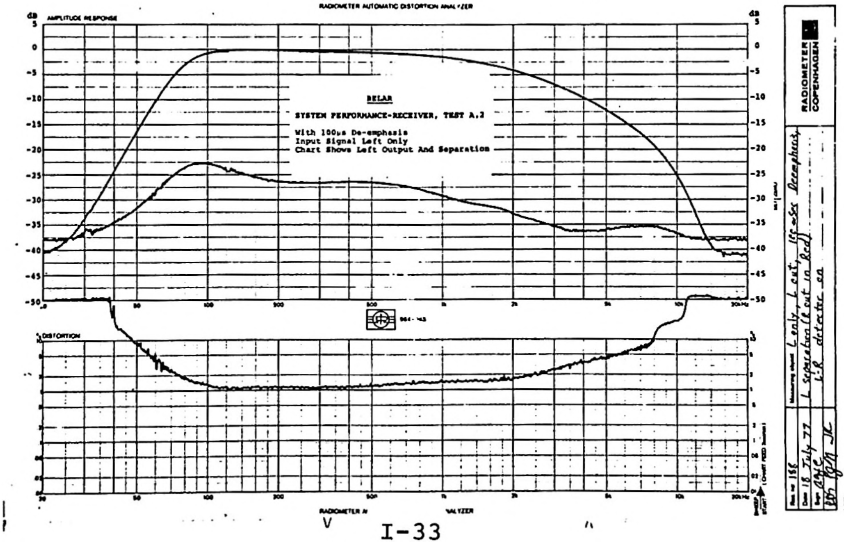
BELAR

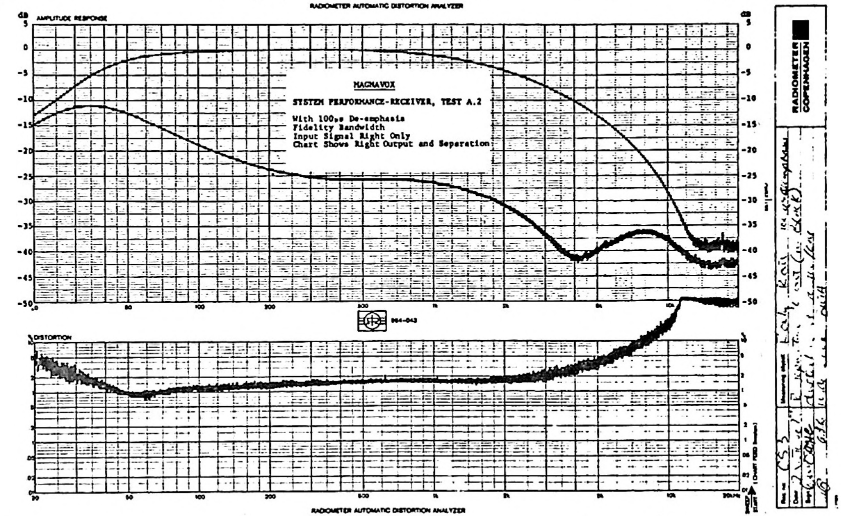
SYSTEM PERFORMANCE-RECEIVER, TEST A.2

With 100μs De-emphasis
Input Signal L = -R
Chart Shows Right Output


RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
MAGNAVOX
SYSTEM PERFORMANCE-RECEIVER, TEST A.2
With 100µs De-emphasis
Fidelity Bandwidth
Input Signal Left Only
Chart Shows Left Output and Separation
984-043
DISTORTION
RADIOMETER COPENHAGEN
Left out / separation
MAGNAVOX


RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
MOTOROLA
SYSTEM PERFORMANCE-RECEIVER, TEST A.2
With 100µs De-emphasis
Pilot Tone On
Input Signal Left Only
Chart Shows Left Output And Separation
984-043
DISTORTION
RADIOMETER COPENHAGEN
139
11 July 77
L only L out 100µs de-emphasis
L separation (R out (in red) pilot
Tone on

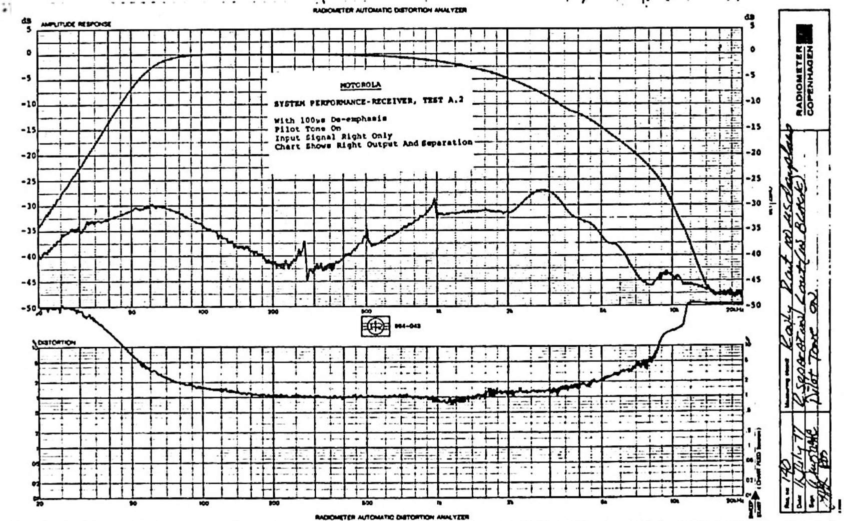

RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
BELAR
SYSTEM PERFORMANCE-RECEIVER, TEST A.2
With 100µs De-emphasis
Input Signal Left Only
Chart Shows Left Output And Separation
984-43
DISTORTION
RADIOMETER COPENHAGEN
155
18 July 77
L only, L out, 150µsec Deemphasis
L separation (R out in Red)
L:R detector on



MAGNAVOX

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

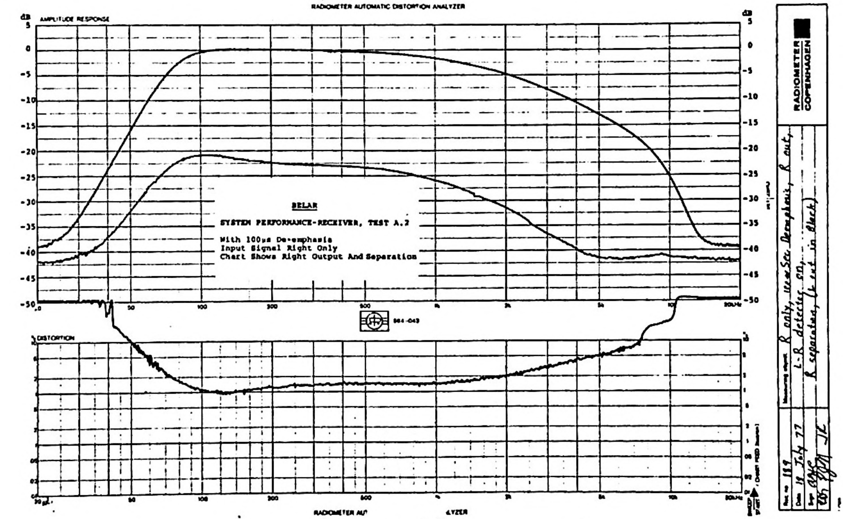
With 100μs De-emphasis
Fidelity Bandwidth
Input Signal Right Only
Chart Shows Right Output and Separation



MOTOROLA

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

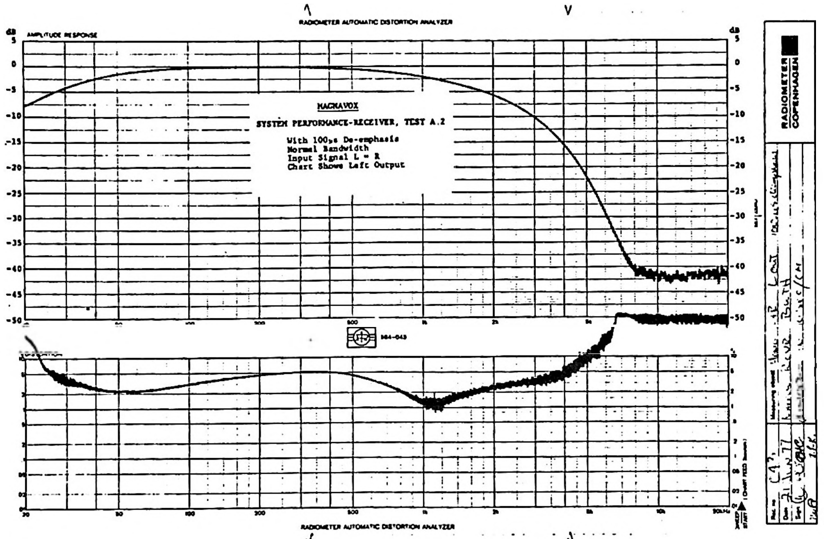
With 100μs De-emphasis
Pilot Tone On
Input Signal Right Only
Chart Shows Right Output And Separation



BELAR

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

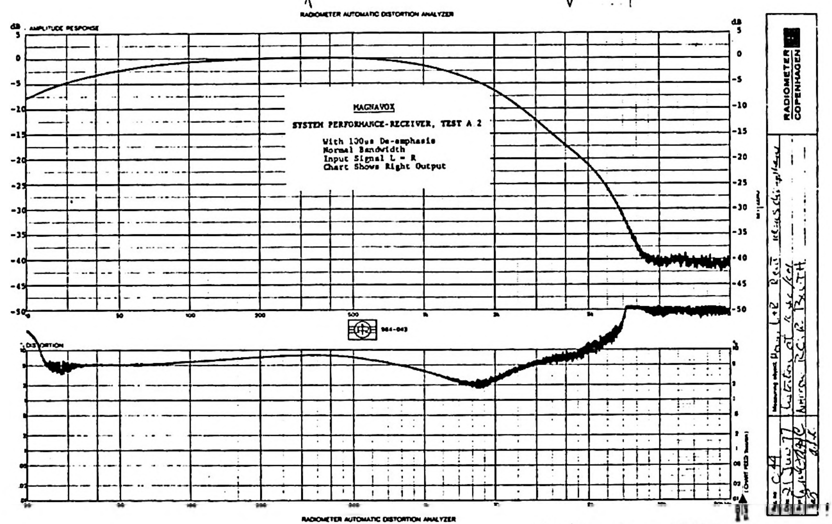
With 100μs De-emphasis
Input Signal Right Only
Chart Shows Right Output And Separation



MAGNAVOX

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

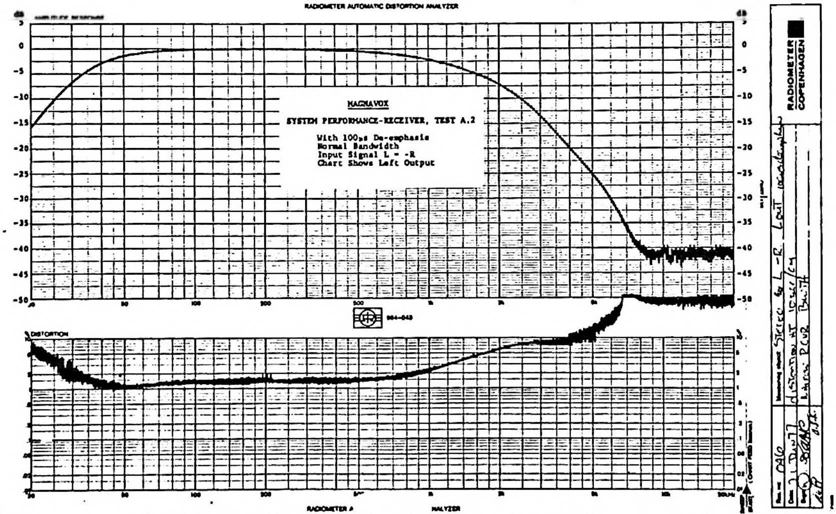
With 100μs De-emphasis
Normal Bandwidth
Input Signal L = R
Chart Shows Left Output



MAGNAVOX

SYSTEM PERFORMANCE-RECEIVER, TEST A 2

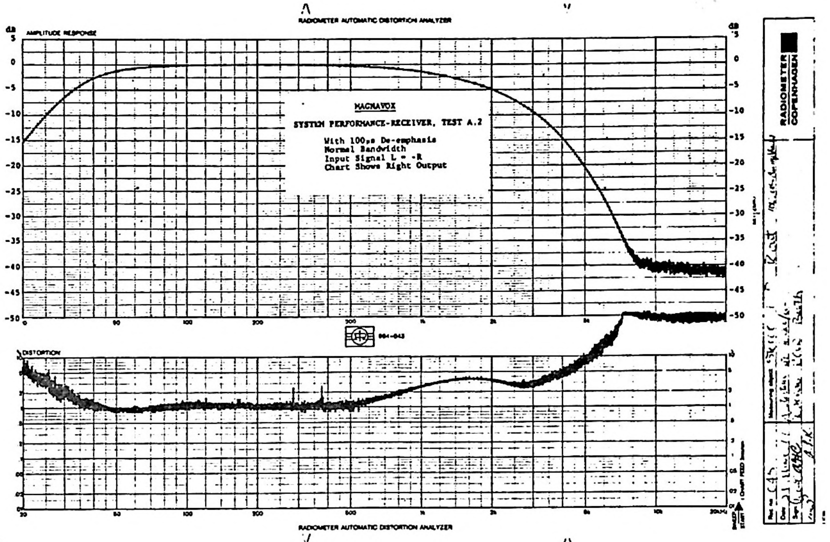
With 100μs De-emphasis
Normal Bandwidth
Input Signal L = R
Chart Shows Right Output



MAGNAVOX

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

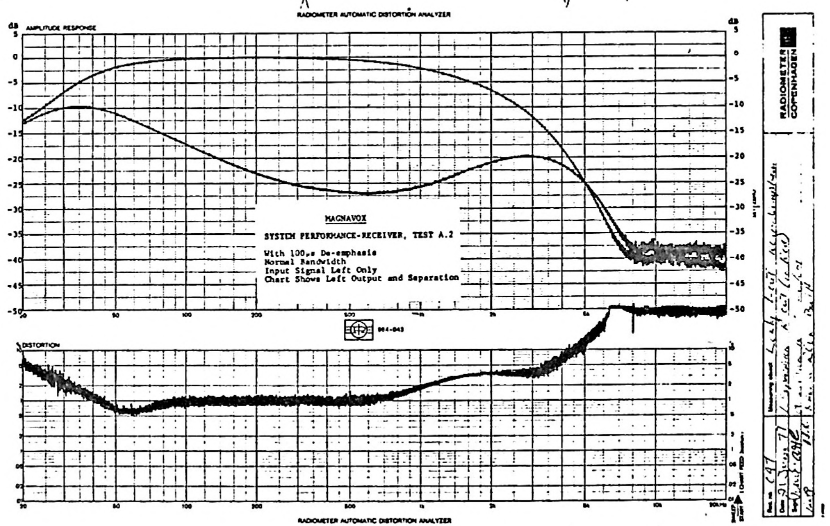
With 100μs De-emphasis
Normal Bandwidth
Input Signal L = -R
Chart Shows Left Output



MAGNAVOX

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

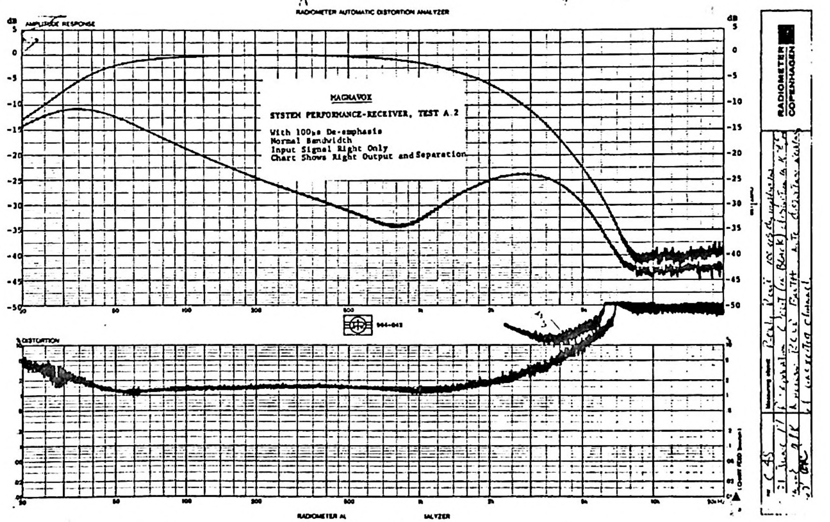
With 100µs De-emphasis
Normal Bandwidth
Input Signal L = -R
Chart Shows Right Output



MAGNAVOX

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

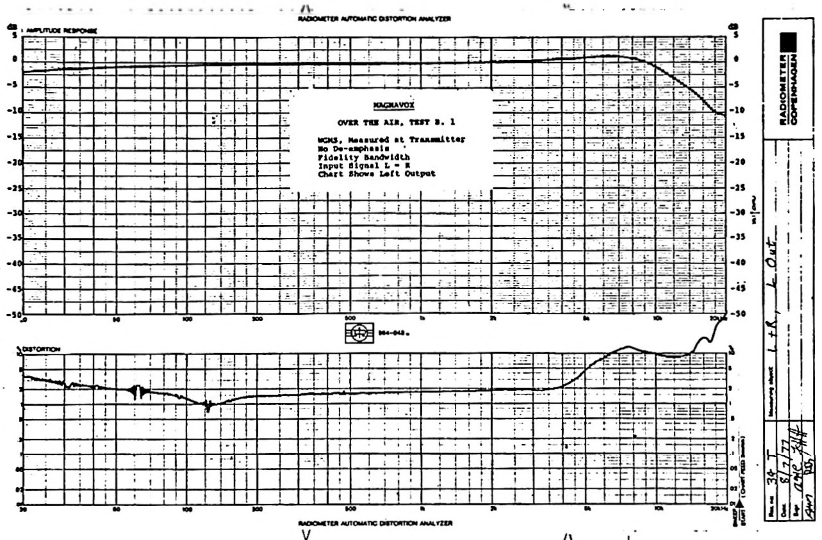
With 100µs De-emphasis
Normal Bandwidth
Input Signal Left Only
Chart Shows Left Output and Separation



MAGNAVOX

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

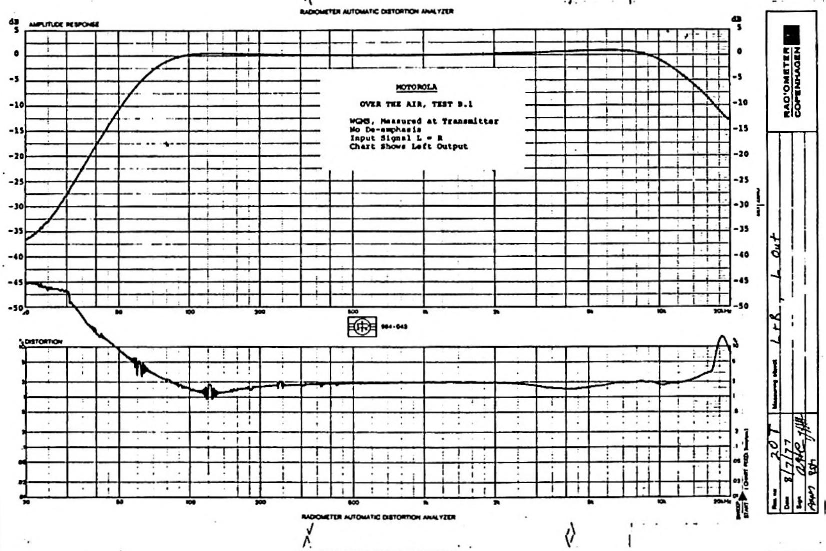
With 100µs De-emphasis
Normal Bandwidth
Input Signal Right Only
Chart Shows Right Output and Separation



MAGNAVOX

OVER THE AIR, TEST B. 1

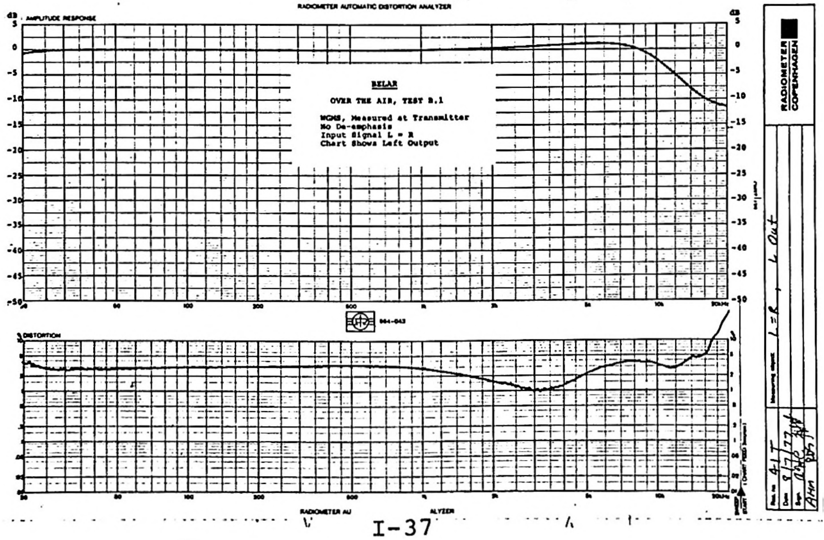
WGMS, Measured at Transmitter
No De-emphasis
Fidelity Bandwidth
Input Signal L = R
Chart Shows Left Output



MOTOROLA

OVER THE AIR, TEST B.1

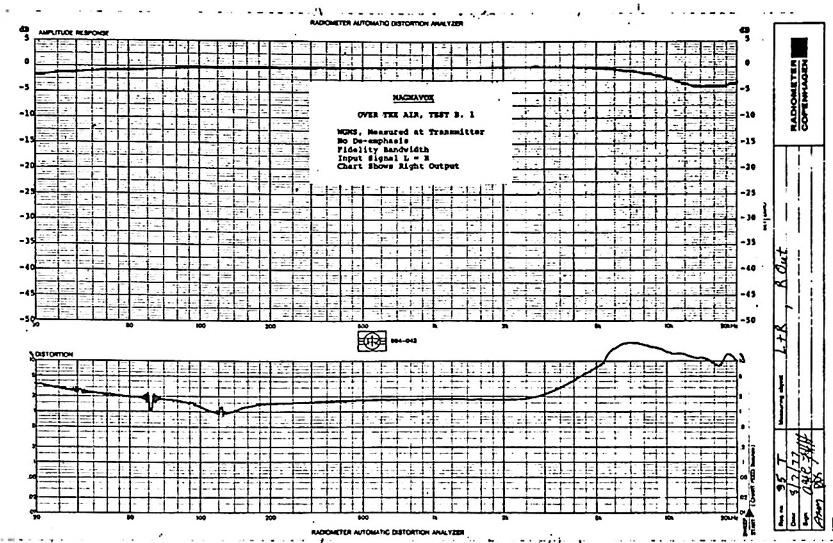
WGMS, Measured at Transmitter
No De-emphasis
Input Signal L = R
Chart Shows Left Output



BELAR

OVER THE AIR, TEST B.1

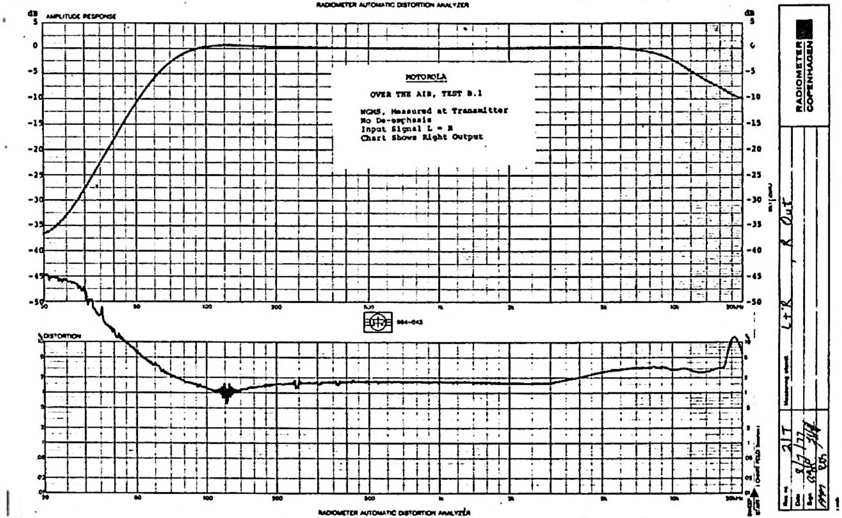
WGMS, Measured at Transmitter
No De-emphasis
Input Signal L = R
Chart Shows Left Output



MAGNAVOX

OVER THE AIR, TEST B. 1

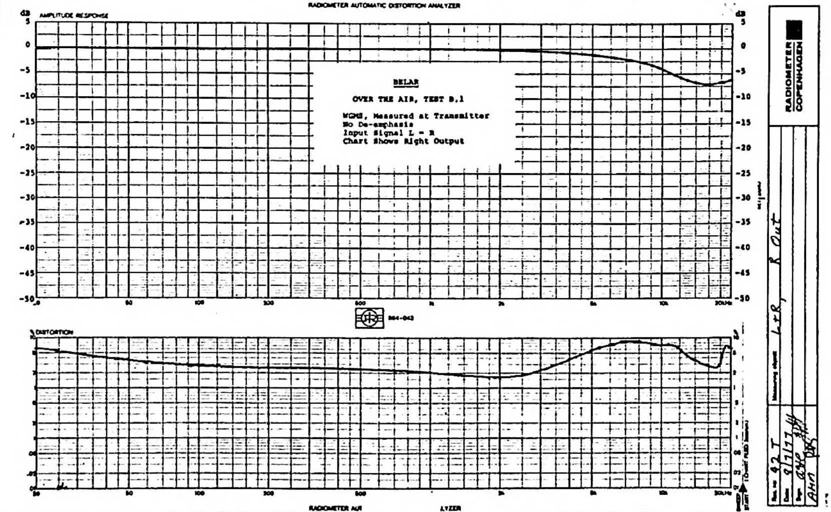
WGMS, Measured at Transmitter
No De-emphasis
Fidelity Bandwidth
Input Signal L = R
Chart Shows Right Output



MOTOROLA

OVER THE AIR, TEST B.1

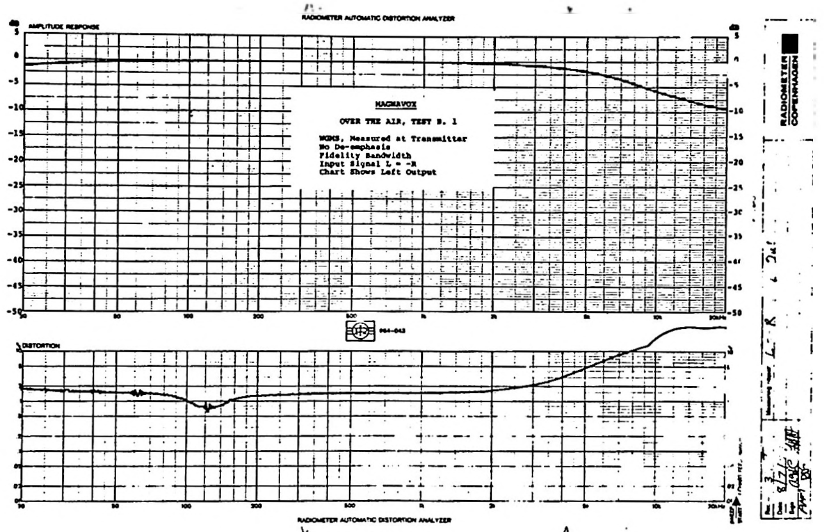
WGMS, Measured at Transmitter
No De-emphasis
Input Signal L = R
Chart Shows Right Output



BELAR

OVER THE AIR, TEST B.1

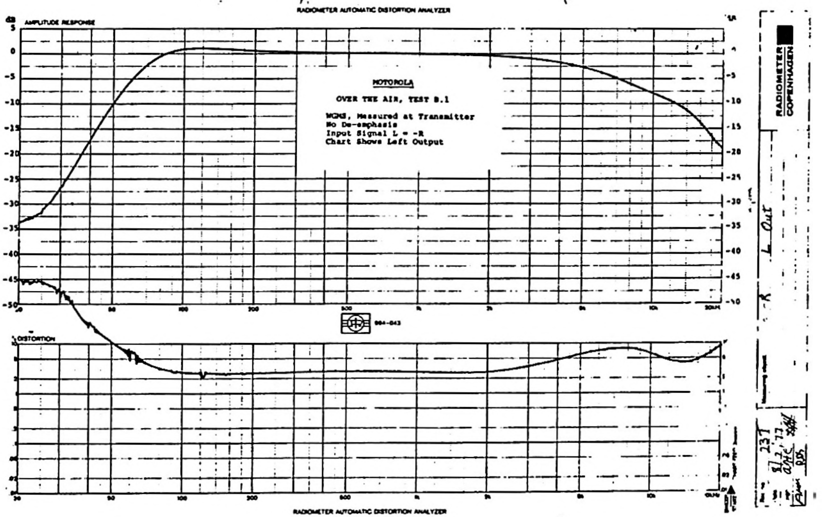
WGMS, Measured at Transmitter
No De-emphasis
Input Signal L = R
Chart Shows Right Output



MAGNAVOX

OVER THE AIR, TEST B. 1

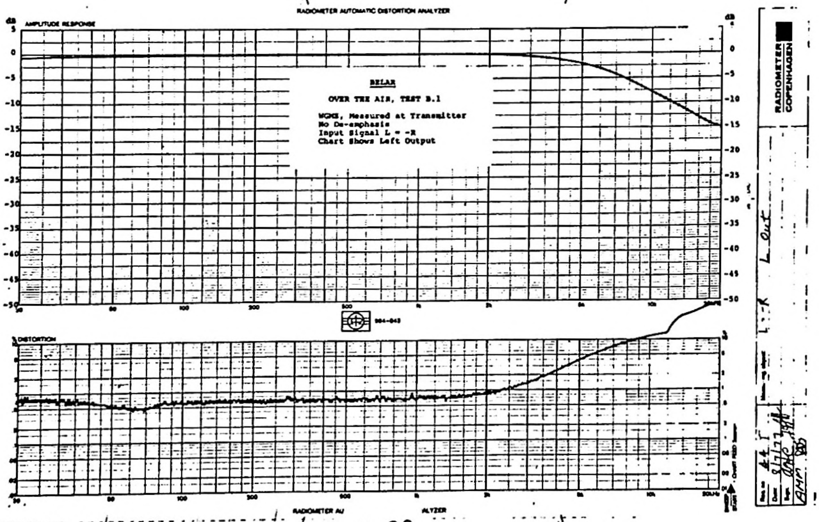
WGMS, Measured at Transmitter
No De-emphasis
Fidelity Bandwidth
Input Signal L = -R
Chart Shows Left Output



MOTOROLA

OVER THE AIR, TEST B.1

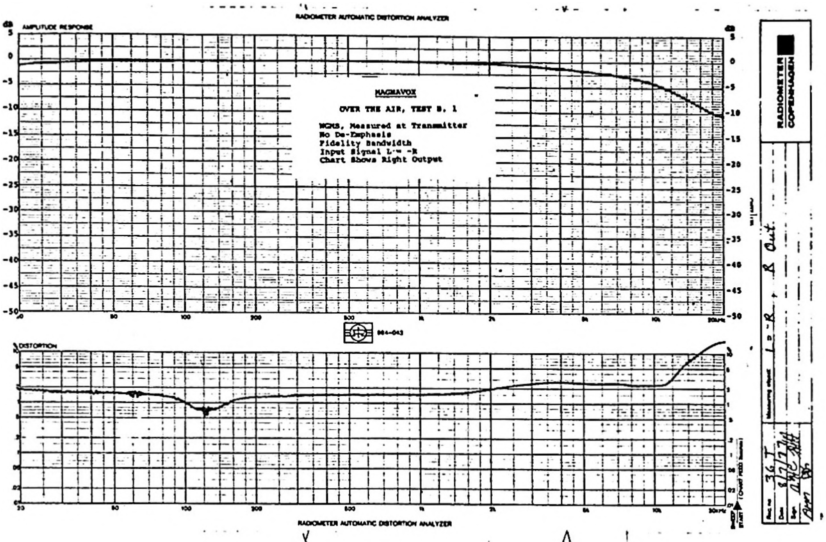
WGMS, Measured at Transmitter
No De-emphasis
Input Signal L = -R
Chart Shows Left Output

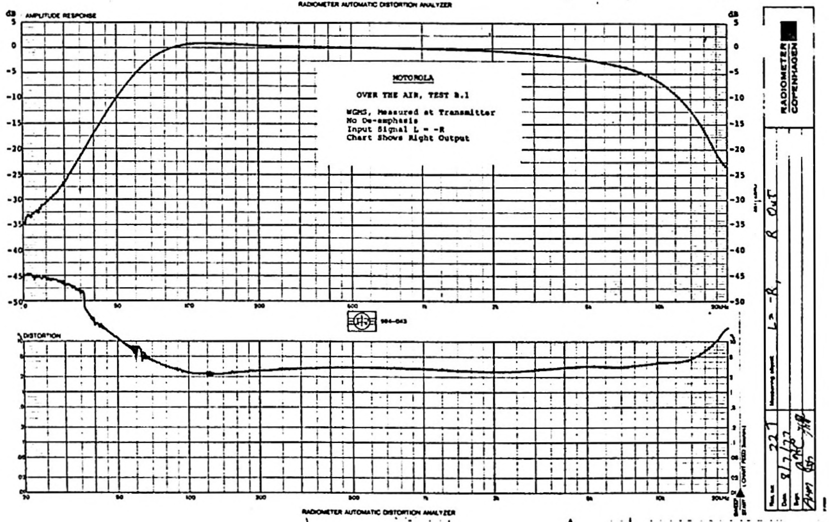


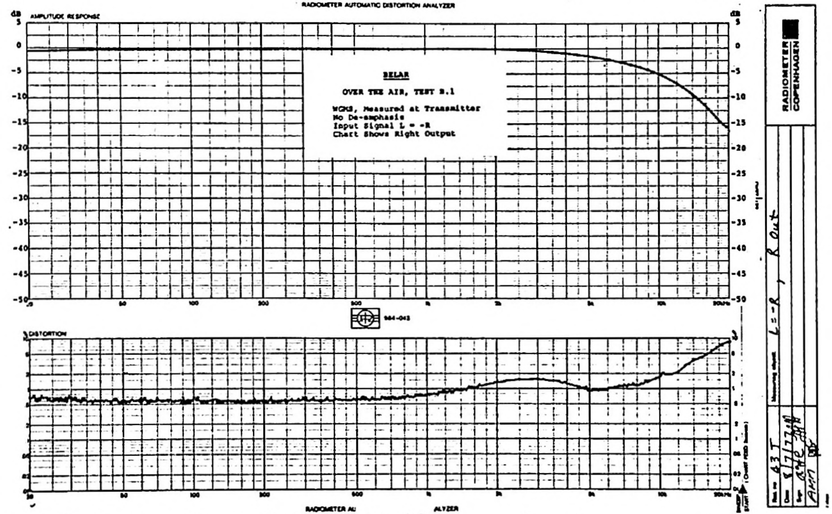
BELAR

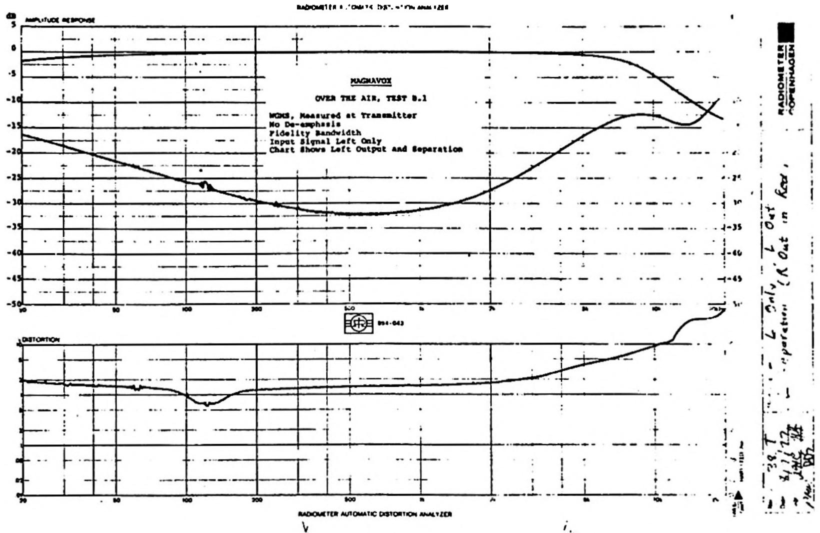
OVER THE AIR, TEST B.1

WGMS, Measured at Transmitter
No De-emphasis
Input Signal L = -R
Chart Shows Left Output


RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
MAGNAVOX
OVER THE AIR, TEST B. 1
WGMS, Measured at Transmitter
No De-Emphasis
Fidelity Bandwidth
Input Signal L = -R
Chart Shows Right Output
20
50
100
200
500
1k
2k
5k
10k
20kHz
984-043
DISTORTION
RADIOMETER COPENHAGEN
Measuring object L = -R , R Out
Rec no 36 T
Date 8/7/77
Sign AHC
Appr
SWEEP START


RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
MOTOROLA
OVER THE AIR, TEST B.1
WGMS, Measured at Transmitter
No De-emphasis
Input Signal L = -R
Chart Shows Right Output
20
50
100
200
500
1k
2k
5k
10k
20kHz
984-043
DISTORTION
RADIOMETER COPENHAGEN
Measuring object L = -R , R Out
Rec no 22 T
Date 8/7/77
Sign AHC
Appr
SWEEP START

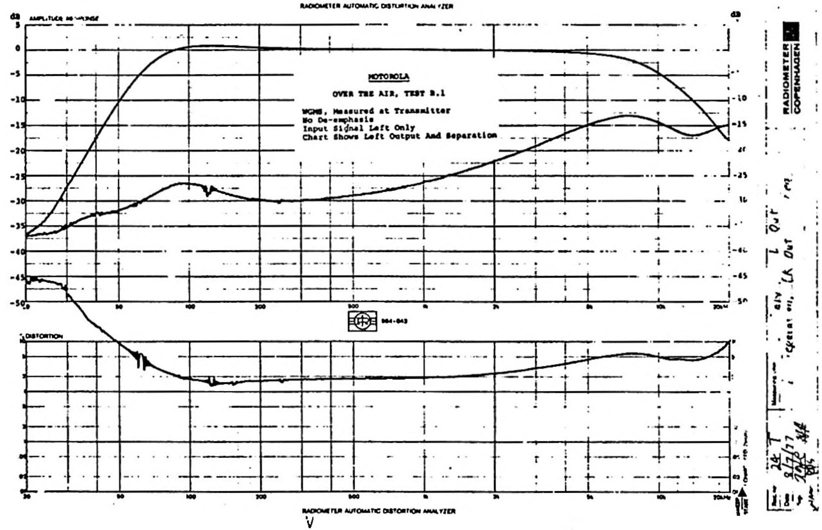

RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
BELAR
OVER THE AIR, TEST B.1
WGMS, Measured at Transmitter
No De-emphasis
Input Signal L = -R
Chart Shows Right Output
20
50
100
200
500
1k
2k
5k
10k
20kHz
984-043
DISTORTION
RADIOMETER COPENHAGEN
Measuring object L = -R , R Out
Rec no 43 T
Date 8/7/77
Sign AHC
Appr AHM
SWEEP START



MAGNAVOX

OVER THE AIR, TEST B.1

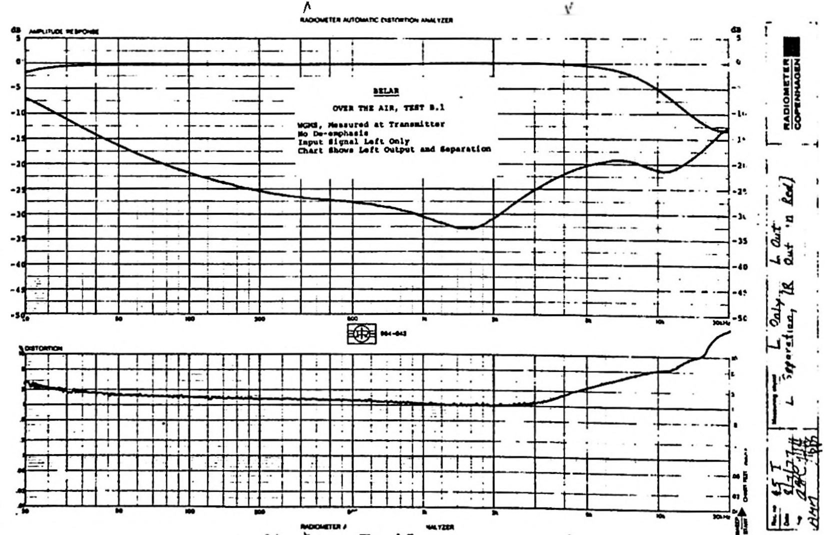
WGMS, Measured at Transmitter
No De-emphasis
Fidelity Bandwidth
Input Signal Left Only
Chart Shows Left Output And Separation



MOTOROLA

OVER THE AIR, TEST B.1

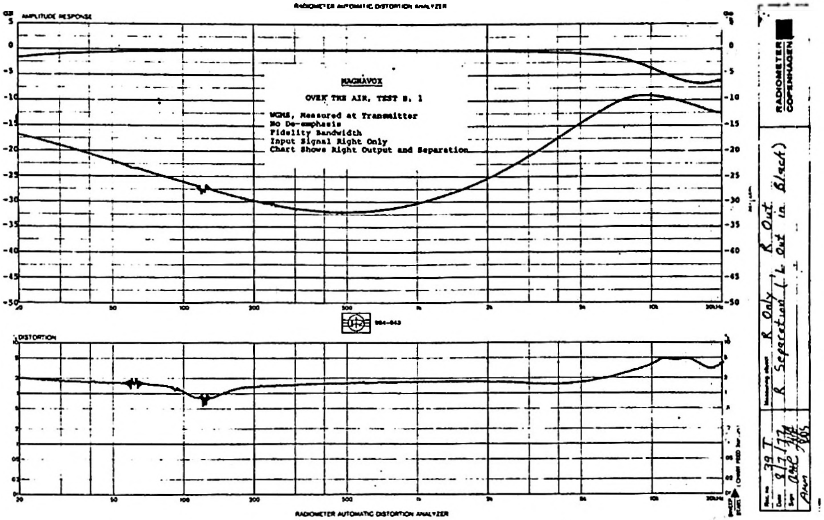
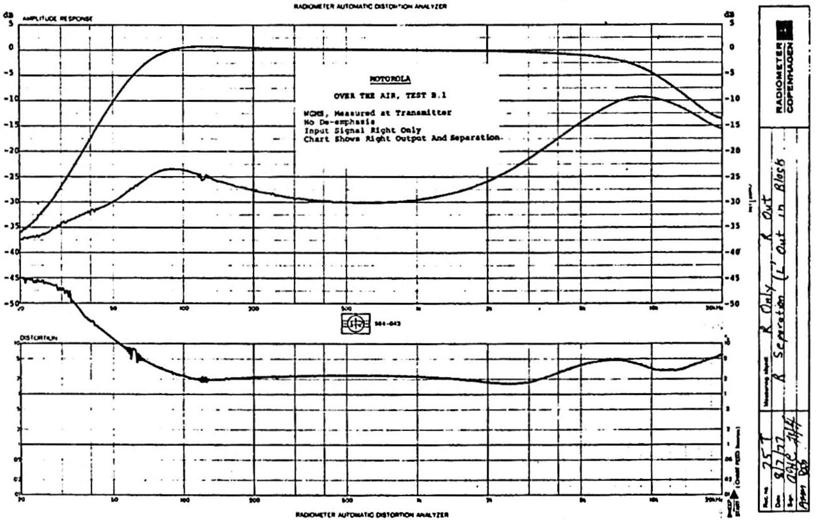
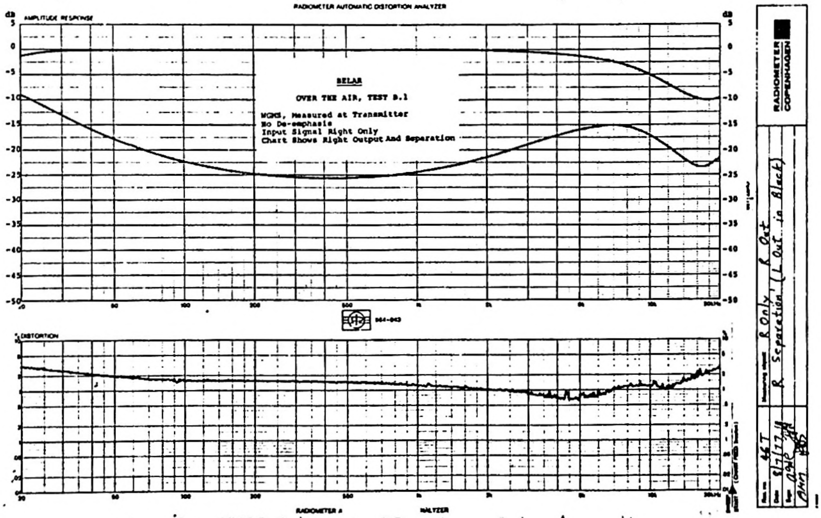
WGMS, Measured at Transmitter
No De-emphasis
Input Signal Left Only
Chart Shows Left Output And Separation

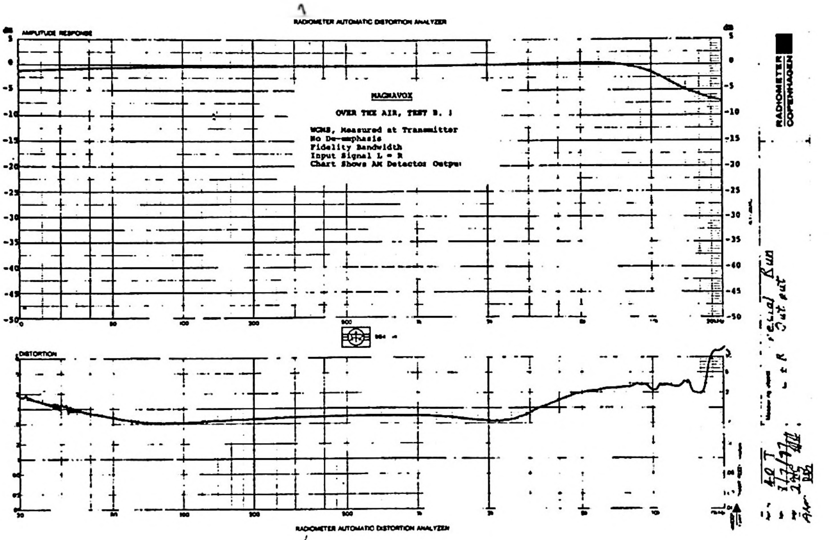


BELAR

OVER THE AIR, TEST B.1

WGMS, Measured at Transmitter
No De-emphasis
Input Signal Left Only
Chart Shows Left Output and Separation


RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
MAGNAVOX
OVER THE AIR, TEST B. 1
WGMS, Measured at Transmitter
No De-emphasis
Fidelity Bandwidth
Input Signal Right Only
Chart Shows Right Output and Separation
20
50
100
200
500
1k
2k
5k
10k
20kHz
984-043
DISTORTION
RADIOMETER AUTOMATIC DISTORTION ANALYZER
RADIOMETER
COPENHAGEN
R Only R Out
R Separation ('L' Out in Black)
39 T
8/7/77
AMC

RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
MOTOROLA
OVER THE AIR, TEST B.1
WGMS, Measured at Transmitter
No De-emphasis
Input Signal Right Only
Chart Shows Right Output And Separation
20
50
100
200
500
1k
2k
5k
10k
20kHz
984-043
DISTORTION
RADIOMETER AUTOMATIC DISTORTION ANALYZER
RADIOMETER
COPENHAGEN
R Only R Out
R Separation ('L' Out in Black)
25 T
8/7/77
AMC

RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
BELAR
OVER THE AIR, TEST B.1
WGMS, Measured at Transmitter
No De-emphasis
Input Signal Right Only
Chart Shows Right Output And Separation
20
50
100
200
500
1k
2k
5k
10k
20kHz
984-043
DISTORTION
RADIOMETER A NALYZER
RADIOMETER
COPENHAGEN
R Only R Out
R Separation ('L Out in Black)
46 T
8/7/77
AMC

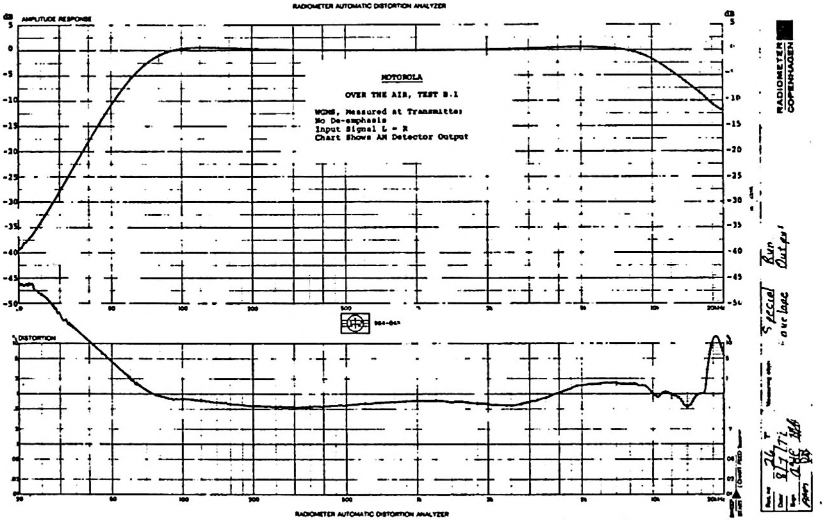


MAGNAVOX

OVER THE AIR, TEST B. 1

WCMS, Measured at Transmitter
No De-emphasis
Fidelity Bandwidth
Input Signal L = R
Chart Shows AM Detector Output

Special Run
Output
L = R
40 T
8/7/77
AHC
AHM

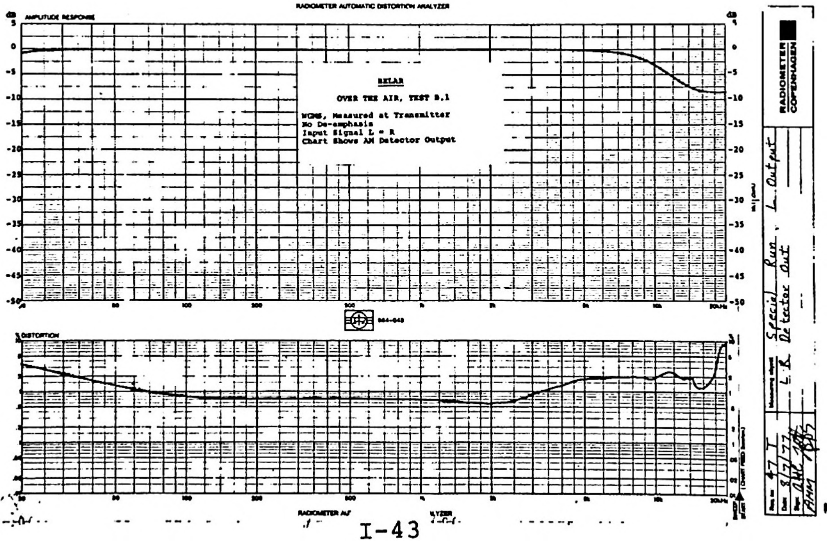


MOTOROLA

OVER THE AIR, TEST B.1

WCMS, Measured at Transmitter
No De-emphasis
Input Signal L = R
Chart Shows AM Detector Output

Special Run
Envelope Output
26 T
8/7/77
AHC
AHM

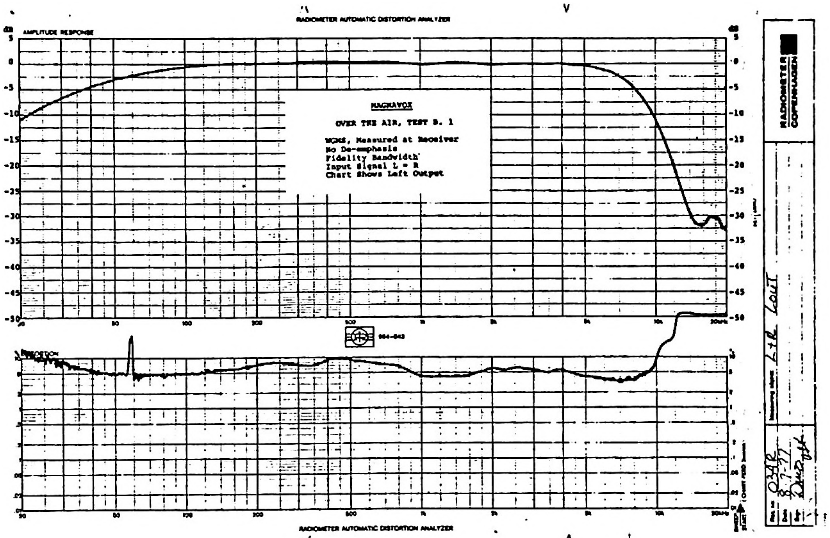


RELAR

OVER THE AIR, TEST B.1

WCMS, Measured at Transmitter
No De-emphasis
Input Signal L = R
Chart Shows AM Detector Output

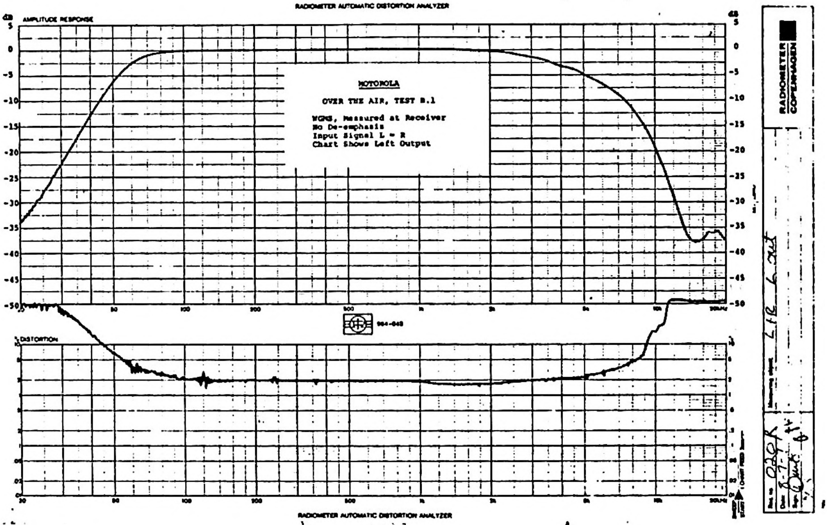
L.R Special Run L Output
Detector Out
47 I
8/7/77
AHC
AHM



MAGNAVOX

OVER THE AIR, TEST B. 1

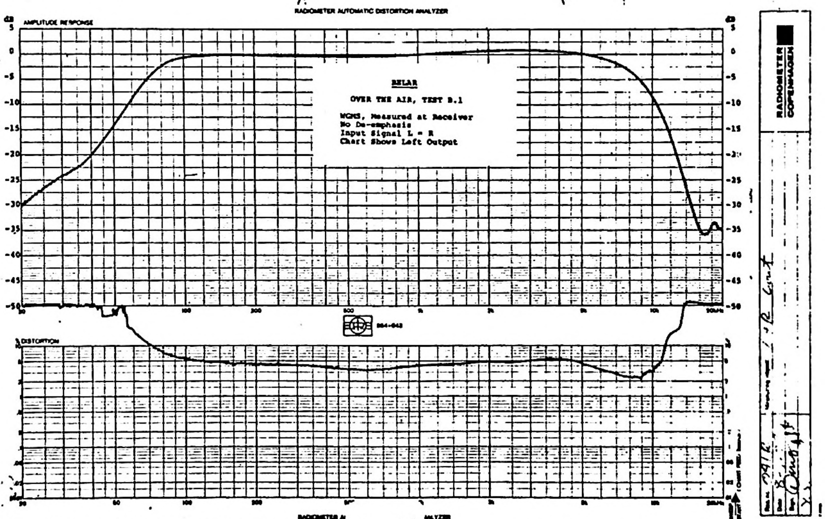
WGMS, Measured at Receiver
No De-emphasis
Fidelity Bandwidth
Input Signal L = R
Chart Shows Left Output



MOTOROLA

OVER THE AIR, TEST B.1

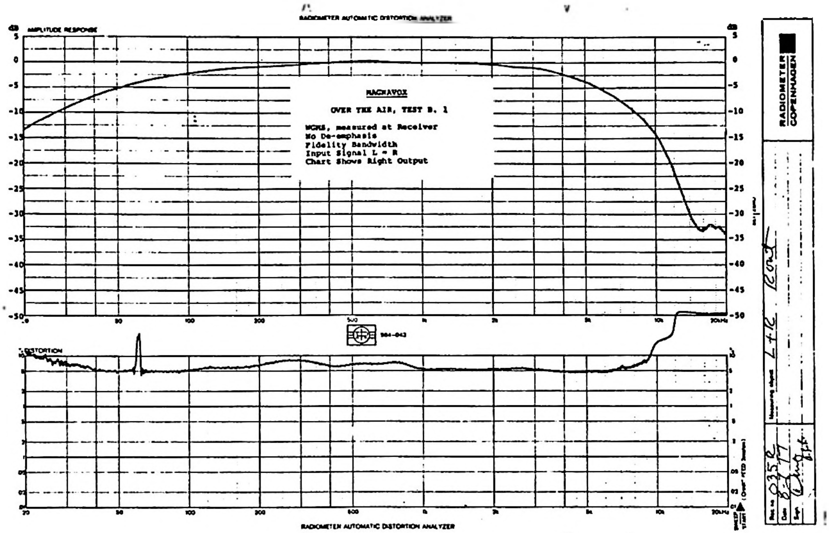
WGMS, Measured at Receiver
No De-emphasis
Input Signal L = R
Chart Shows Left Output



BELAR

OVER THE AIR, TEST B.1

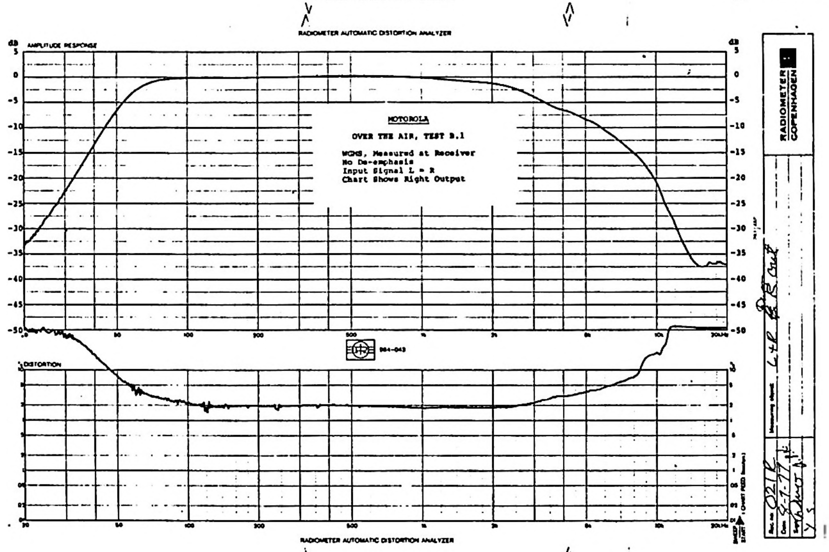
WGMS, Measured at Receiver
No De-emphasis
Input Signal L = R
Chart Shows Left Output



MAGNAVOX

OVER THE AIR, TEST B. 1

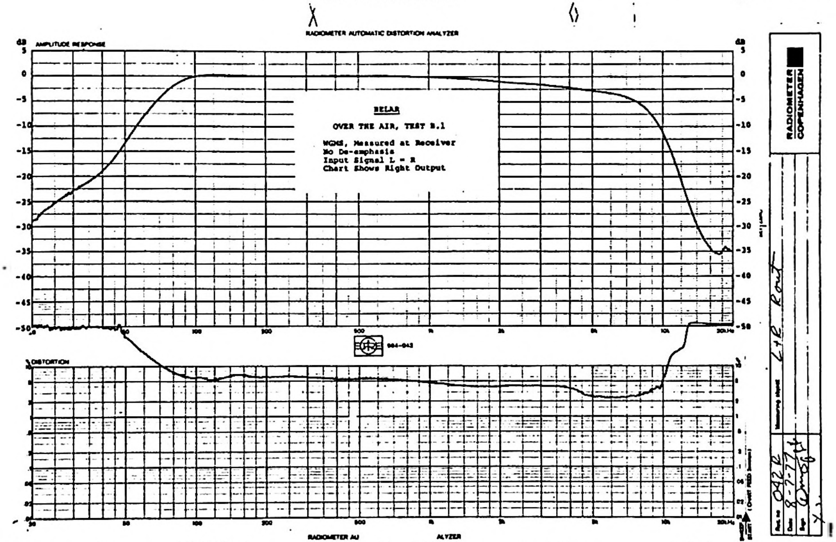
WGMS, measured at Receiver
No De-emphasis
Fidelity Bandwidth
Input Signal L = R
Chart Shows Right Output



MOTOROLA

OVER THE AIR, TEST B.1

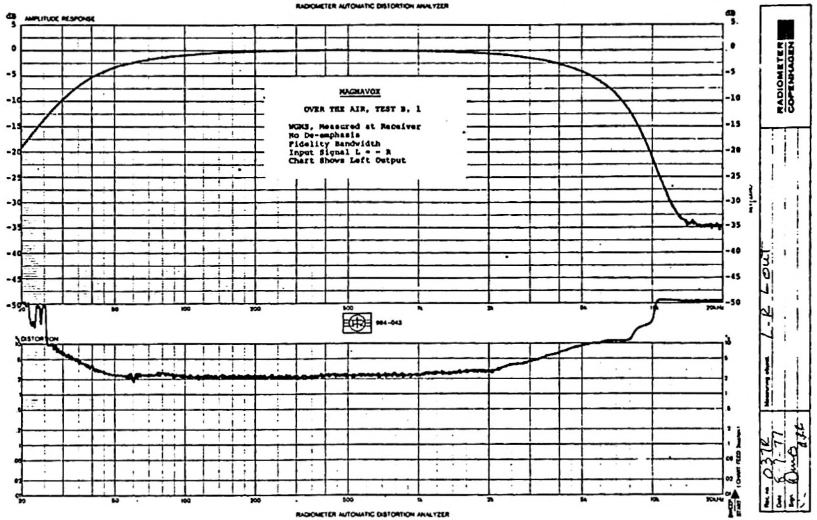
WGMS, Measured at Receiver
No De-emphasis
Input Signal L = R
Chart Shows Right Output



BELAR

OVER THE AIR, TEST B.1

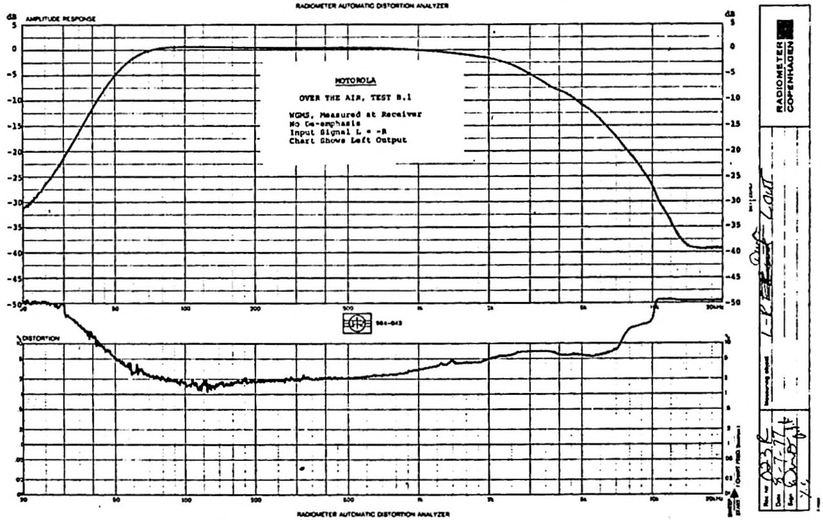
WGMS, Measured at Receiver
No De-emphasis
Input Signal L = R
Chart Shows Right Output



MAGNAVOX

OVER THE AIR, TEST B. 1

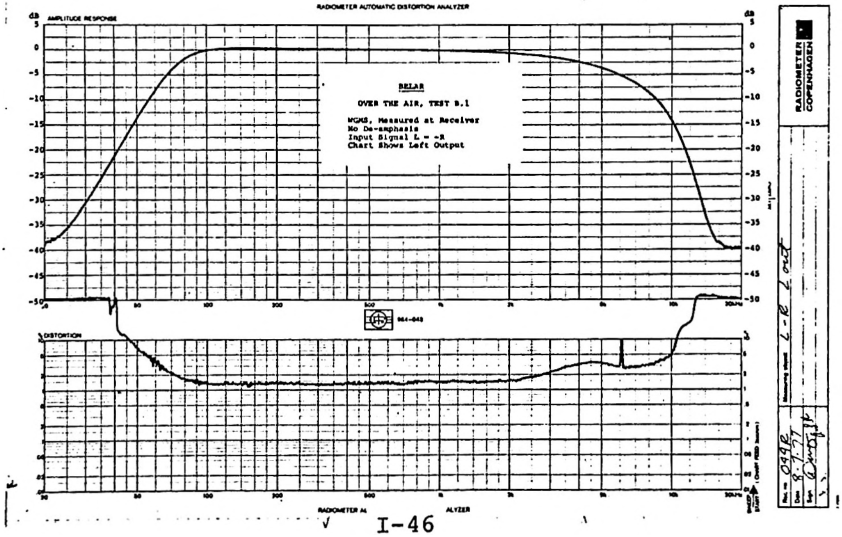
WGMS, Measured at Receiver
No De-emphasis
Fidelity Bandwidth
Input Signal L = - R
Chart Shows Left Output



MOTOROLA

OVER THE AIR, TEST B.1

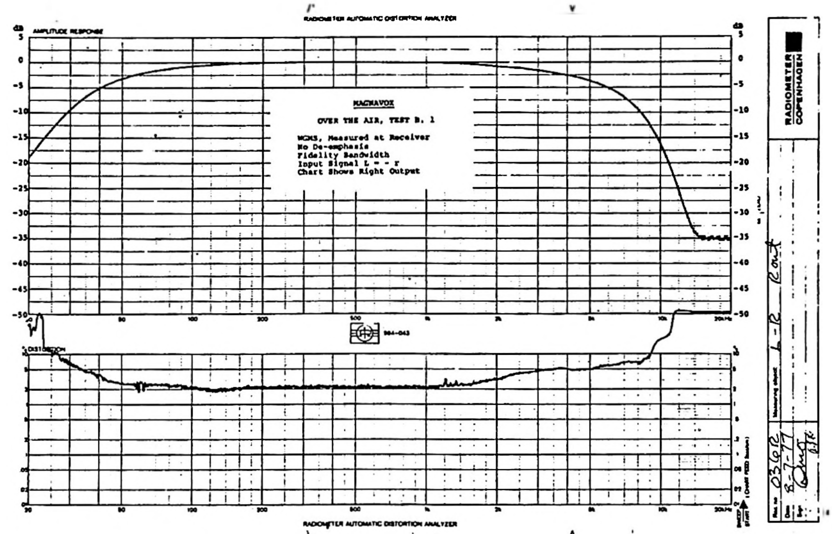
WGMS, Measured at Receiver
No De-emphasis
Input Signal L = -R
Chart Shows Left Output



BELAR

OVER THE AIR, TEST B.1

WGMS, Measured at Receiver
No De-emphasis
Input Signal L = -R
Chart Shows Left Output

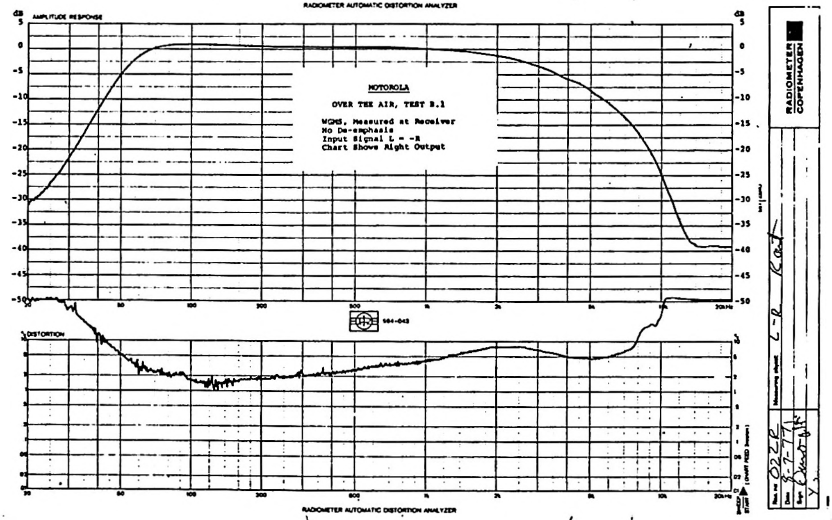


MAGNAVOX

OVER THE AIR, TEST B. 1

WGMS, Measured at Receiver
No De-emphasis
Fidelity Bandwidth
Input Signal L = - r
Chart Shows Right Output

Measuring object L-R Rout
Rec. no 0301R
Date 8-7-77

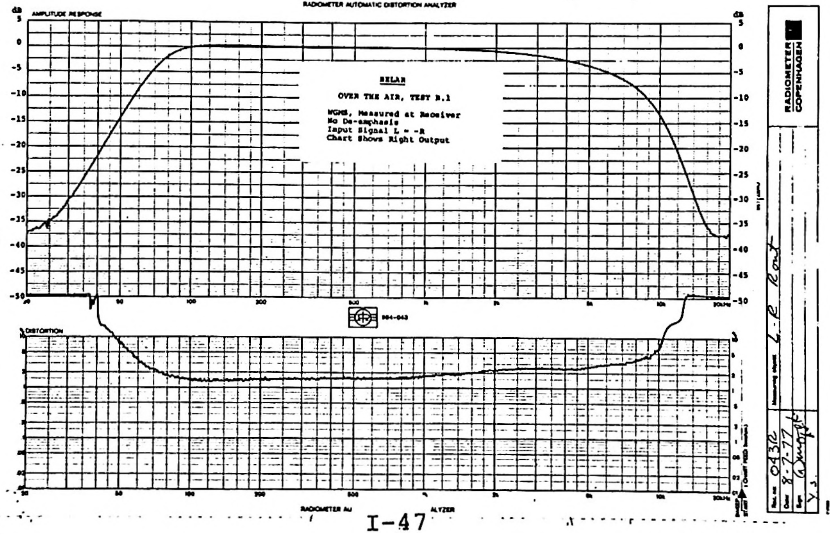


MOTOROLA

OVER THE AIR, TEST B.1

WGMS, Measured at Receiver
No De-emphasis
Input Signal L = -R
Chart Shows Right Output

Measuring object L-R Rout
Rec. no 022R
Date 8-7-77
Y.S.

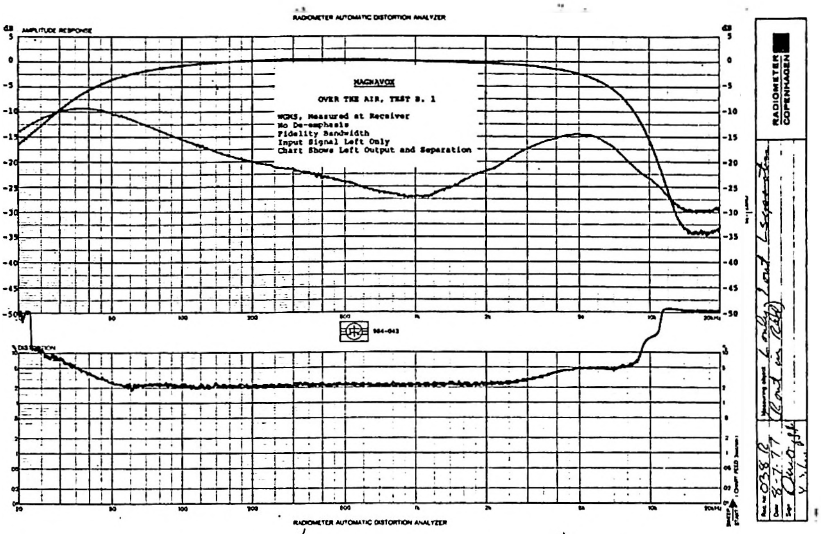


BELAR

OVER THE AIR, TEST B.1

WGMS, Measured at Receiver
No De-emphasis
Input Signal L = -R
Chart Shows Right Output

Measuring object L-R Rout
Rec. no 043R
Date 8-7-77
Y.S.

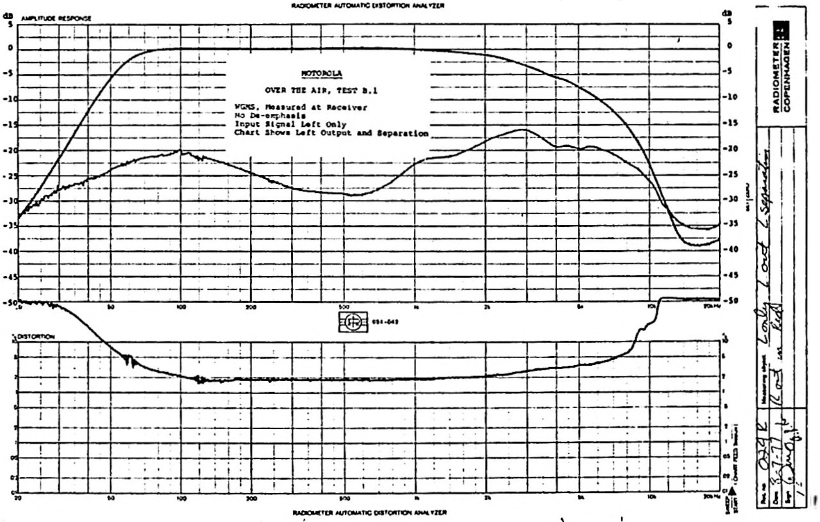


MAGNAVOX

OVER THE AIR, TEST B. 1

WGMS, Measured at Receiver
No De-emphasis
Fidelity Bandwidth
Input Signal Left Only
Chart Shows Left Output and Separation

Rec no 038 R
Date 8-7-77
Sign Quo ...
Measuring object L only L out L separation
R out in R(L)

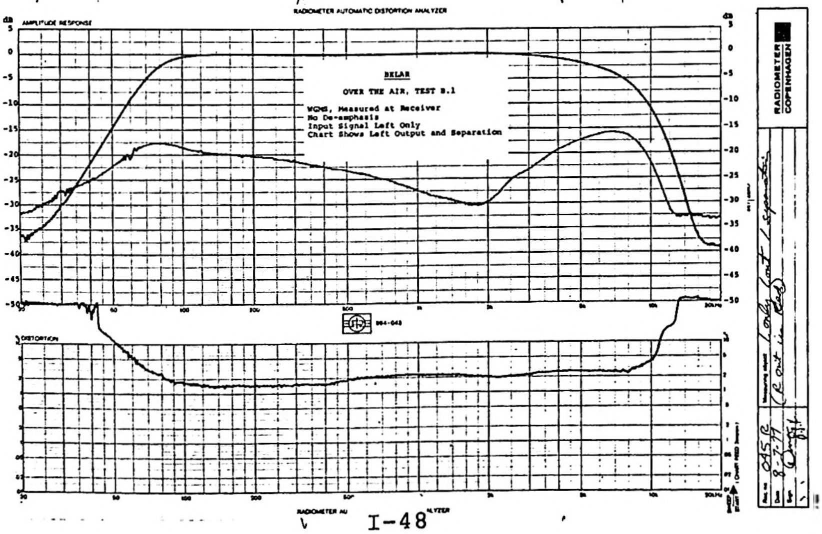


MOTOROLA

OVER THE AIR, TEST B.1

WGMS, Measured at Receiver
No De-emphasis
Input Signal Left Only
Chart Shows Left Output and Separation

Rec no 034 R
Date 8-7-77
Sign Quo ...
Measuring object L only L out L separation
R out in R(L)

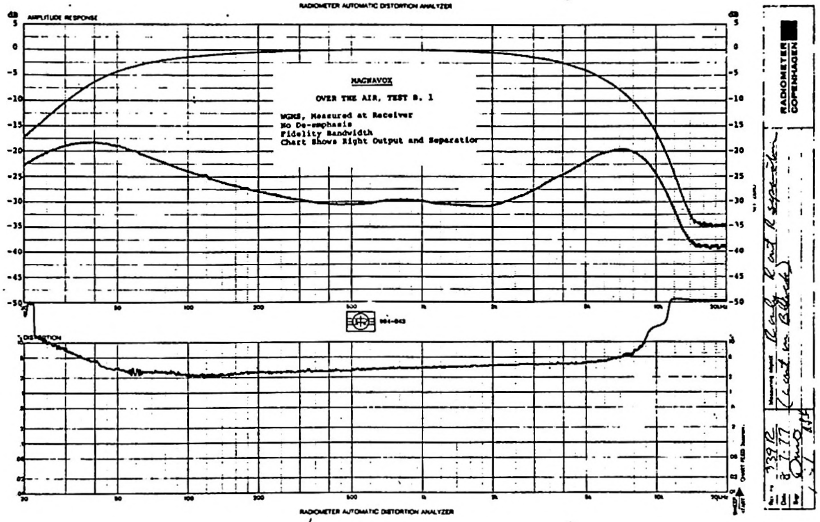


BELAR

OVER THE AIR, TEST B.1

WGMS, Measured at Receiver
No De-emphasis
Input Signal Left Only
Chart Shows Left Output and Separation

Rec no 045 R
Date 8-7-77
Sign Quo ...
Measuring object L only L out L separation
(R out in Red)



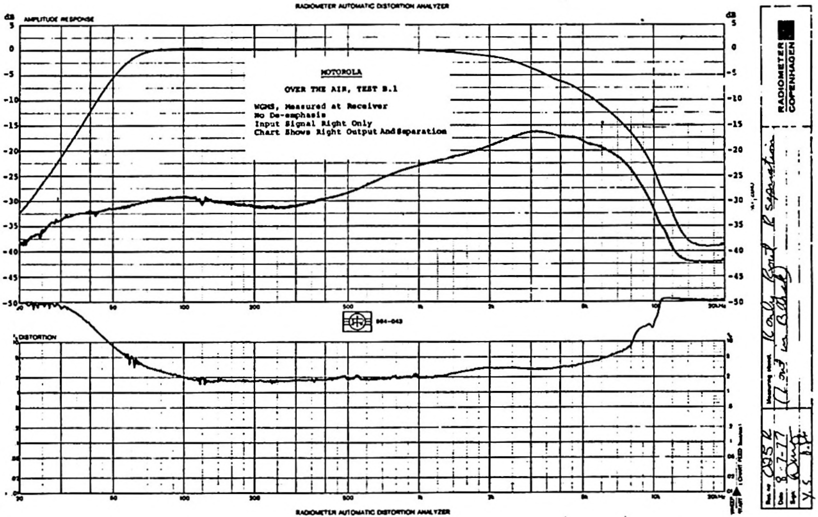
MAGNAVOX

OVER THE AIR, TEST B. 1

WGMS, Measured at Receiver
No De-emphasis
Fidelity Bandwidth
Chart Shows Right Output and Separation

R only R out R separation
(L out in Black)

339 R
8-7-77



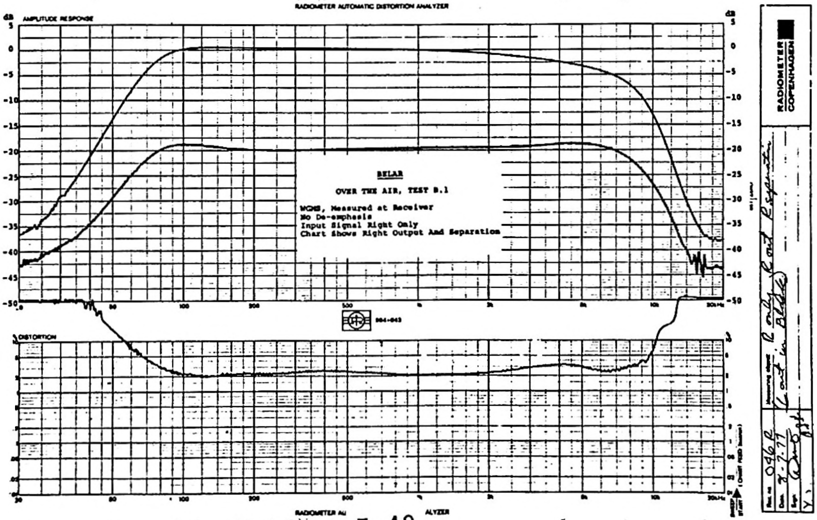
MOTOROLA

OVER THE AIR, TEST B.1

WGMS, Measured at Receiver
No De-emphasis
Input Signal Right Only
Chart Shows Right Output And Separation

R only R out R separation
(L out in Black)

095 R
8-7-77



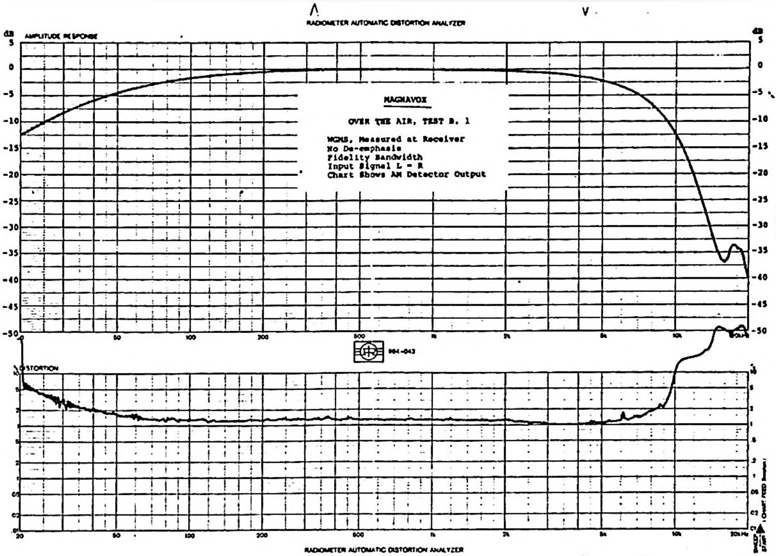
BELAR

OVER THE AIR, TEST B.1

WGMS, Measured at Receiver
No De-emphasis
Input Signal Right Only
Chart Shows Right Output And Separation

R only R out R separation
(L out in Black)

096 R
8-7-77



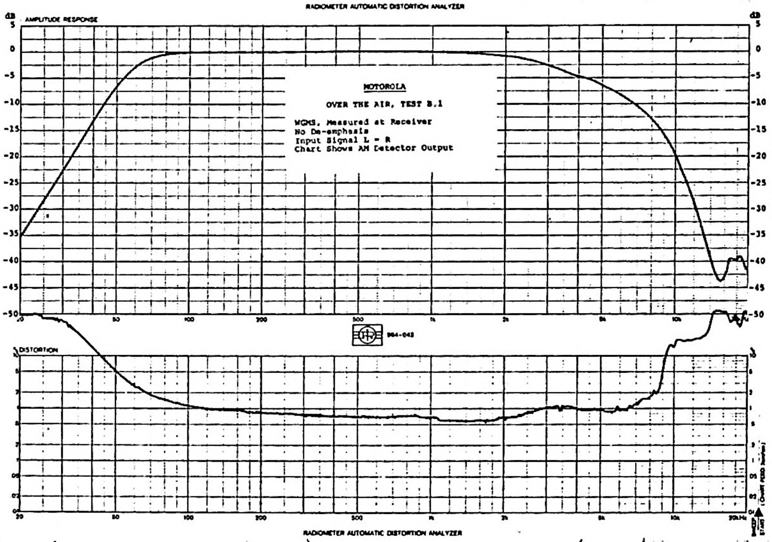
MAGNAVOX

OVER THE AIR, TEST B. 1

WGMS, Measured at Receiver
No De-emphasis
Fidelity Bandwidth
Input Signal L - R
Chart Shows AM Detector Output

RADIOMETER
COPENHAGEN

Measuring object: L Out RCVR IN Mono
Rec. no 0240R
Date 8-7-77
Sign. Dms



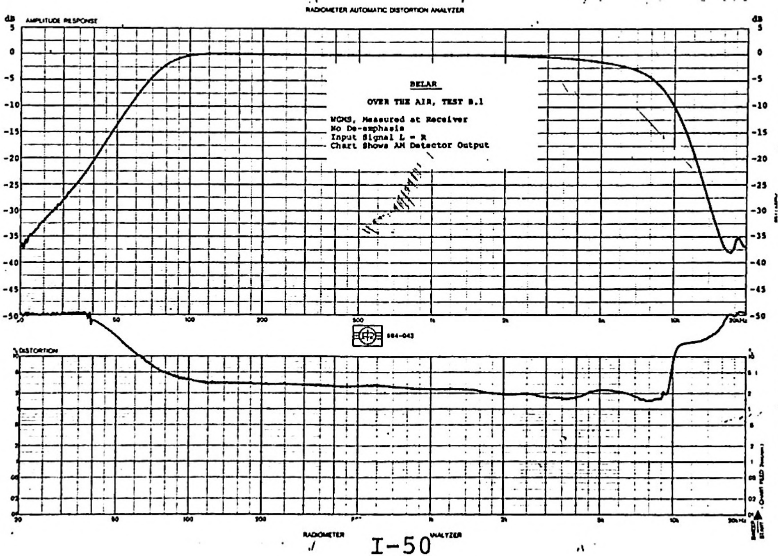
MOTOROLA

OVER THE AIR, TEST B.1

WGMS, Measured at Receiver
No De-emphasis
Input Signal L - R
Chart Shows AM Detector Output

RADIOMETER
COPENHAGEN

Measuring object: L+R Lost Special Run
envelope detector only RCVR in Mono
Rec. no 0261R
Date 8-7-77
Sign. Dms



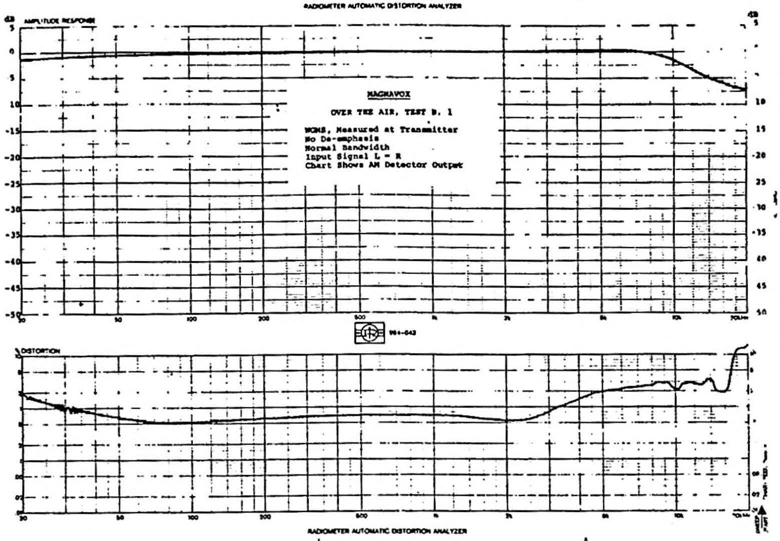
BELAR

OVER THE AIR, TEST B.1

WGMS, Measured at Receiver
No De-emphasis
Input Signal L - R
Chart Shows AM Detector Output

RADIOMETER
COPENHAGEN

Measuring object: Special Run L-R detector
RCVR in MONO
Rec. no 0471R
Date 8-7-77
Sign. Dms

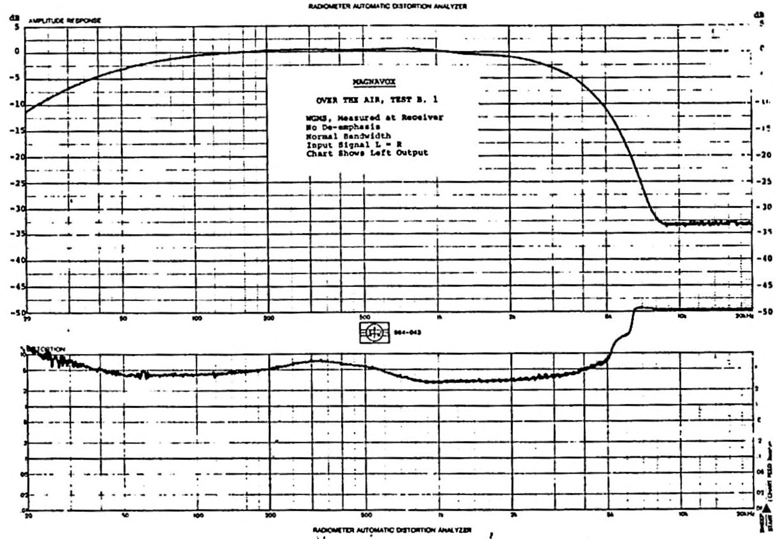


MAGNAVOX

OVER THE AIR, TEST B. 1

WGMS, Measured at Transmitter
No De-emphasis
Normal Bandwidth
Input Signal L = R
Chart Shows AM Detector Output

Special Run
output
8-1-77

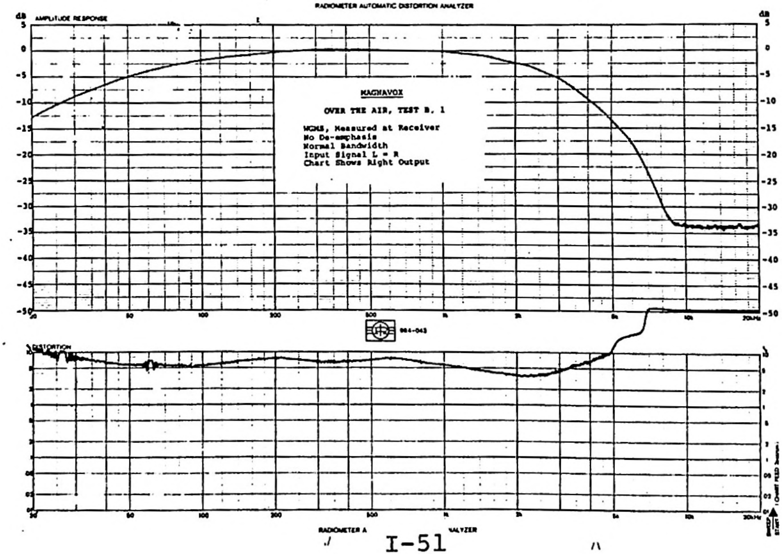


MAGNAVOX

OVER THE AIR, TEST B. 1

WGMS, Measured at Receiver
No De-emphasis
Normal Bandwidth
Input Signal L = R
Chart Shows Left Output

L+R L out
0277R
8-1-77

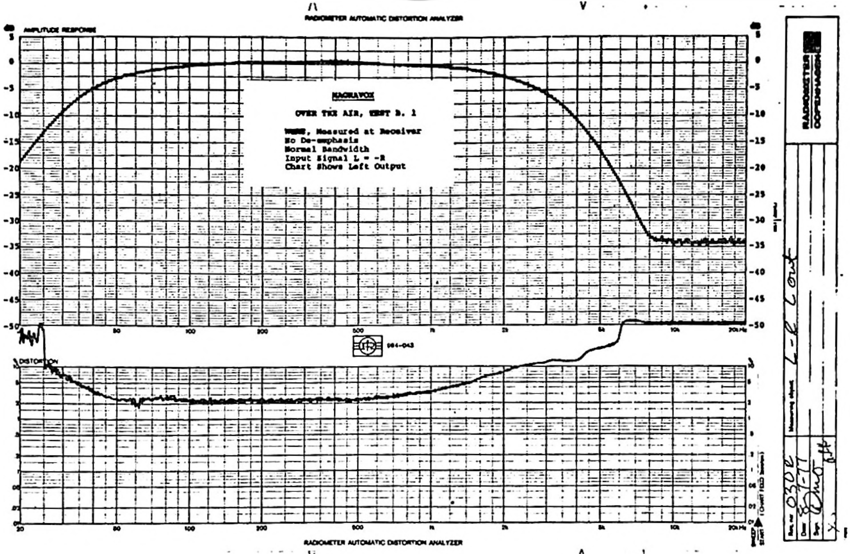


MAGNAVOX

OVER THE AIR, TEST B. 1

WGMS, Measured at Receiver
No De-emphasis
Normal Bandwidth
Input Signal L = R
Chart Shows Right Output

L+R R out
0278L
8-1-77



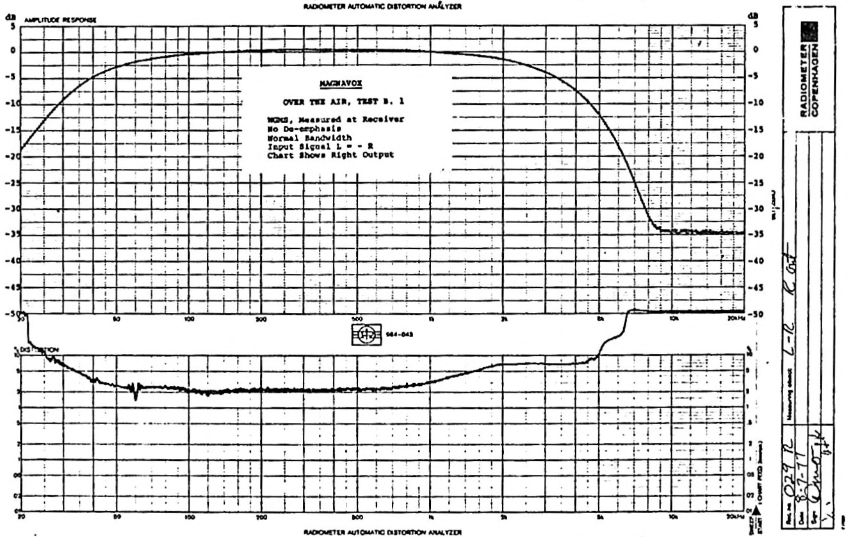
MAGNAVOX

OVER THE AIR, TEST B. 1

WGMS, Measured at Receiver
No De-emphasis
Normal Bandwidth
Input Signal L = -R
Chart Shows Left Output

L-R L out

030 L
8-7-77
DMO



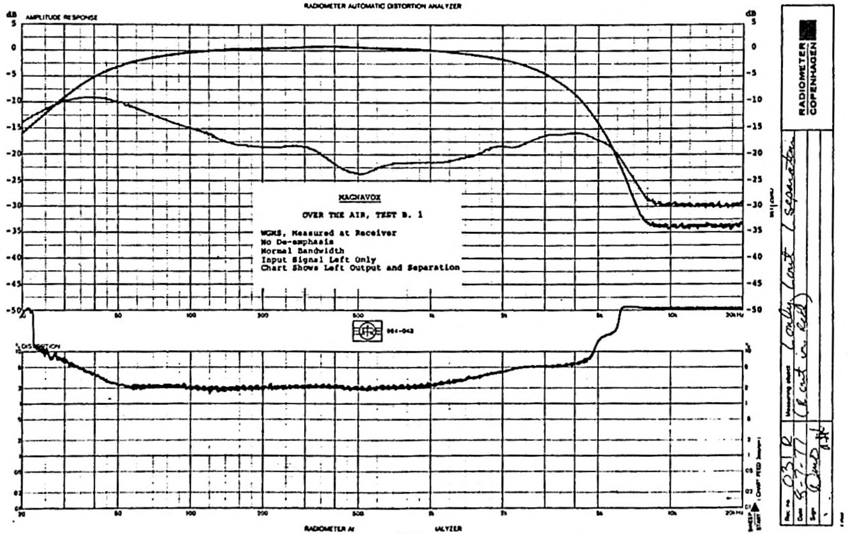
MAGNAVOX

OVER THE AIR, TEST B. 1

WGMS, Measured at Receiver
No De-emphasis
Normal Bandwidth
Input Signal L = - R
Chart Shows Right Output

L-R R out

029 R
8-7-77
DMO



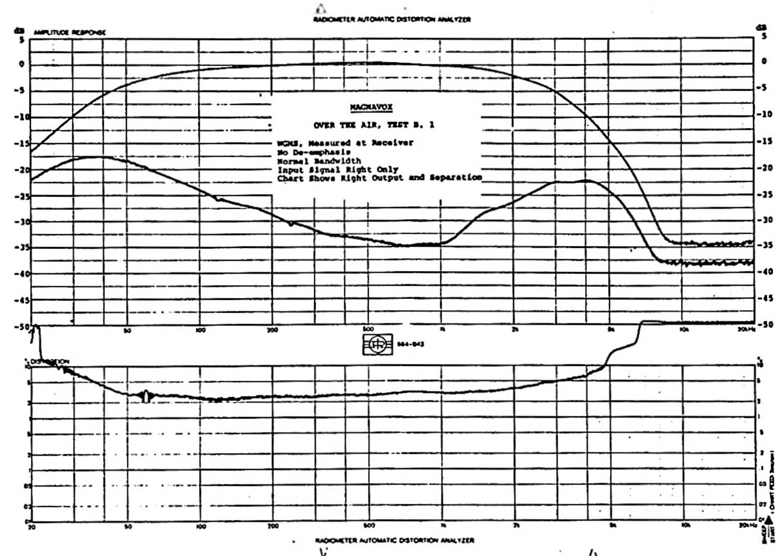
MAGNAVOX

OVER THE AIR, TEST B. 1

WGMS, Measured at Receiver
No De-emphasis
Normal Bandwidth
Input Signal Left Only
Chart Shows Left Output and Separation

L only L out / separation
(R out in red)

031 R
8-7-77
DMO



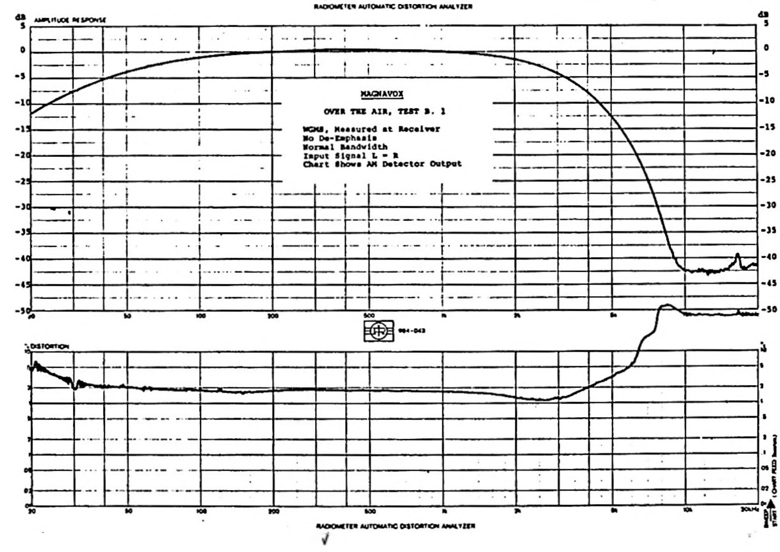
MAGNAVOX

OVER THE AIR, TEST B. 1

WCMS, Measured at Receiver
No De-emphasis
Normal Bandwidth
Input Signal Right Only
Chart Shows Right Output and Separation

Rec. no. 032R
Date 8-7-77
Measuring object R only R out Separation (L out in black)

RADIOMETER
COPENHAGEN



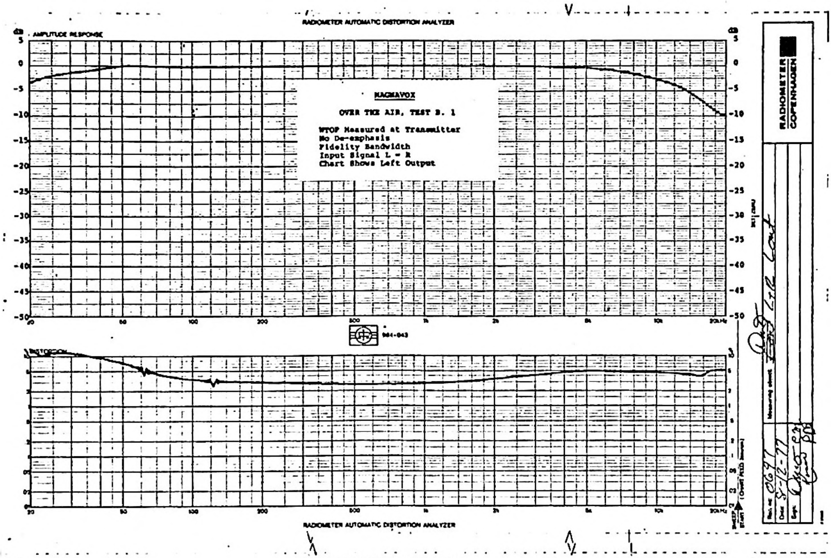
MAGNAVOX

OVER THE AIR, TEST B. 1

WCMS, Measured at Receiver
No De-Emphasis
Normal Bandwidth
Input Signal L = R
Chart Shows AM Detector Output

Rec. no. 033R
Date 8-7-77
Measuring object Special Run RCVR in MONO Lout

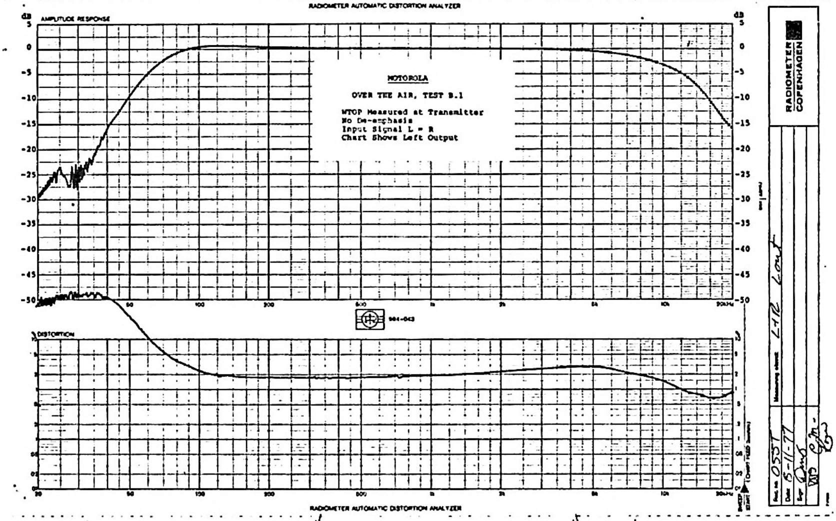
RADIOMETER
COPENHAGEN



MAGNAVOX

OVER THE AIR, TEST B. 1

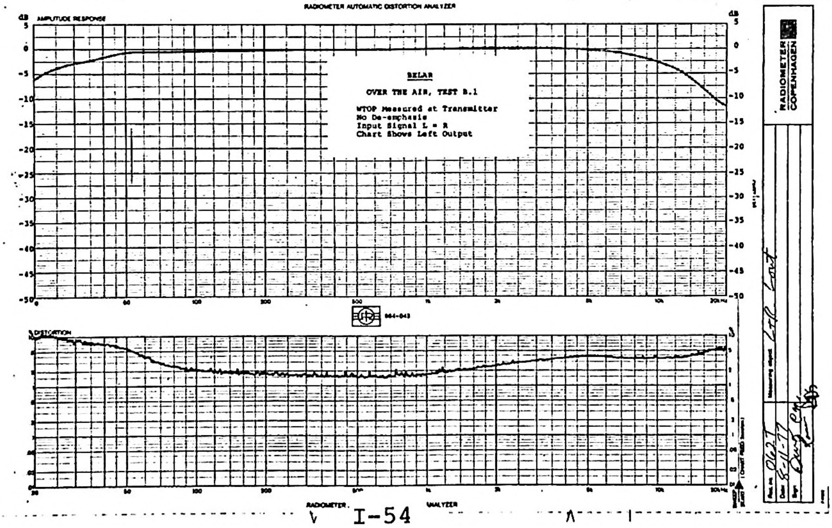
WTOP Measured at Transmitter
No De-emphasis
Fidelity Bandwidth
Input Signal L = R
Chart Shows Left Output



MOTOROLA

OVER THE AIR, TEST B.1

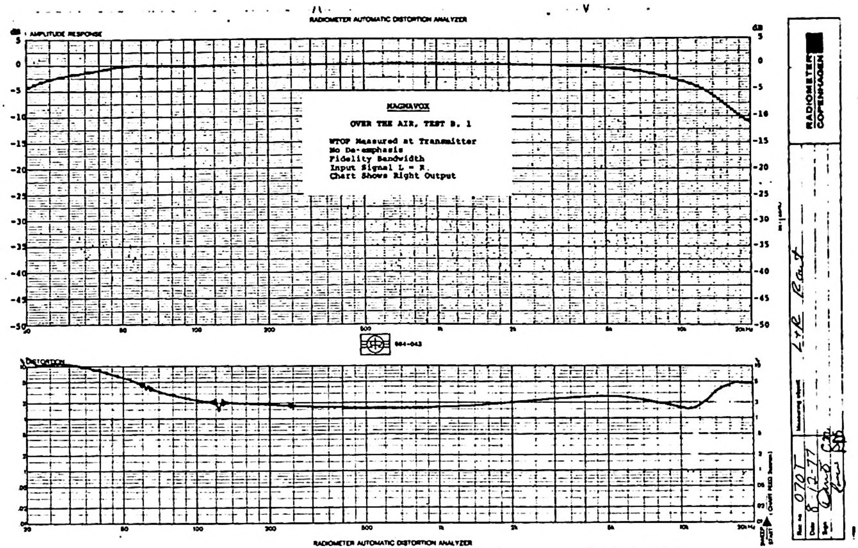
WTOP Measured at Transmitter
No De-emphasis
Input Signal L = R
Chart Shows Left Output



BELAR

OVER THE AIR, TEST B.1

WTOP Measured at Transmitter
No De-emphasis
Input Signal L = R
Chart Shows Left Output

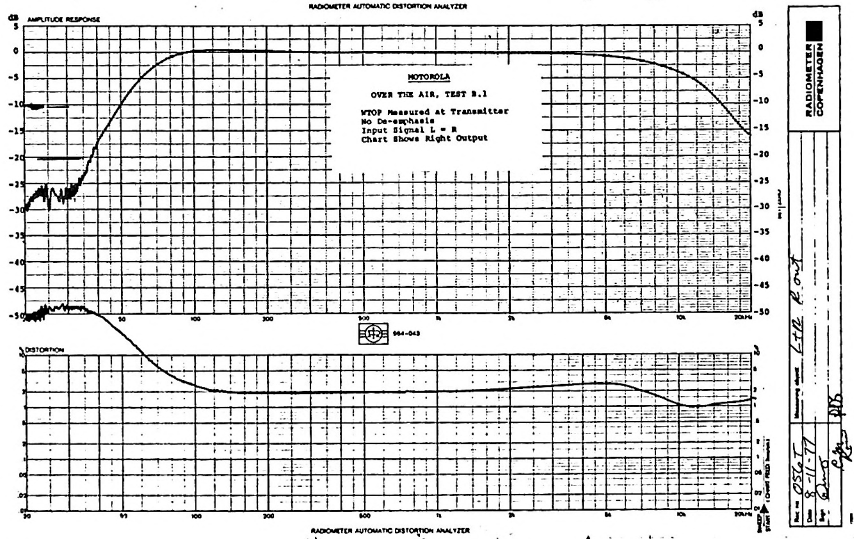


MAGNAVOX

OVER THE AIR, TEST B. 1

WTOP Measured at Transmitter
No De-emphasis
Fidelity Bandwidth
Input Signal L = R.
Chart Shows Right Output

Rec. no 070T
Date 8-12-77
Measuring object L+R Rout

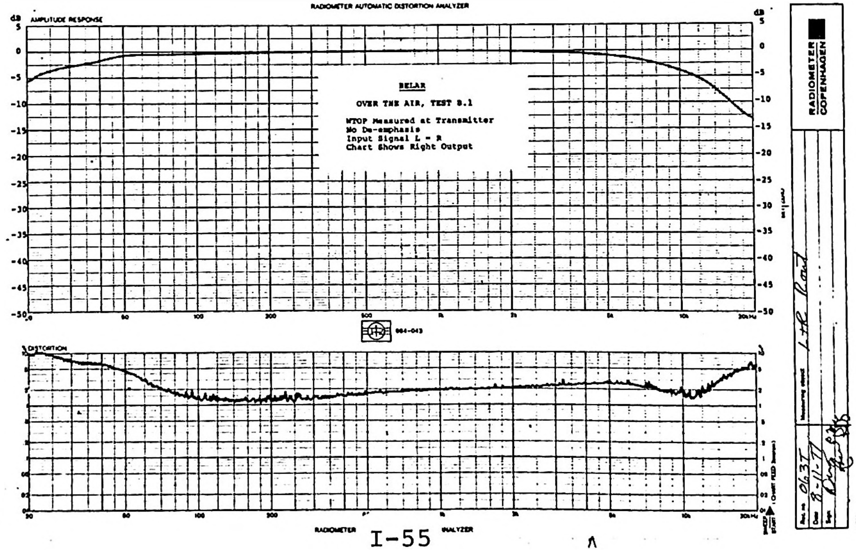


MOTOROLA

OVER THE AIR, TEST B.1

WTOP Measured at Transmitter
No De-emphasis
Input Signal L = R
Chart Shows Right Output

Rec. no 056T
Date 8-11-77
Measuring object L+R R out

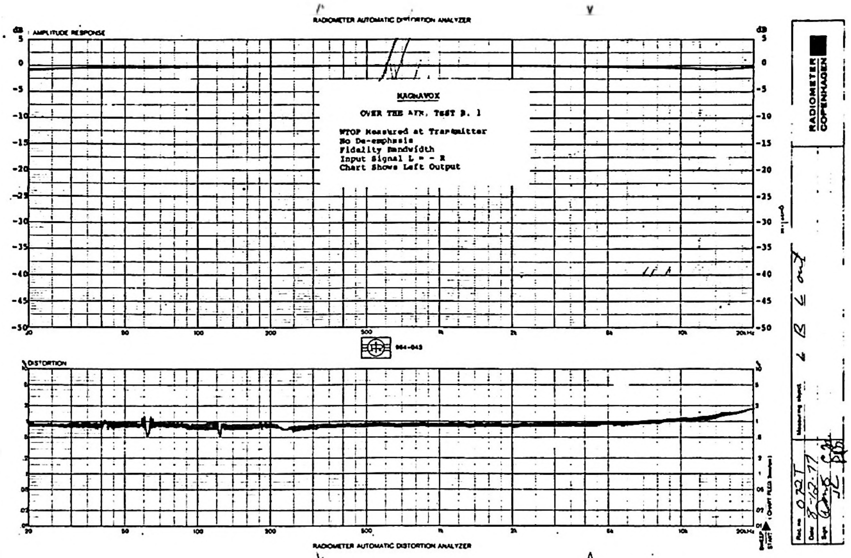


BELAR

OVER THE AIR, TEST B.1

WTOP Measured at Transmitter
No De-emphasis
Input Signal L = R
Chart Shows Right Output

Rec. no 063T
Date 8-11-77
Measuring object L+R Rout

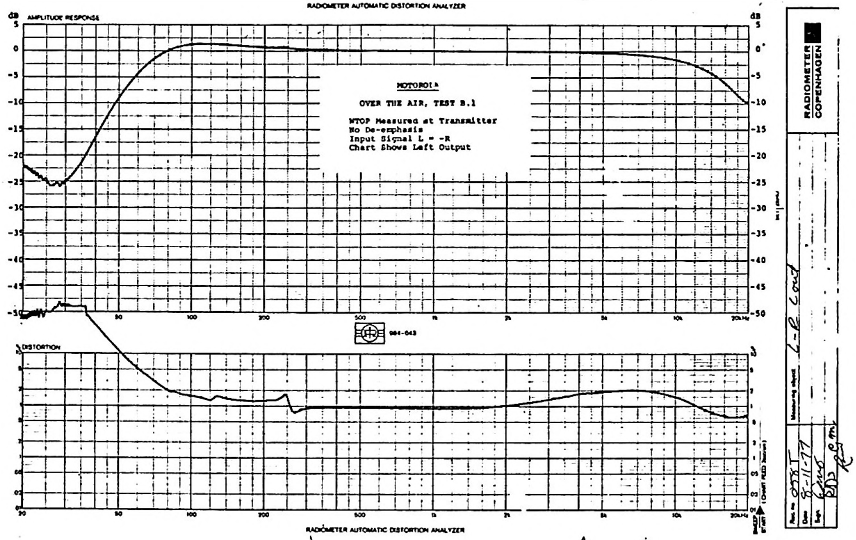


MAGNAVOX

OVER THE AIR, TEST B.1

WTOP Measured at Transmitter
No De-emphasis
Fidelity Bandwidth
Input Signal L = - R
Chart Shows Left Output

072T
8-12-77
L R L out

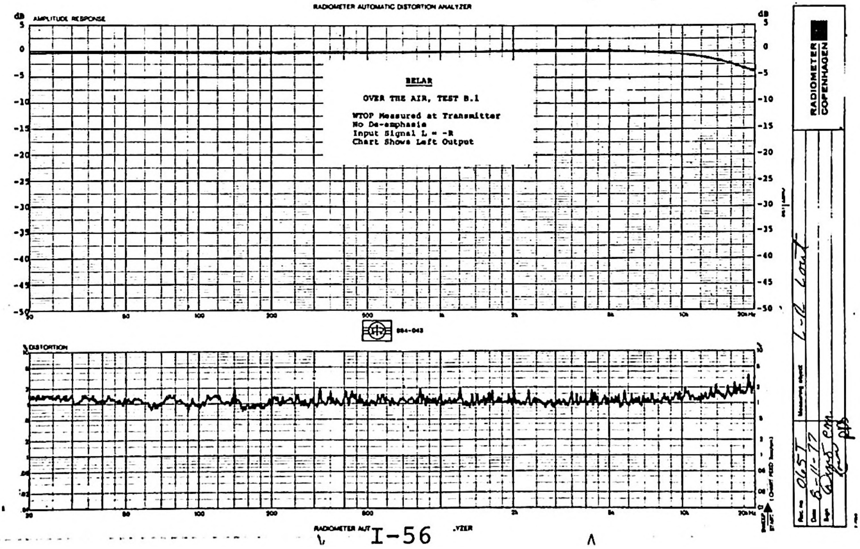


MOTOROLA

OVER THE AIR, TEST B.1

WTOP Measured at Transmitter
No De-emphasis
Input Signal L = -R
Chart Shows Left Output

078T
8-11-77
L-R L out

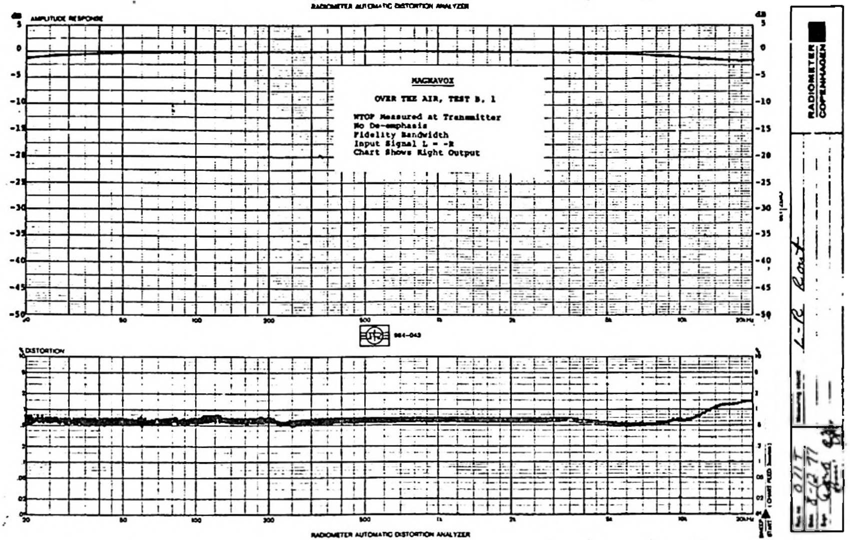


BELAR

OVER THE AIR, TEST B.1

WTOP Measured at Transmitter
No De-emphasis
Input Signal L = -R
Chart Shows Left Output

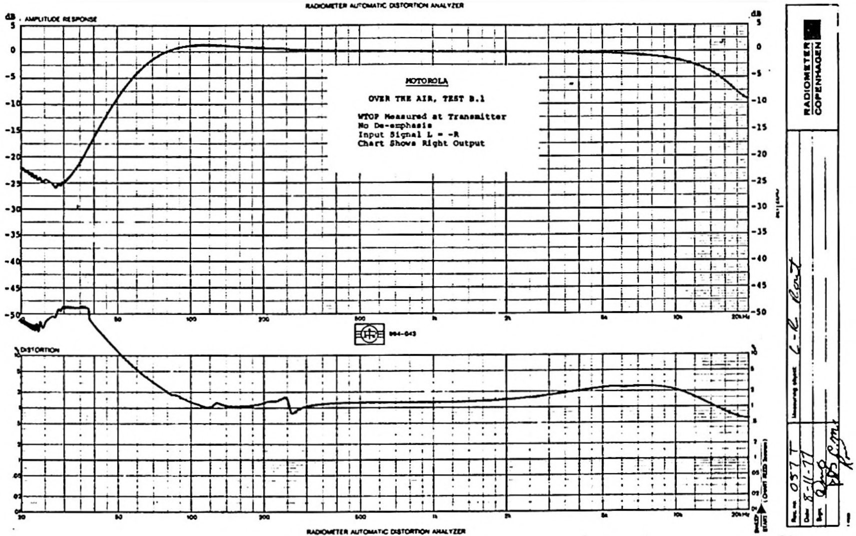
065T
8-11-77
L-R L out



MAGNAVOX

OVER THE AIR, TEST B. 1

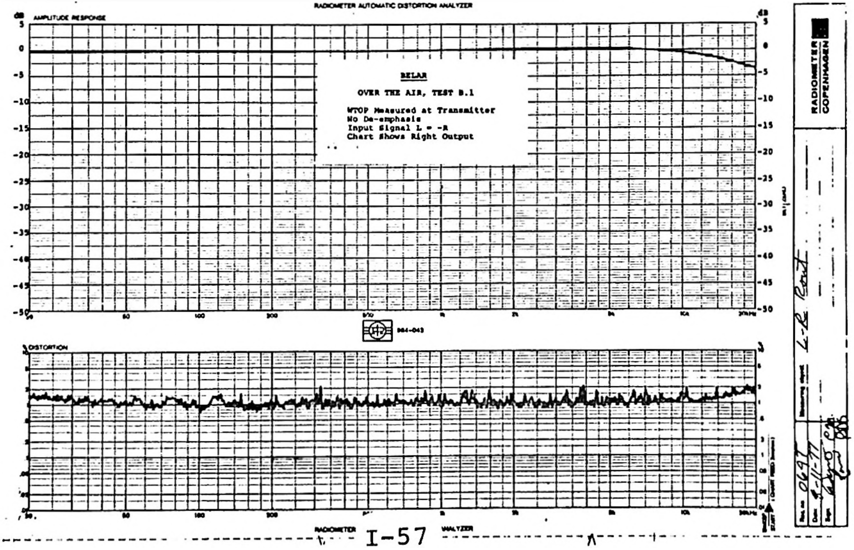
WTOP Measured at Transmitter
No De-emphasis
Fidelity Bandwidth
Input Signal L = -R
Chart Shows Right Output



MOTOROLA

OVER THE AIR, TEST B.1

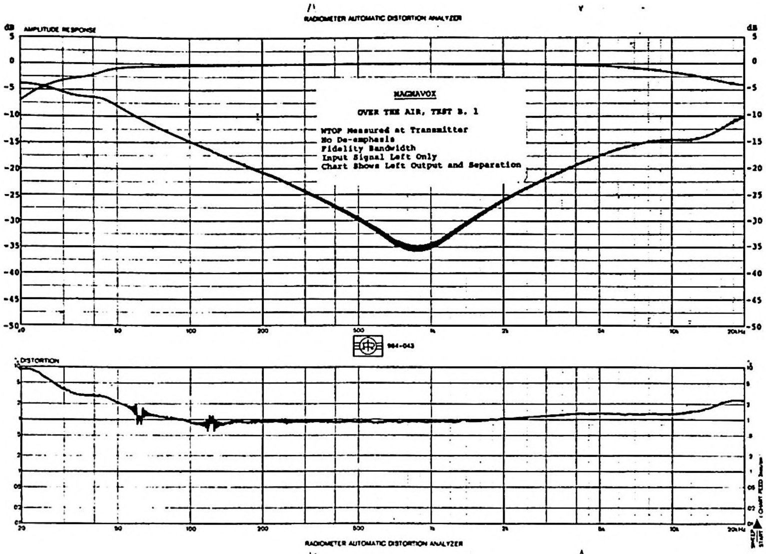
WTOP Measured at Transmitter
No De-emphasis
Input Signal L = -R
Chart Shows Right Output



BELAR

OVER THE AIR, TEST B.1

WTOP Measured at Transmitter
No De-emphasis
Input Signal L = -R
Chart Shows Right Output



MAGNAVOX

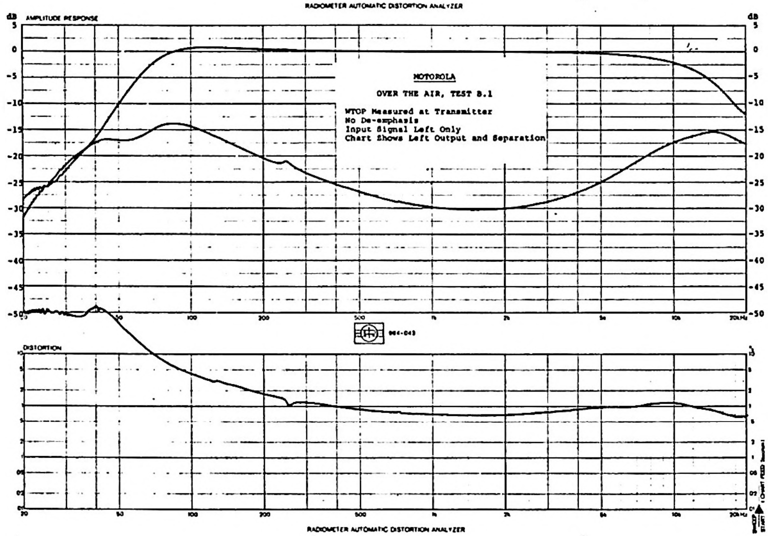
OVER THE AIR, TEST B. 1

WTOP Measured at Transmitter
No De-emphasis
Fidelity Bandwidth
Input Signal Left Only
Chart Shows Left Output and Separation

RADIOMETER
COPENHAGEN

Rt. 073T
Date 8-12-77
Sign. Omg cm
JL PDS

Measuring object L only L out L separation
(R out in PDS)
22.5 kHz in L-R



MOTOROLA

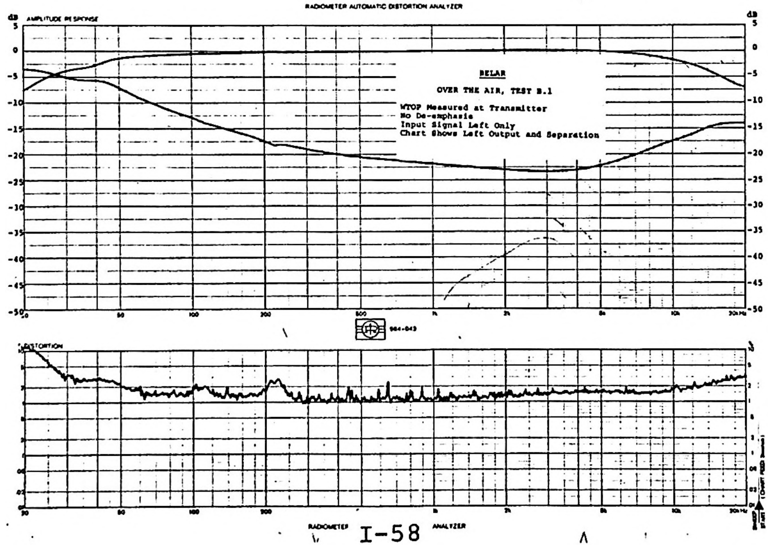
OVER THE AIR, TEST B.1

WTOP Measured at Transmitter
No De-emphasis
Input Signal Left Only
Chart Shows Left Output and Separation

RADIOMETER
COPENHAGEN

Rec. no. 059T
Date 8-11-77
Sign. Omg
Cm
Rm PDS

Measuring object L only L out L separation
(R out in PDS)



BELAR

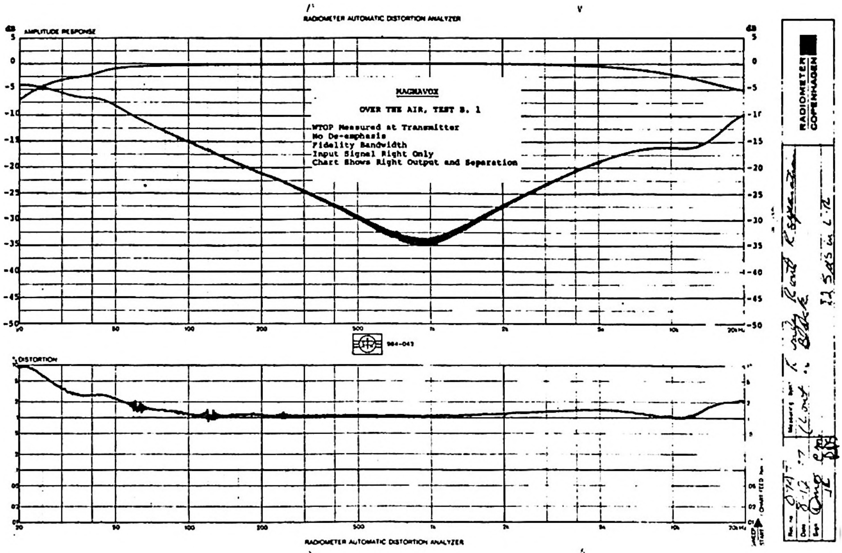
OVER THE AIR, TEST B.1

WTOP Measured at Transmitter
No De-emphasis
Input Signal Left Only
Chart Shows Left Output and Separation

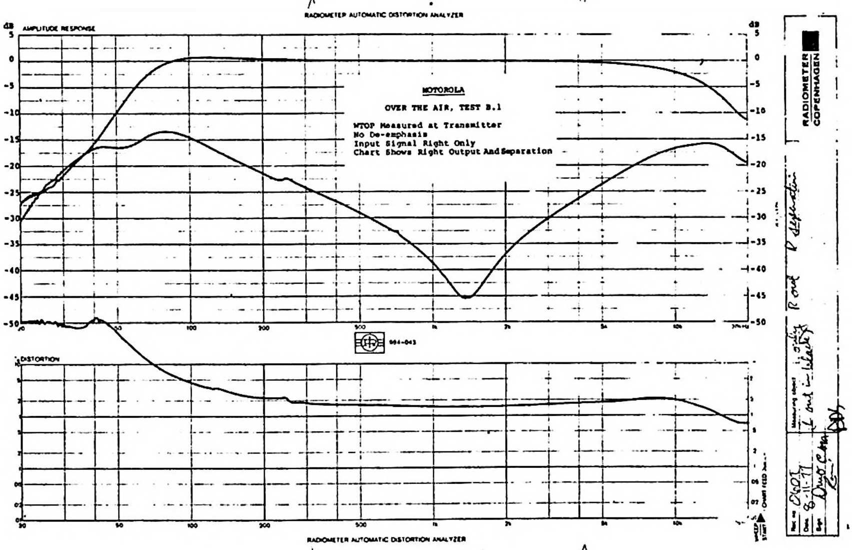
RADIOMETER
COPENHAGEN

Rec. no. 066T
Date 8-11-77
Sign. Omg Cm
Rm PDS

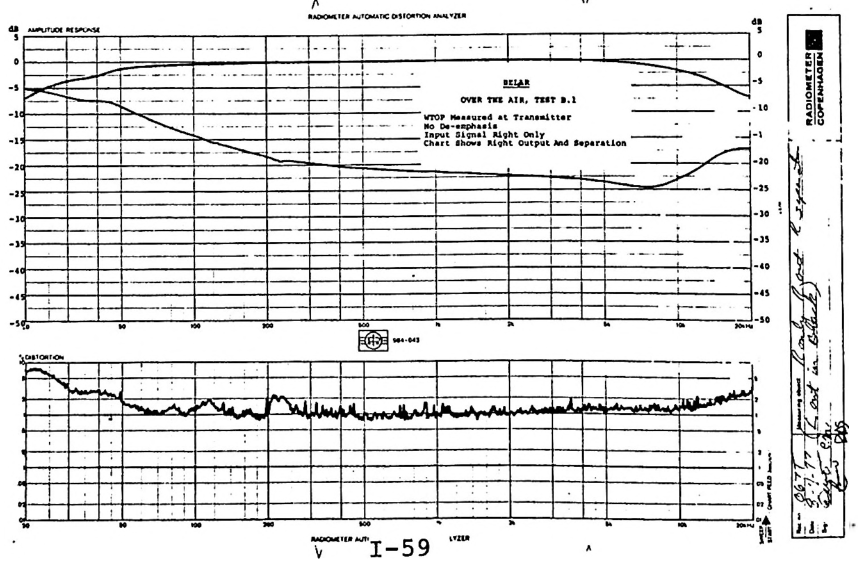
Measuring object L only L out L separation
(R out in PDS)



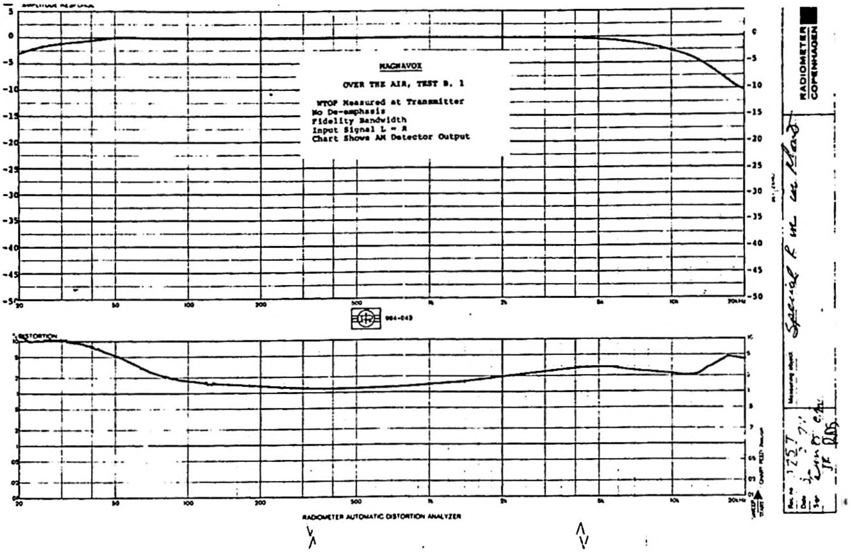
Rec. no 0727
Date 8-12-77
Sign Doug Ch JE
Measuring object R only R out R separation
(L out in Black)
JJ 5dB in L'R



Rec. no 0601
Date 8-11-77
Sign Doug Cham
Measuring object R out R separation
L out in black

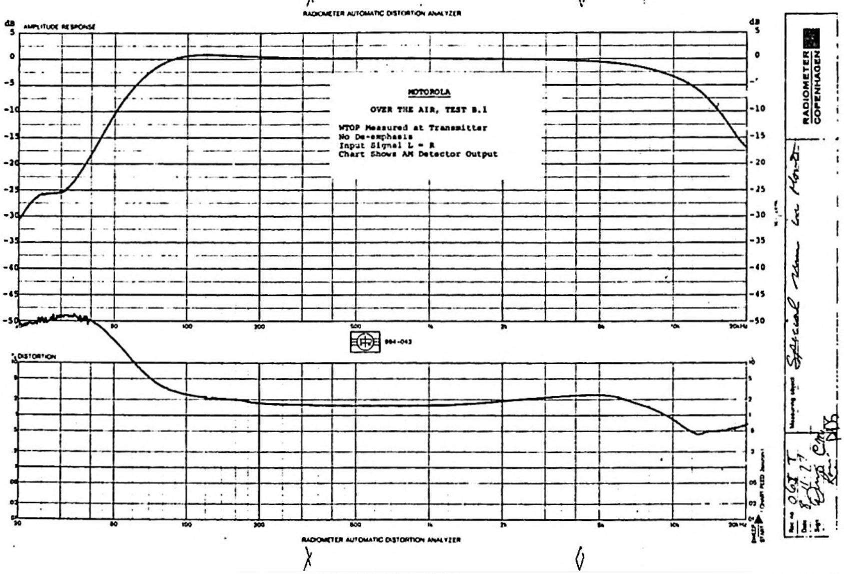


Rec. no 0677
Date 8-7-77
Measuring object R only R out R separat
(L out in Black)


MAGNAVOX

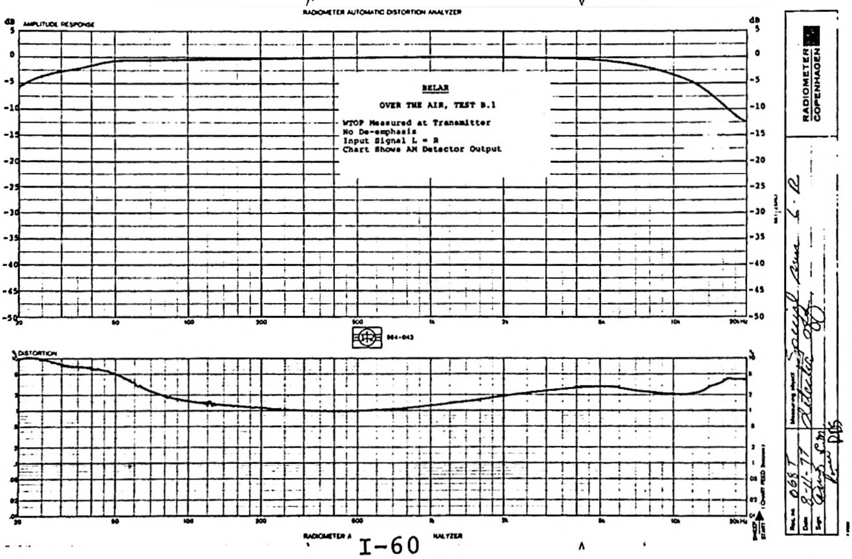
OVER THE AIR, TEST B. 1

WTOP Measured at Transmitter
No De-emphasis
Fidelity Bandwidth
Input Signal L = R
Chart Shows AM Detector Output


MOTOROLA

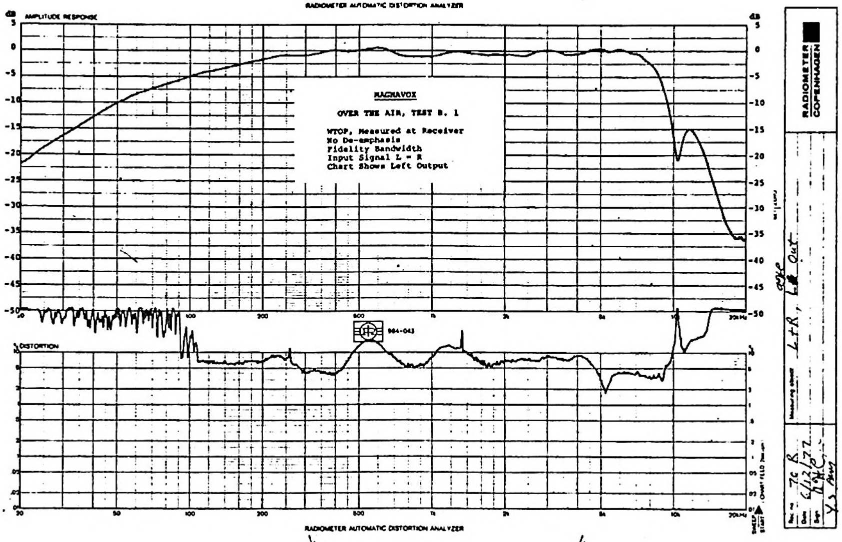
OVER THE AIR, TEST B.1

WTOP Measured at Transmitter
No De-emphasis
Input Signal L = R
Chart Shows AM Detector Output


BELAR

OVER THE AIR, TEST B.1

WTOP Measured at Transmitter
No De-emphasis
Input Signal L = R
Chart Shows AM Detector Output



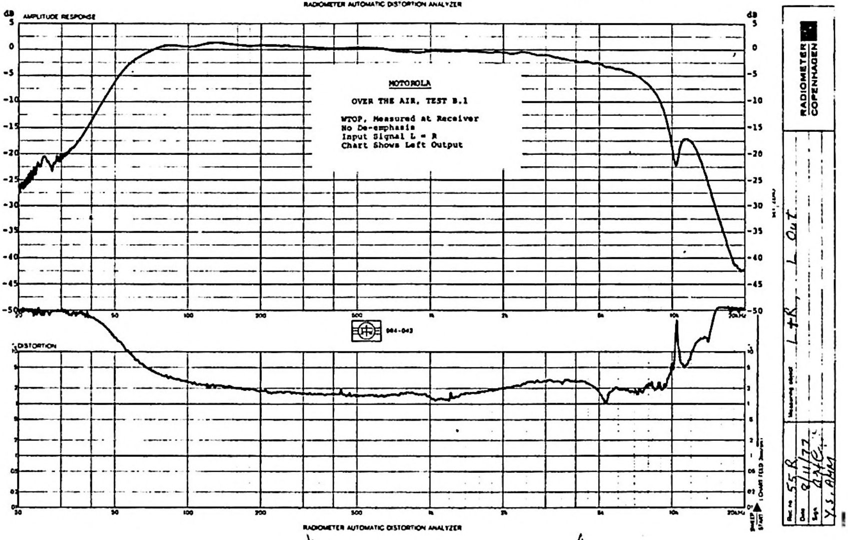
MAGNAVOX

OVER THE AIR, TEST B. 1

WTOP, Measured at Receiver
No De-emphasis
Fidelity Bandwidth
Input Signal L = R
Chart Shows Left Output

L+R, L Out

Rec no 7C R
Date 2/12/77
Sign AHC
Y.S.



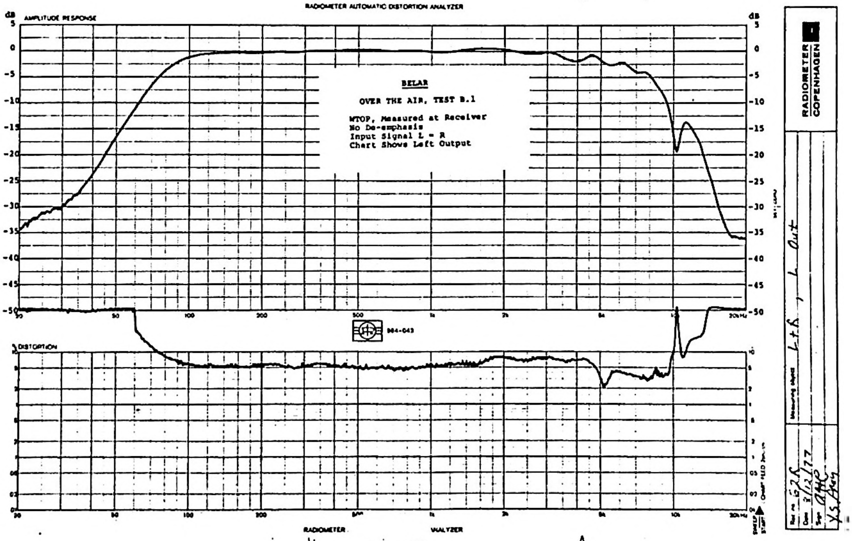
MOTOROLA

OVER THE AIR, TEST B.1

WTOP, Measured at Receiver
No De-emphasis
Input Signal L = R
Chart Shows Left Output

L+R, L Out

Rec no 55 R
Date 2/11/77
Sign AHC
Y.S.



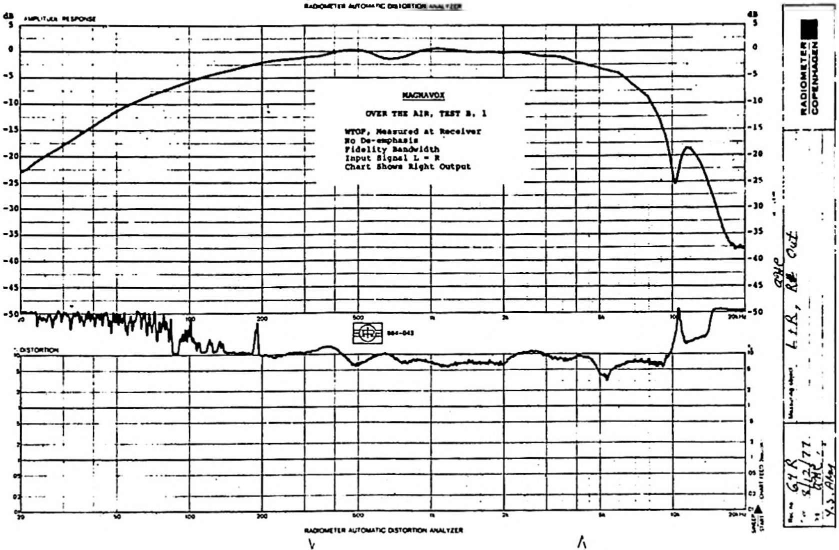
BELAR

OVER THE AIR, TEST B.1

WTOP, Measured at Receiver
No De-emphasis
Input Signal L = R
Chart Shows Left Output

L+R, L Out

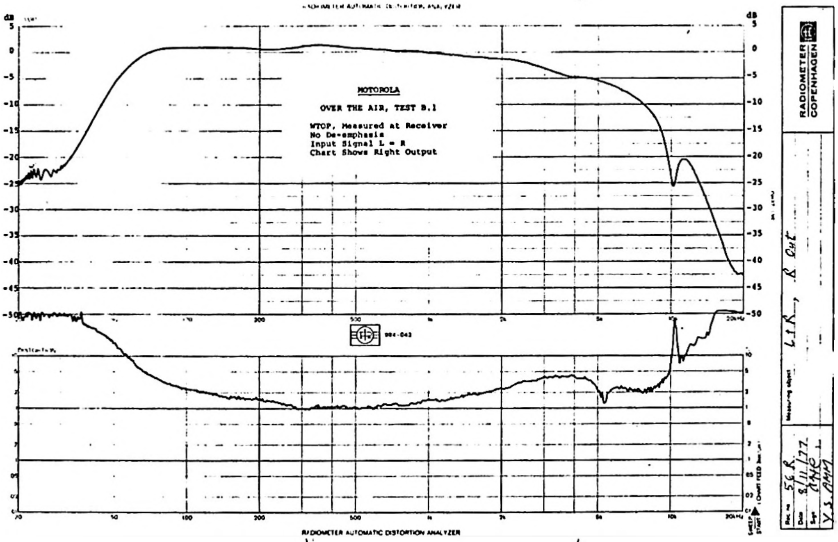
Rec no 67 R
Date 2/12/77
Sign AHC
Y.S.



MAGNAVOX

OVER THE AIR, TEST B. 1

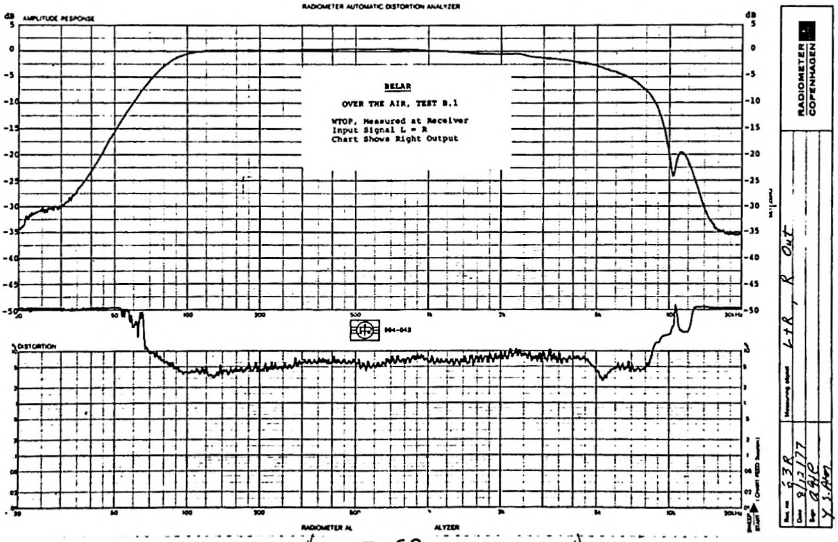
WTOP, Measured at Receiver
No De-emphasis
Fidelity Bandwidth
Input Signal L = R
Chart Shows Right Output



MOTOROLA

OVER THE AIR, TEST B.1

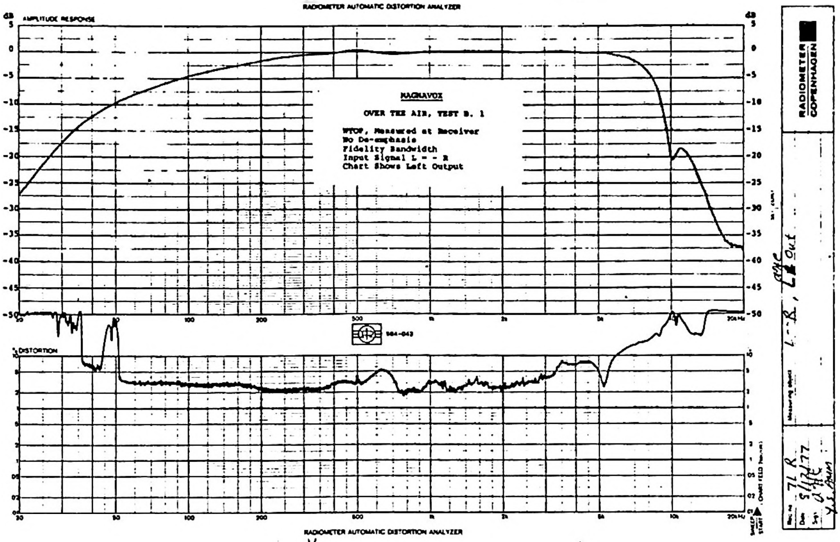
WTOP, Measured at Receiver
No De-emphasis
Input Signal L = R
Chart Shows Right Output



BELAR

OVER THE AIR, TEST B.1

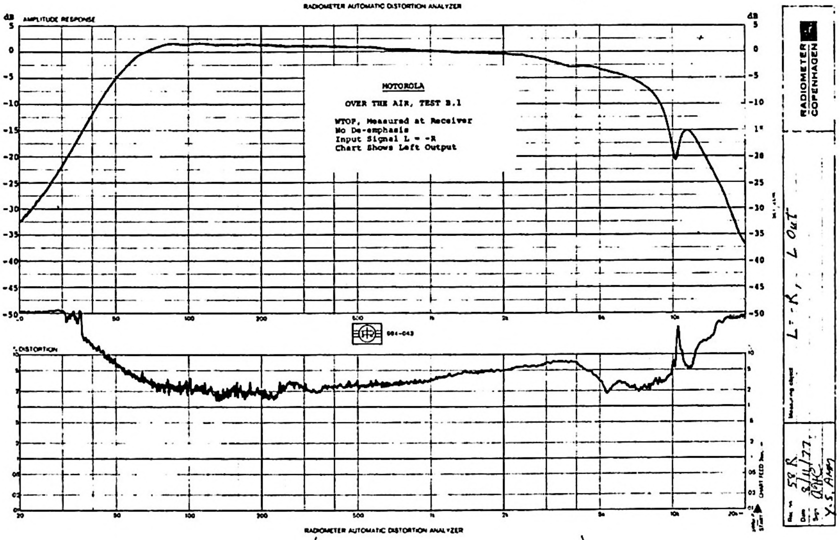
WTOP, Measured at Receiver
Input Signal L = R
Chart Shows Right Output



MAGNAVOX

OVER THE AIR, TEST B. 1

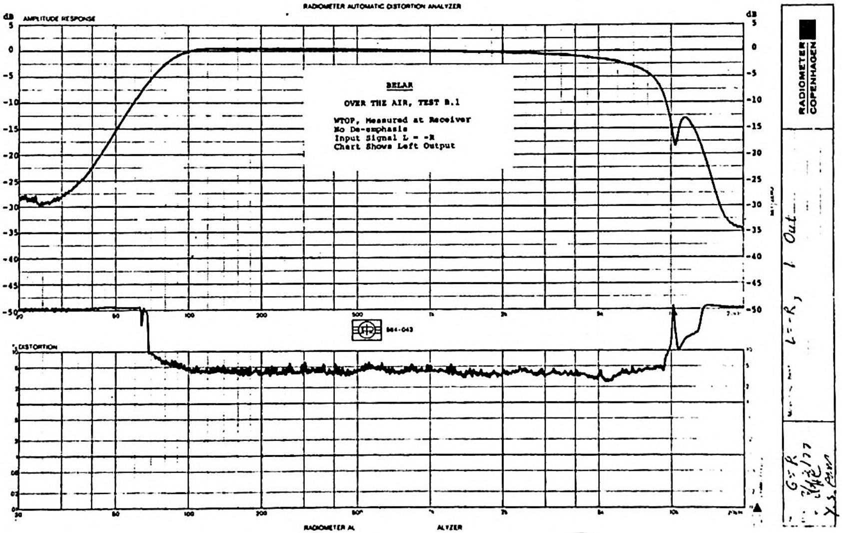
WTOP, Measured at Receiver
No De-emphasis
Fidelity Bandwidth
Input Signal L = - R
Chart Shows Left Output



MOTOROLA

OVER THE AIR, TEST B.1

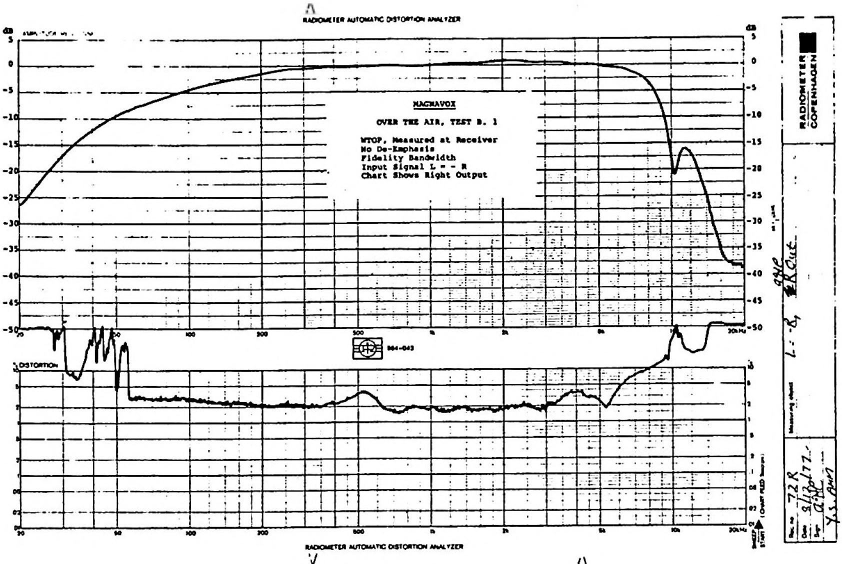
WTOP, Measured at Receiver
No De-emphasis
Input Signal L = -R
Chart Shows Left Output



BELAR

OVER THE AIR, TEST B.1

WTOP, Measured at Receiver
No De-emphasis
Input Signal L = -R
Chart Shows Left Output



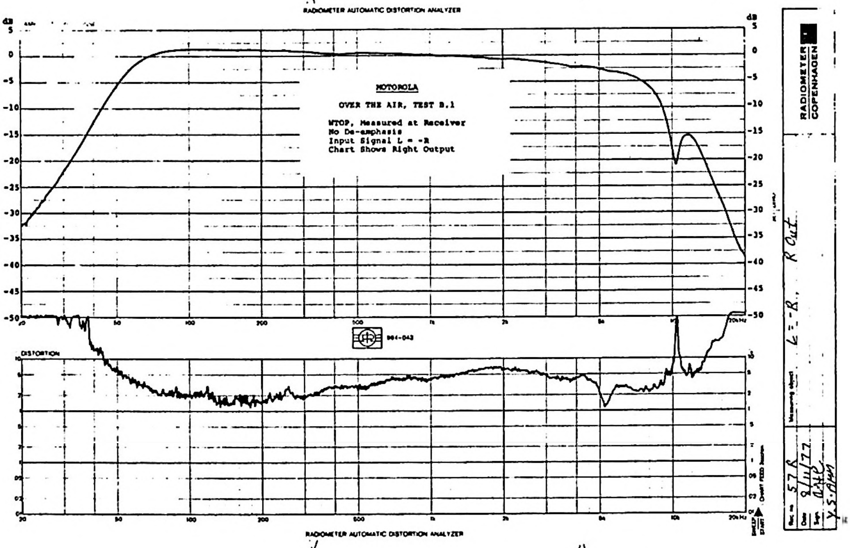
MAGNAVOX

OVER THE AIR, TEST B. 1

WTOP, Measured at Receiver
No De-Emphasis
Fidelity Bandwidth
Input Signal L = - R
Chart Shows Right Output

L = -R, ~~R~~ R Out 94C

72R
8/12/77
AHC
Y.S. AHM



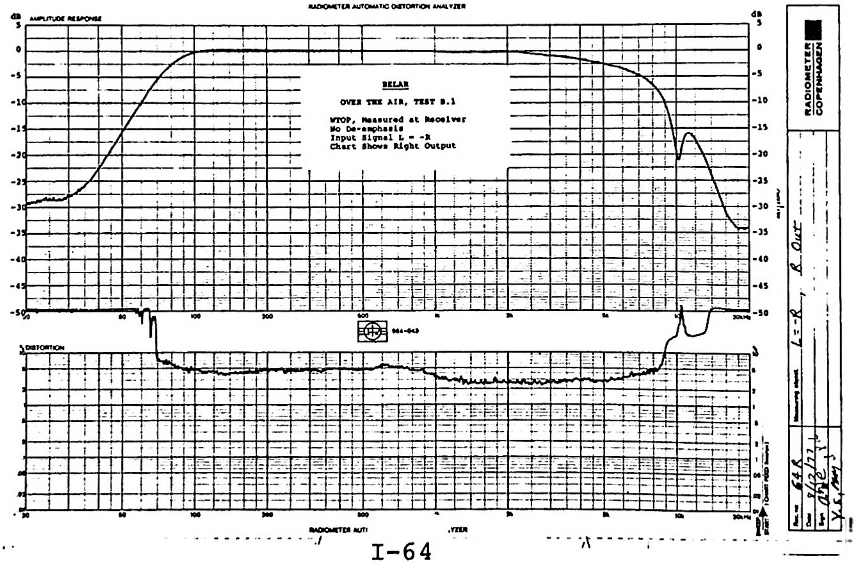
MOTOROLA

OVER THE AIR, TEST B.1

WTOP, Measured at Receiver
No De-emphasis
Input Signal L = -R
Chart Shows Right Output

L = -R, R Out

57R
8/11/77
AHC
Y.S. AHM



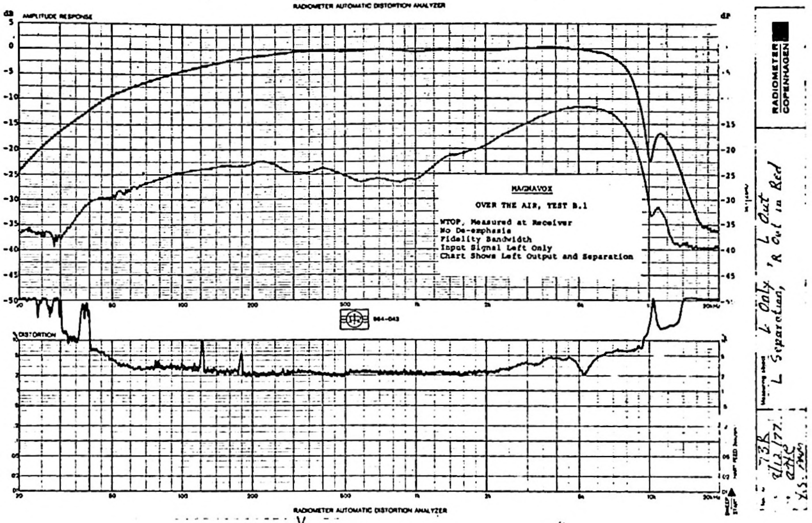
BELAR

OVER THE AIR, TEST B.1

WTOP, Measured at Receiver
No De-emphasis
Input Signal L = -R
Chart Shows Right Output

L = -R, R Out

64R
8/12/77
AHC
Y.S. AHM



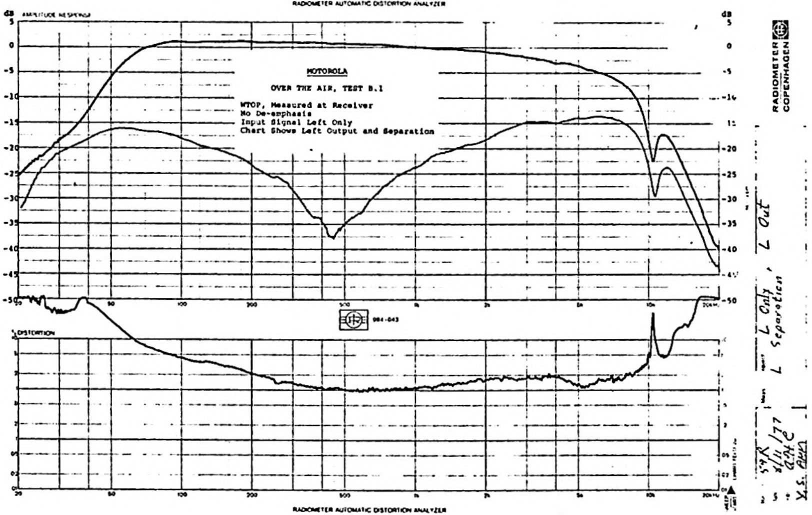
MAGNAVOX

OVER THE AIR, TEST B.1

WTOP, Measured at Receiver
No De-emphasis
Fidelity Bandwidth
Input Signal Left Only
Chart Shows Left Output and Separation

L Only, L Out
L Separation, R Out in Red

73R
2/12/77
AHC
Y.S. [illegible]



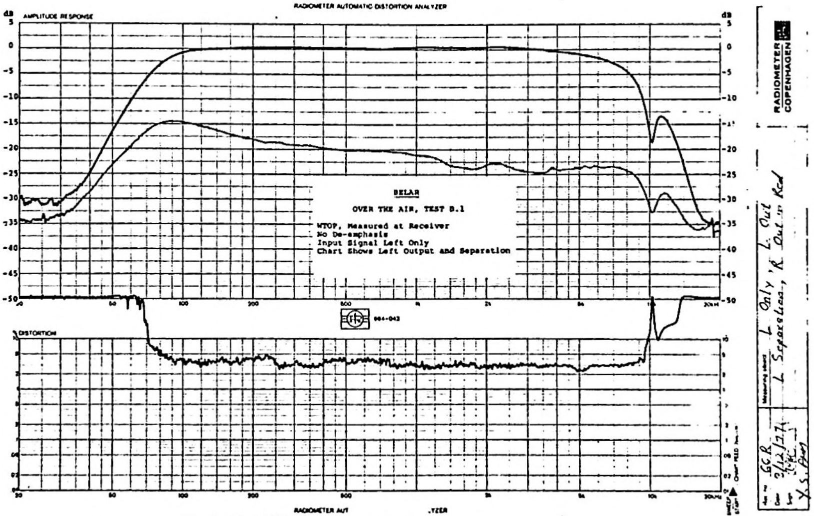
MOTOROLA

OVER THE AIR, TEST B.1

WTOP, Measured at Receiver
No De-emphasis
Input Signal Left Only
Chart Shows Left Output and Separation

L Only, L Out
L Separation

54R
2/11/77
AHC
Y.S. [illegible]



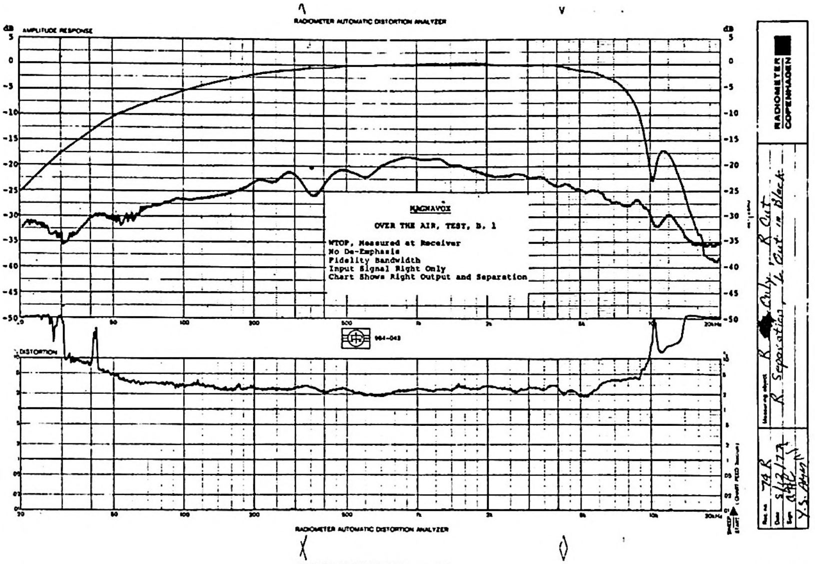
BELAR

OVER THE AIR, TEST B.1

WTOP, Measured at Receiver
No De-emphasis
Input Signal Left Only
Chart Shows Left Output and Separation

L Only, L Out
L Separation, R Out in Red

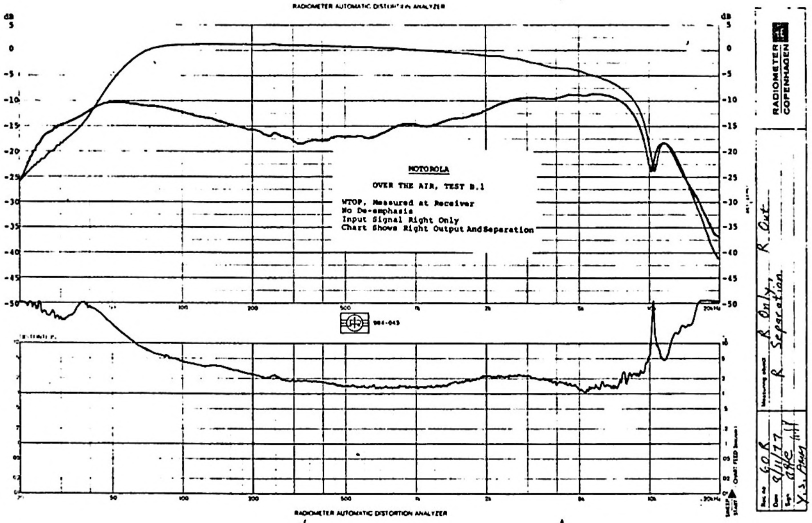
GCR
2/12/77
AHC
Y.S. [illegible]



MAGNAVOX

OVER THE AIR, TEST, B. 1

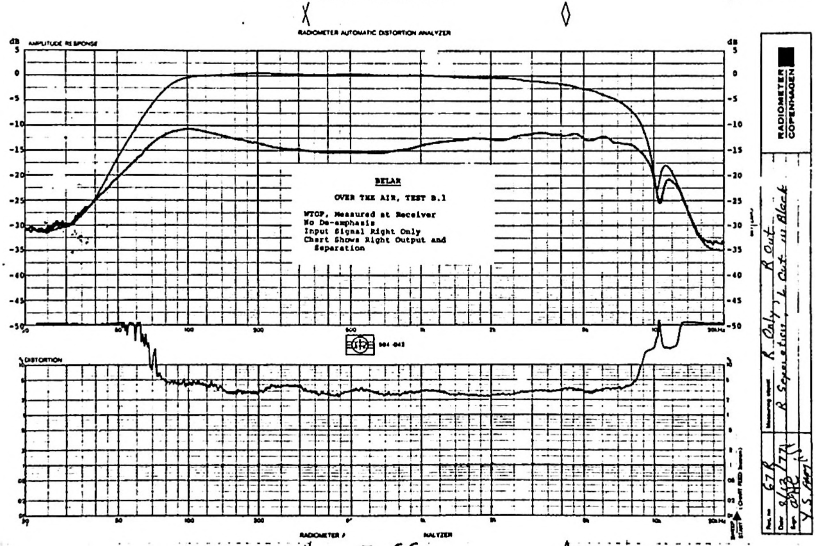
WTOP, Measured at Receiver
No De-Emphasis
Fidelity Bandwidth
Input Signal Right Only
Chart Shows Right Output and Separation



MOTOROLA

OVER THE AIR, TEST B.1

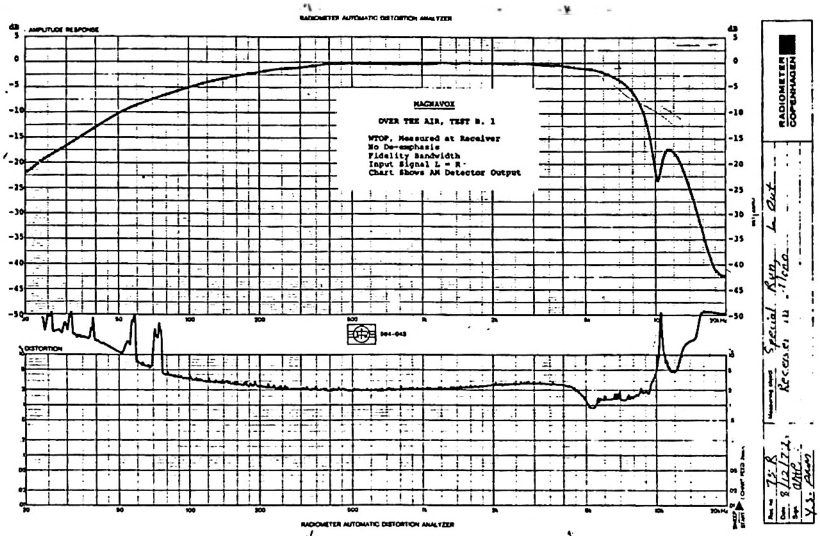
WTOP, Measured at Receiver
No De-emphasis
Input Signal Right Only
Chart Shows Right Output And Separation



BELAR

OVER THE AIR, TEST B.1

WTOP, Measured at Receiver
No De-emphasis
Input Signal Right Only
Chart Shows Right Output and Separation



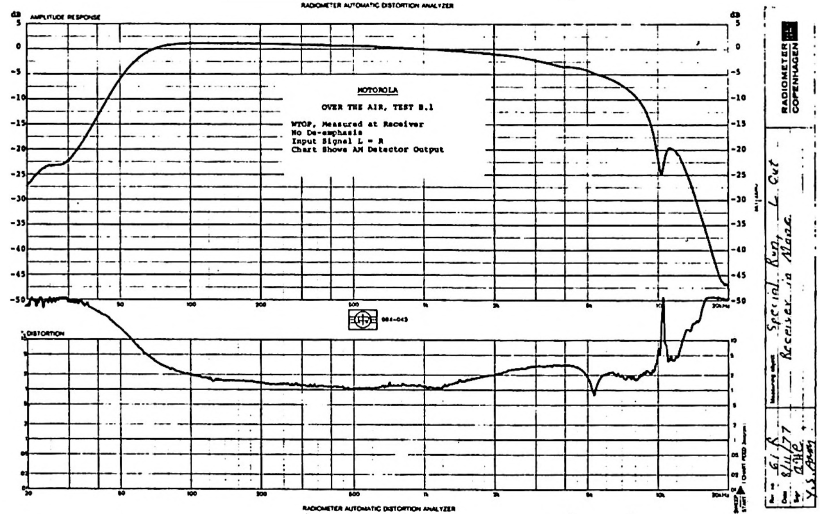
MAGNAVOX

OVER THE AIR, TEST B. 1

WTOP, Measured at Receiver
No De-emphasis
Fidelity Bandwidth
Input Signal L = R
Chart Shows AM Detector Output

Measuring object Special Run, L Out
Receiver in Mono

Rec. no. 75 R
Date 8/12/77
a.H.C.
Y.S. Ann



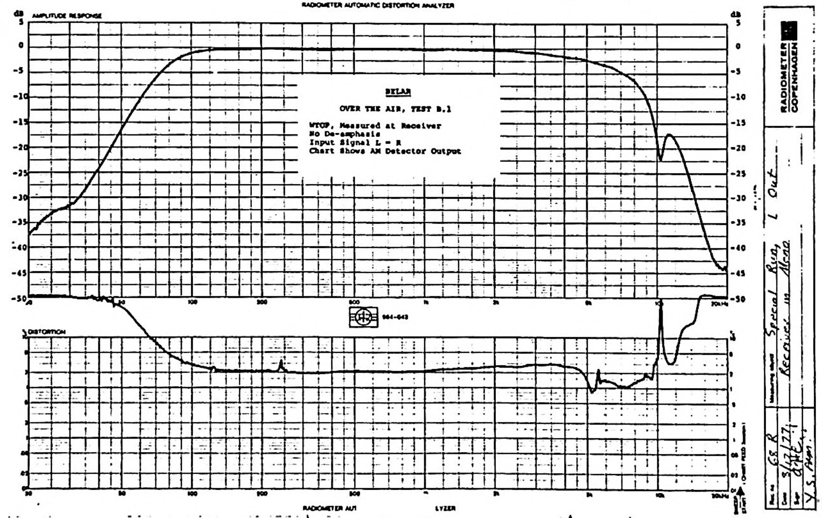
MOTOROLA

OVER THE AIR, TEST B.1

WTOP, Measured at Receiver
No De-emphasis
Input Signal L = R
Chart Shows AM Detector Output

Measuring object Special Run, L Out
Receiver in Mono

Rec. no. 61 R
Date 8/11/77
a.H.C.
Y.S. Ann



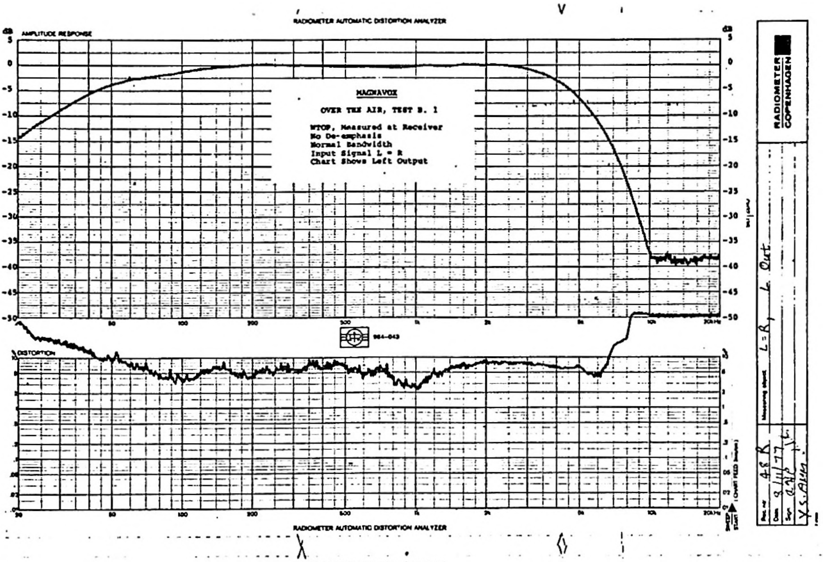
BELAR

OVER THE AIR, TEST B.1

WTOP, Measured at Receiver
No De-emphasis
Input Signal L = R
Chart Shows AM Detector Output

Measuring object Special Run, L Out
Receiver in Mono

Rec. no. 68 R
Date 8/12/77
a.H.C.
Y.S. Ann.



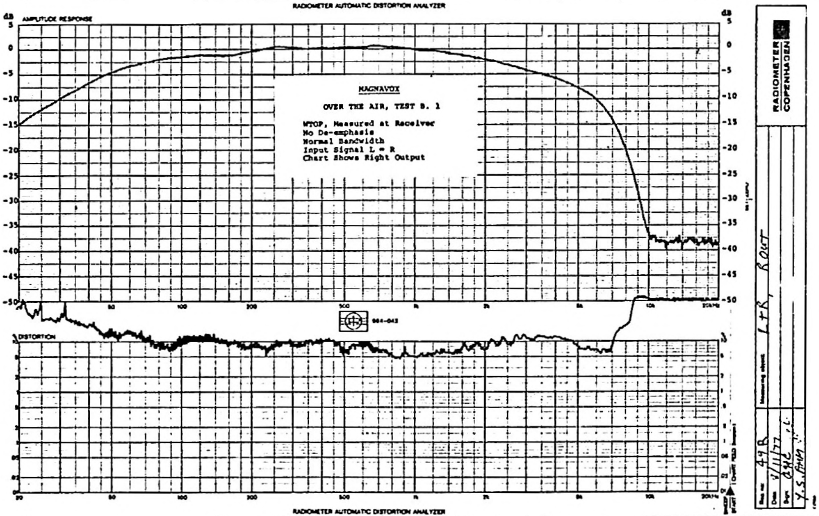
MAGNAVOX

OVER THE AIR, TEST B. 1

WTOP, Measured at Receiver
No De-emphasis
Normal Bandwidth
Input Signal L = R
Chart Shows Left Output

L=R, L Out

48R
8/11/77
AJC
Y.S. AHM



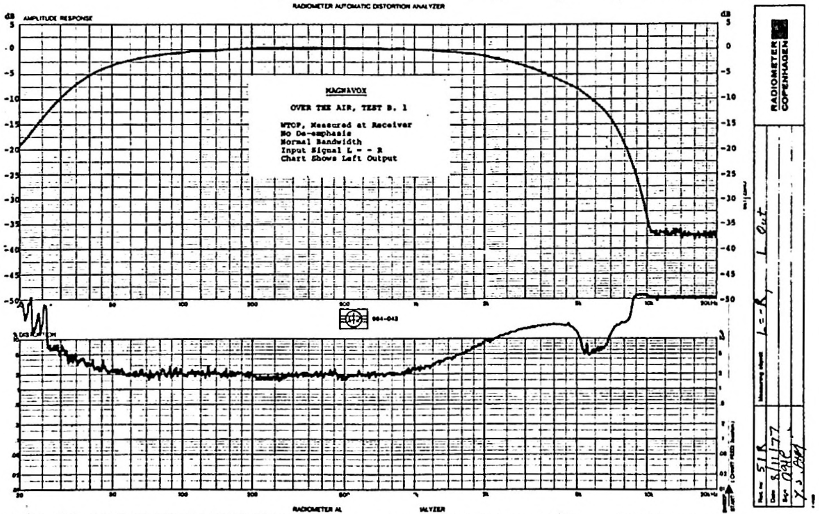
MAGNAVOX

OVER THE AIR, TEST B. 1

WTOP, Measured at Receiver
No De-emphasis
Normal Bandwidth
Input Signal L = R
Chart Shows Right Output

L+R, R Out

49R
8/11/77
AJC
Y.S. AHM



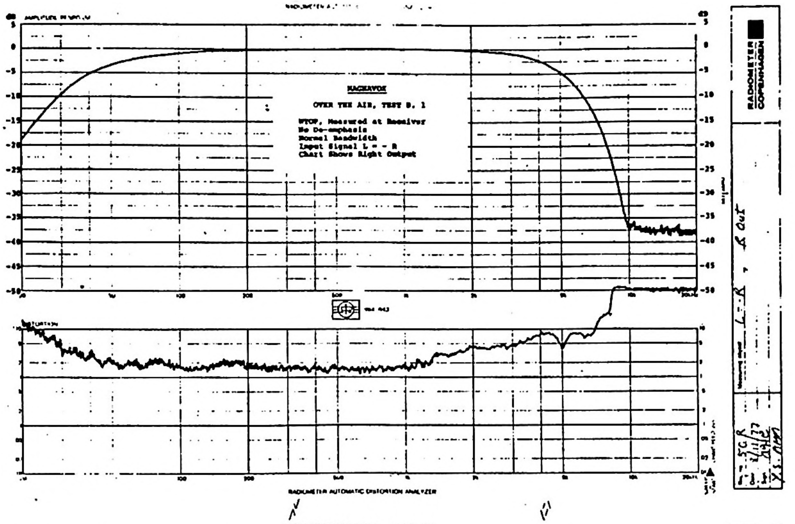
MAGNAVOX

OVER THE AIR, TEST B. 1

WTOP, Measured at Receiver
No De-emphasis
Normal Bandwidth
Input Signal L = - R
Chart Shows Left Output

L=-R, L Out

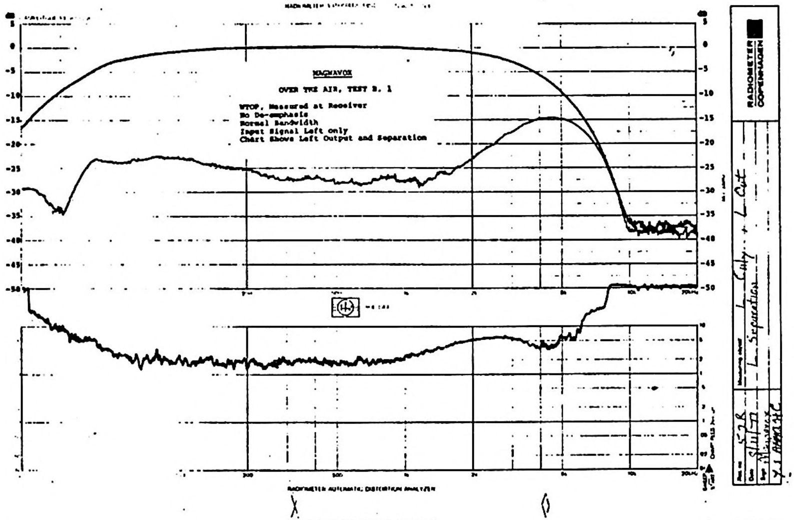
51R
8/11/77
AJC
Y.S. AHM



MAGNAVOX

OVER THE AIR, TEST B. 1

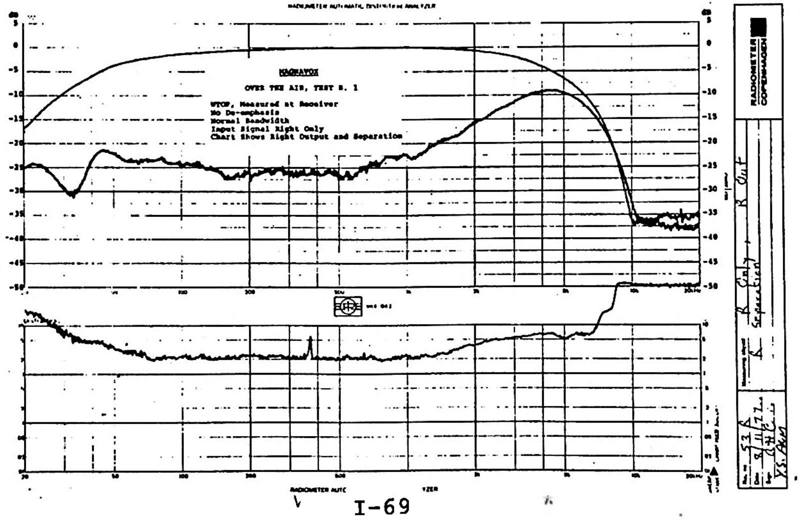
WTOP, Measured at Receiver
No De-emphasis
Normal Bandwidth
Input Signal L = - R
Chart Shows Right Output



MAGNAVOX

OVER THE AIR, TEST B. 1

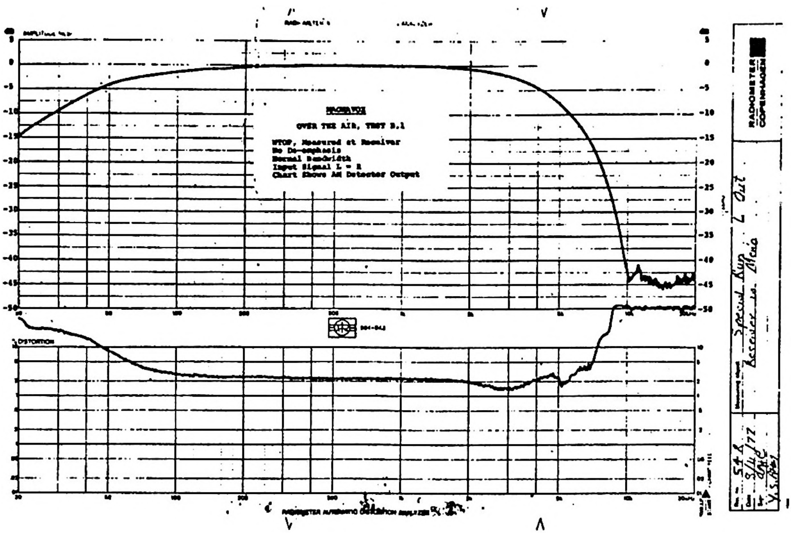
WTOP, Measured at Receiver
No De-emphasis
Normal Bandwidth
Input Signal Left only
Chart Shows Left Output and Separation



MAGNAVOX

OVER THE AIR, TEST B. 1

WTOP, Measured at Receiver
No De-emphasis
Normal Bandwidth
Input Signal Right Only
Chart Shows Right Output and Separation



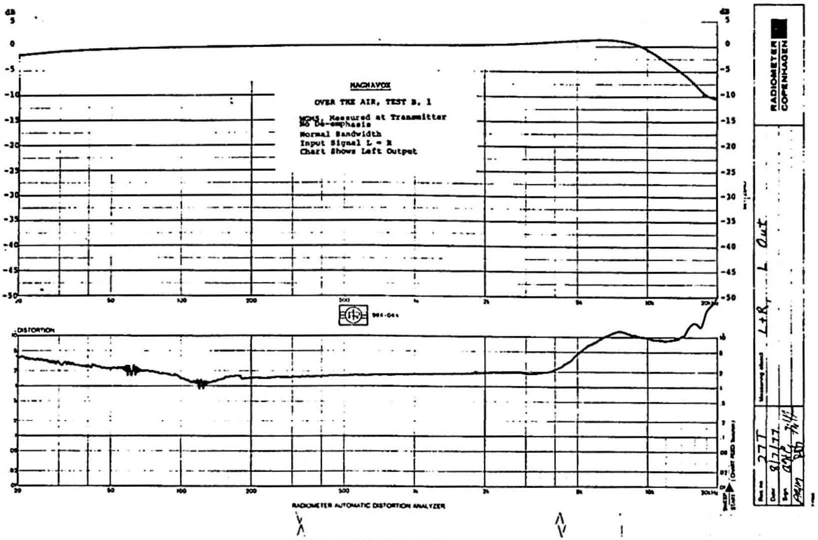
MAGNAVOX

OVER THE AIR, TEST B.1

WTOP, Measured at Receiver
No De-emphasis
Normal Bandwidth
Input Signal L = R
Chart Shows AM Detector Output

Special Run L Out
Receiver in Mono

548
8/14/72
V.S.

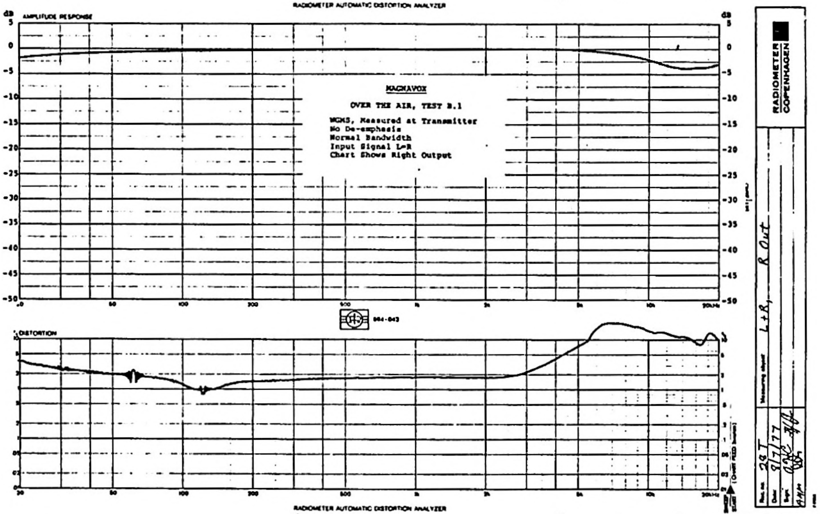


MAGNAVOX

OVER THE AIR, TEST B. 1

WGMS, Measured at Transmitter
No De-emphasis
Normal Bandwidth
Input Signal L = R
Chart Shows Left Output

L+R, L Out
27T
8/7/77
ARP 7/4/7
AMM

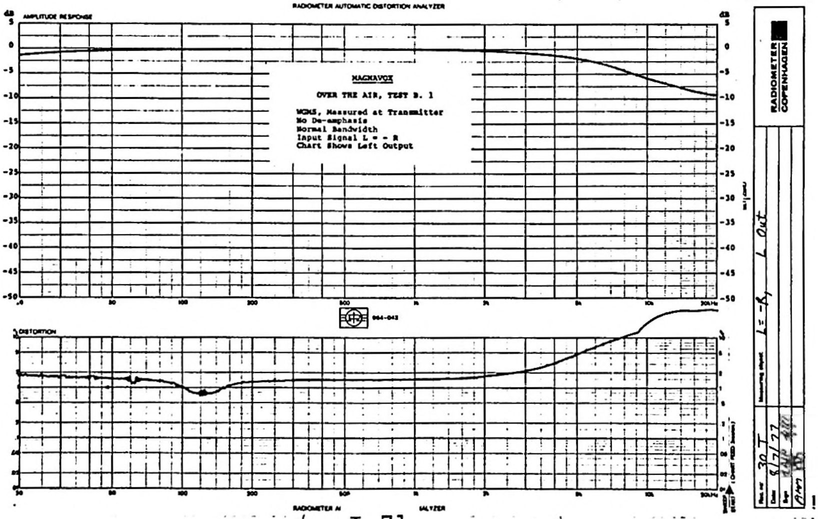


MAGNAVOX

OVER THE AIR, TEST B.1

WGMS, Measured at Transmitter
No De-emphasis
Normal Bandwidth
Input Signal L=R
Chart Shows Right Output

L+R, R Out
28T
8/7/77
ARC 7/4
AMM

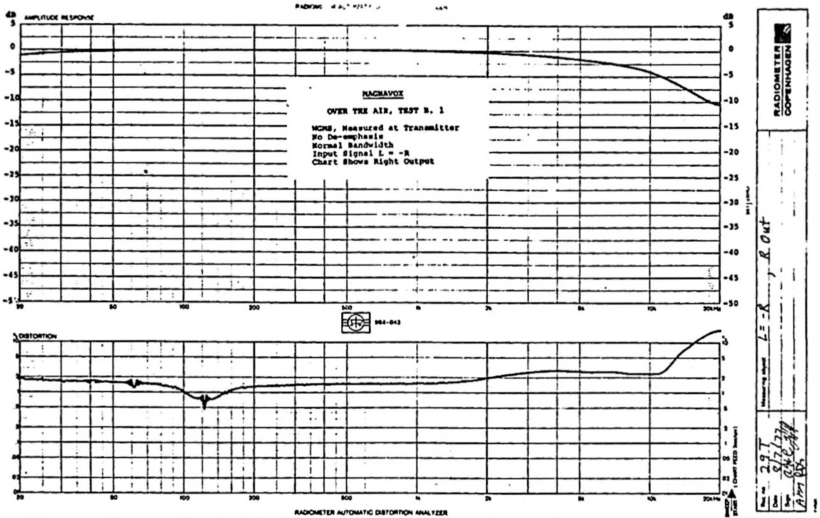


MAGNAVOX

OVER THE AIR, TEST B. 1

WGMS, Measured at Transmitter
No De-emphasis
Normal Bandwidth
Input Signal L = - R
Chart Shows Left Output

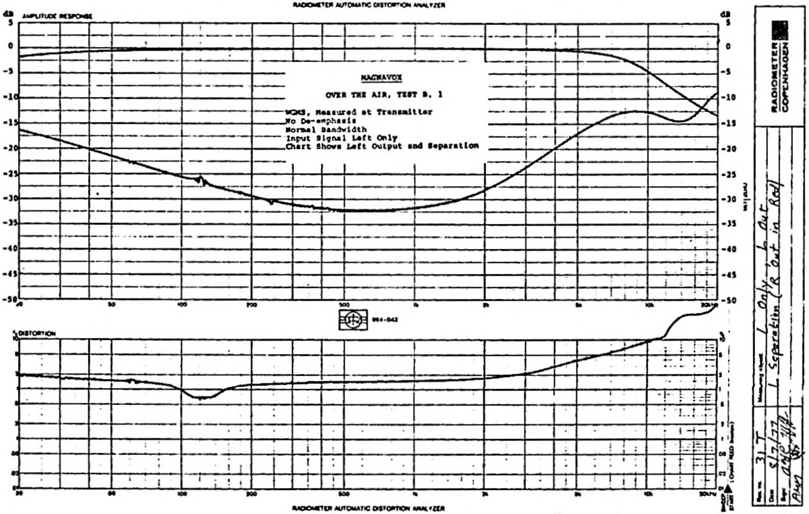
L=-R, L Out
30T
8/7/77
AMM



MAGNAVOX

OVER THE AIR, TEST B. 1

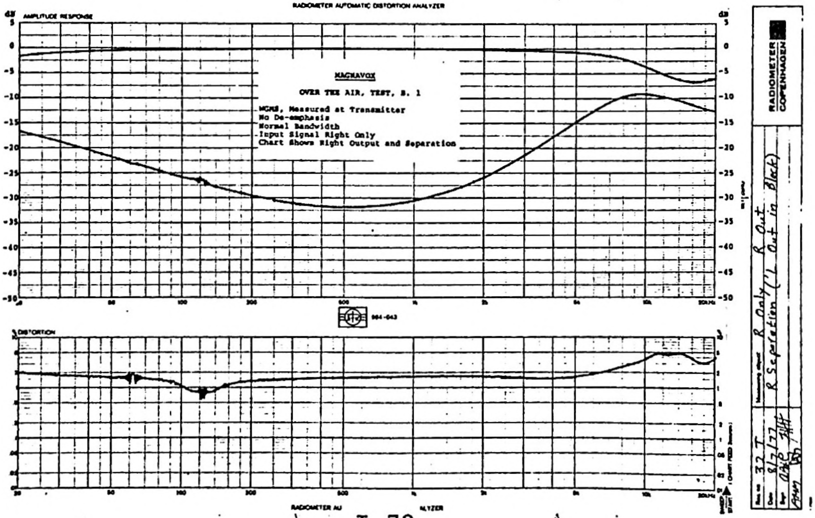
MCMS, Measured at Transmitter
No De-emphasis
Normal Bandwidth
Input Signal L = -R
Chart Shows Right Output



MAGNAVOX

OVER THE AIR, TEST B. 1

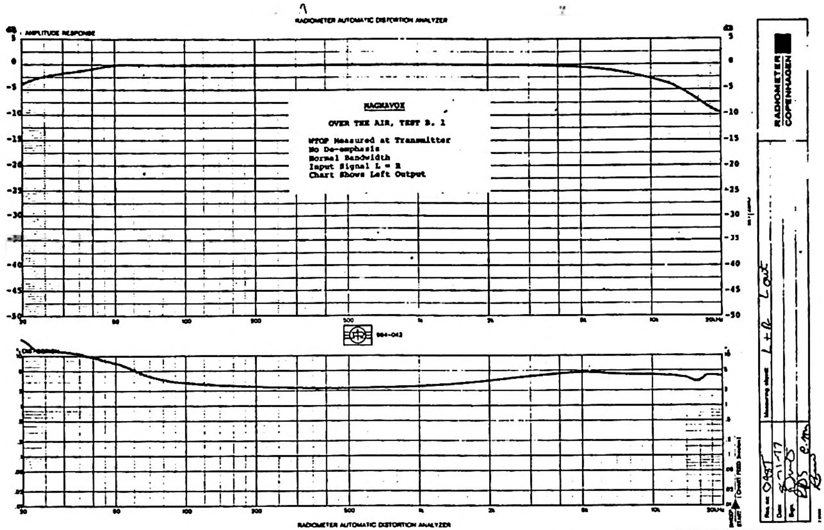
MCMS, Measured at Transmitter
No De-emphasis
Normal Bandwidth
Input Signal Left Only
Chart Shows Left Output and Separation



MAGNAVOX

OVER THE AIR, TEST, B. 1

MCMS, Measured at Transmitter
No De-emphasis
Normal Bandwidth
Input Signal Right Only
Chart Shows Right Output and Separation

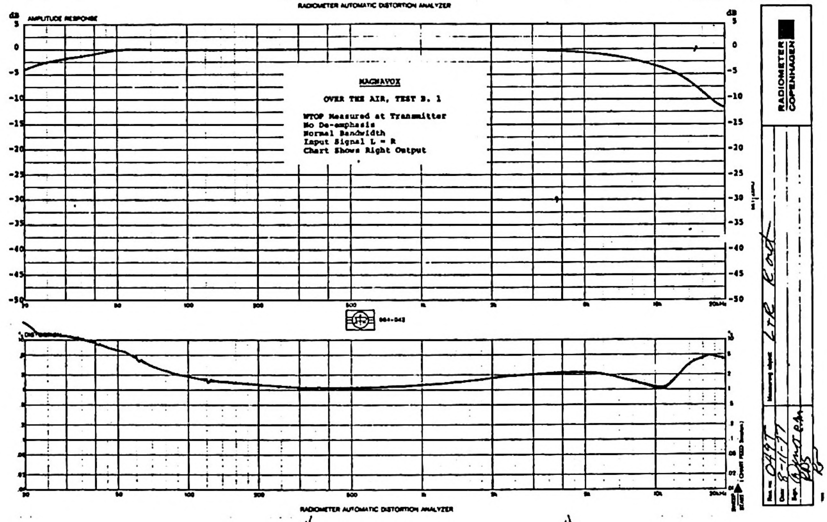


MAGNAVOX

OVER THE AIR, TEST B. 1

WTOP Measured at Transmitter
No De-emphasis
Normal Bandwidth
Input Signal L = R
Chart Shows Left Output

Rec. no. 049T
Date 8-11-77
Measuring object L+R Lout

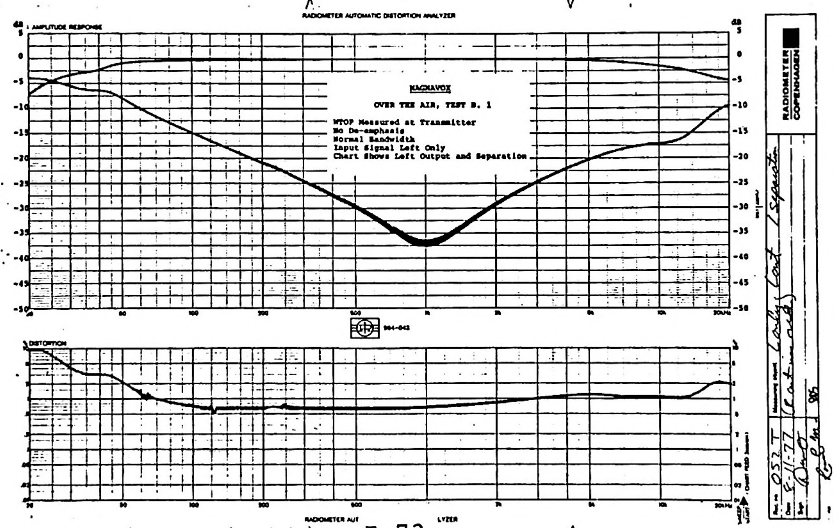


MAGNAVOX

OVER THE AIR, TEST B. 1

WTOP Measured at Transmitter
No De-emphasis
Normal Bandwidth
Input Signal L = R
Chart Shows Right Output

Rec. no. 049T
Date 8-11-77
Measuring object L+R Rout

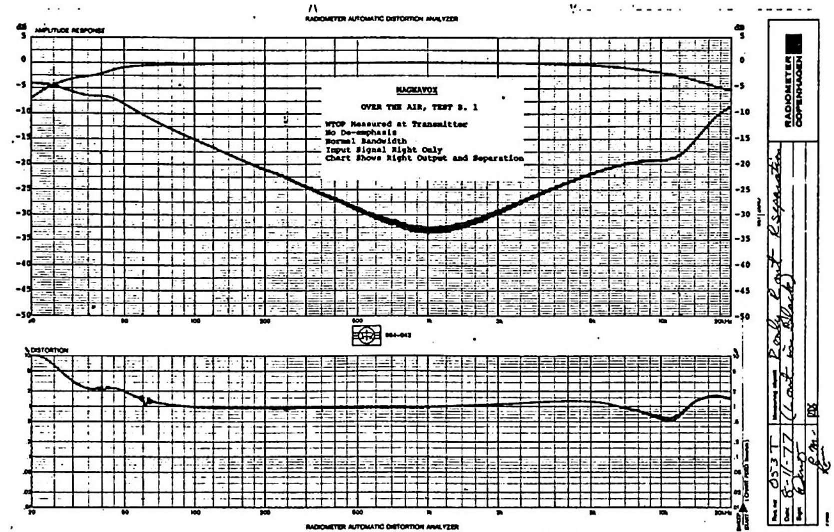


MAGNAVOX

OVER THE AIR, TEST B. 1

WTOP Measured at Transmitter
No De-emphasis
Normal Bandwidth
Input Signal Left Only
Chart Shows Left Output and Separation

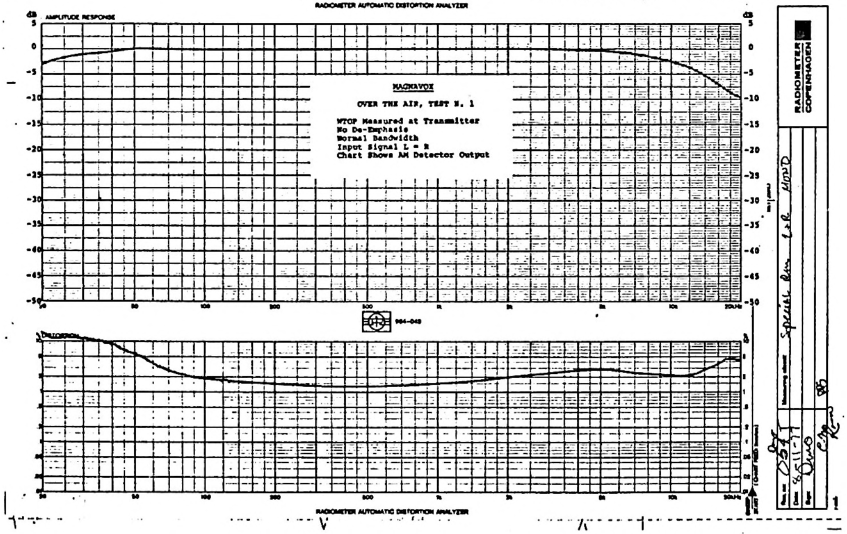
Rec. no. 052T
Date 8-11-77
Measuring object Lonly Lout Lseparation (Continued)



MAGNAVOX

OVER THE AIR, TEST B. 1

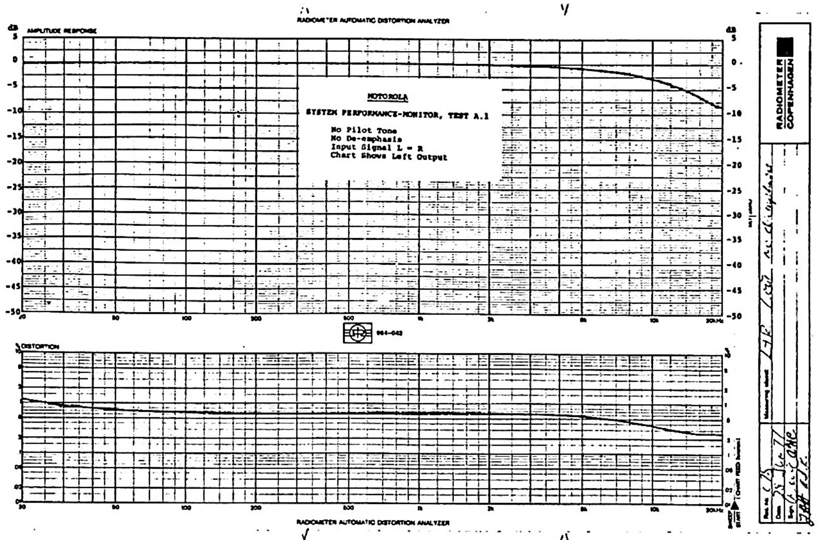
WTOP Measured at Transmitter
No De-emphasis
Normal Bandwidth
Input Signal Right Only
Chart Shows Right Output and Separation



MAGNAVOX

OVER THE AIR, TEST N. 1

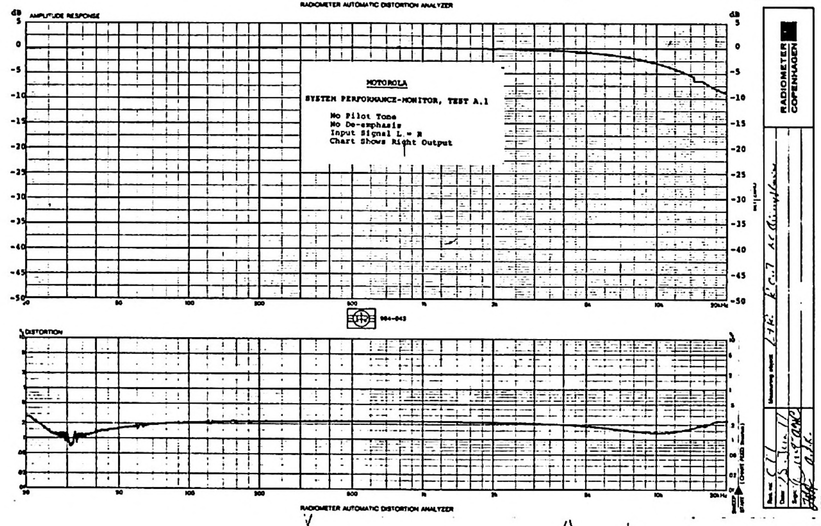
WTOP Measured at Transmitter
No De-Emphasis
Normal Bandwidth
Input Signal L = R
Chart Shows AM Detector Output



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

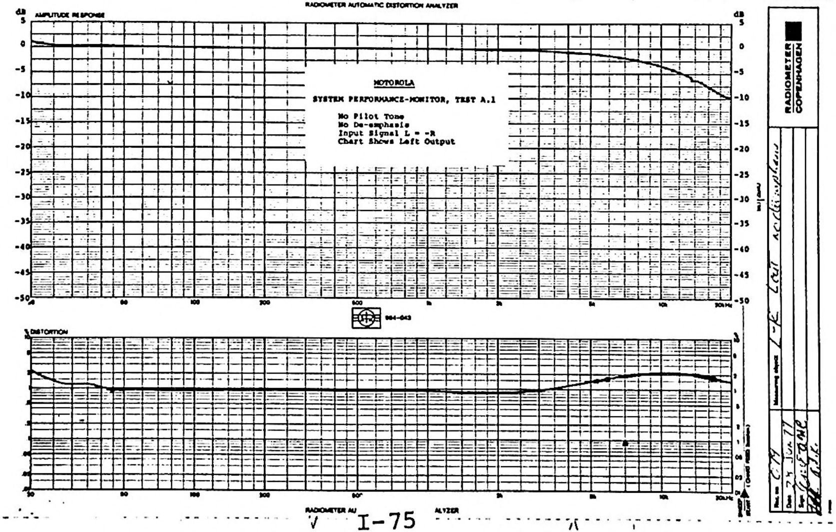
No Pilot Tone
No De-emphasis
Input Signal L = R
Chart Shows Left Output



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

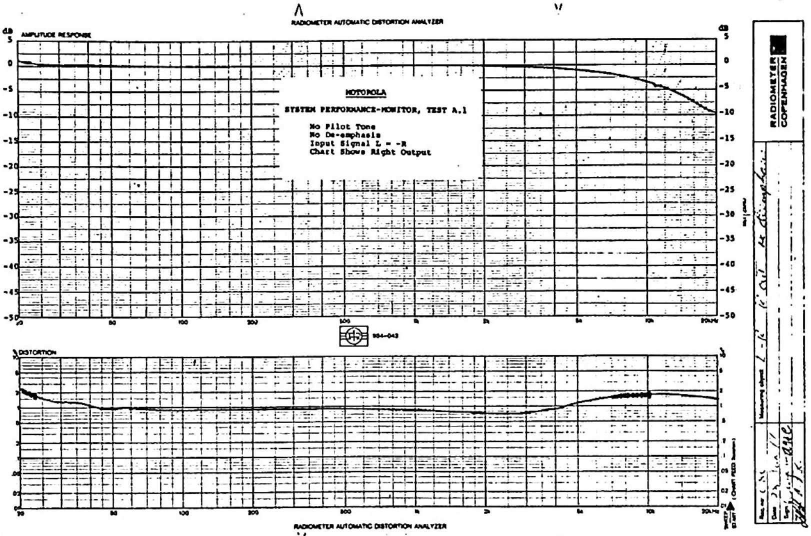
No Pilot Tone
No De-emphasis
Input Signal L = R
Chart Shows Right Output



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

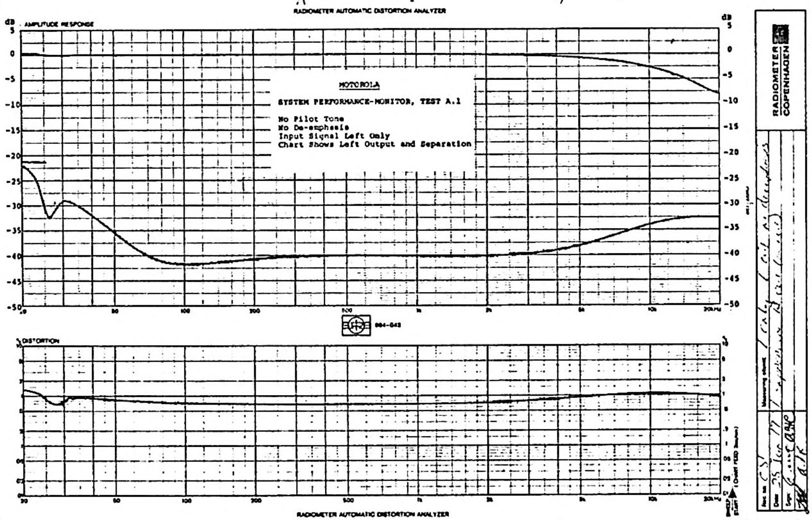
No Pilot Tone
No De-emphasis
Input Signal L = -R
Chart Shows Left Output



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

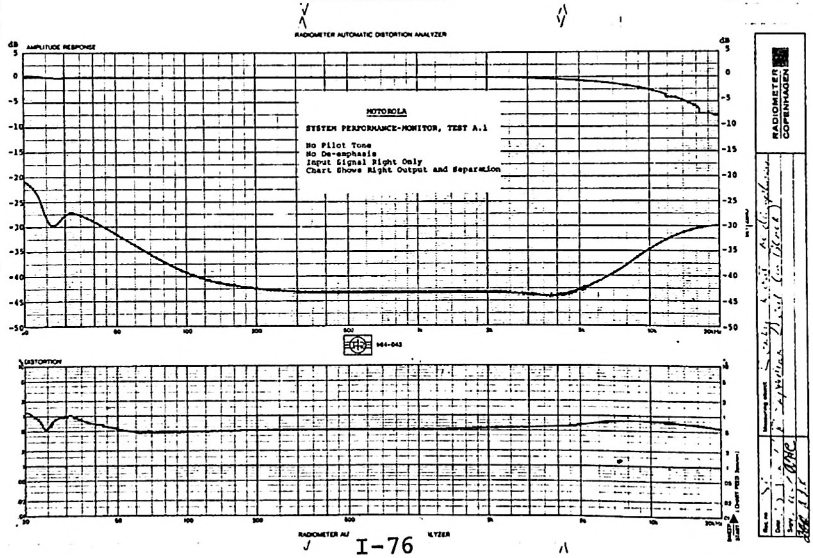
No Pilot Tone
No De-emphasis
Input Signal L = -R
Chart Shows Right Output



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

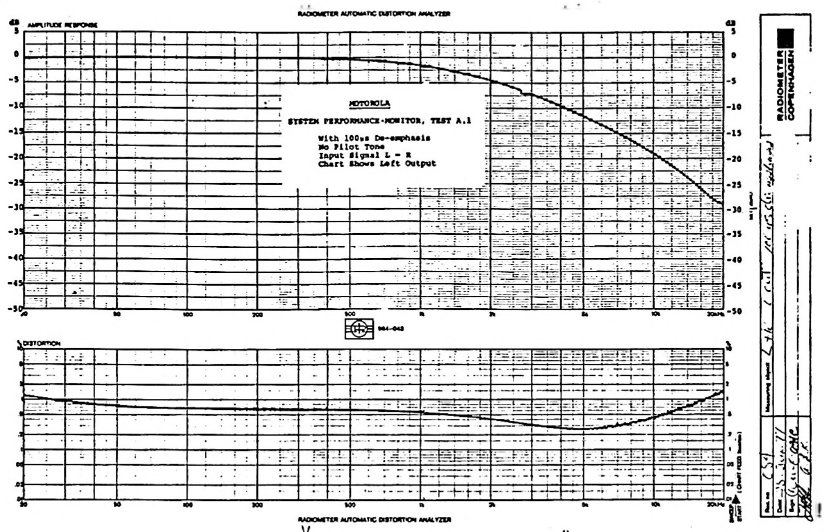
No Pilot Tone
No De-emphasis
Input Signal Left Only
Chart Shows Left Output and Separation



MOTOROLA

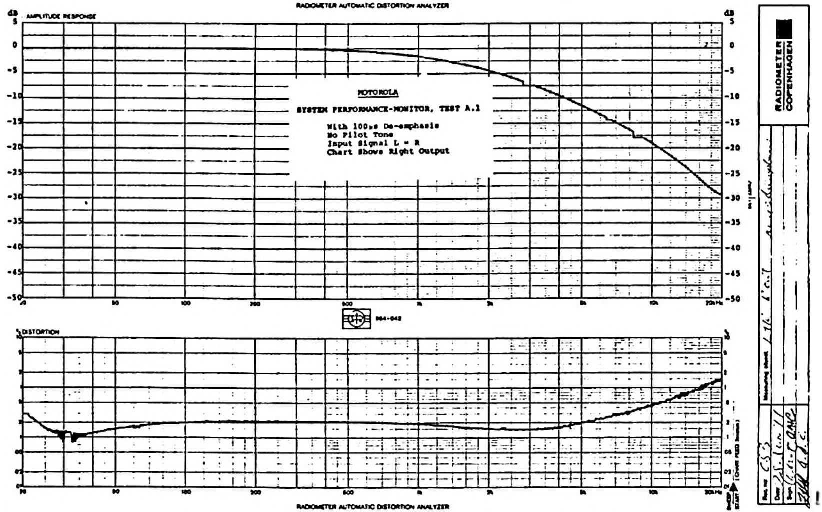
SYSTEM PERFORMANCE-MONITOR, TEST A.1

No Pilot Tone
No De-emphasis
Input Signal Right Only
Chart Shows Right Output and Separation


MOTOROLA

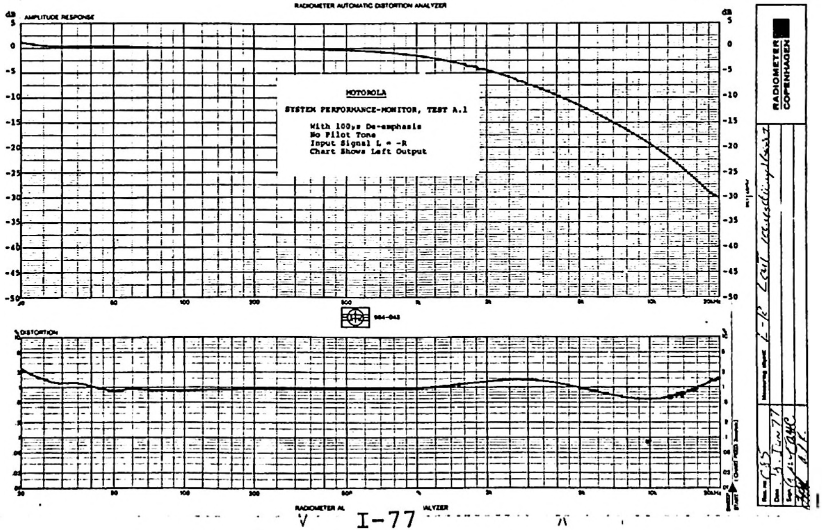
SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100µs De-emphasis
No Pilot Tone
Input Signal L = R
Chart Shows Left Output


MOTOROLA

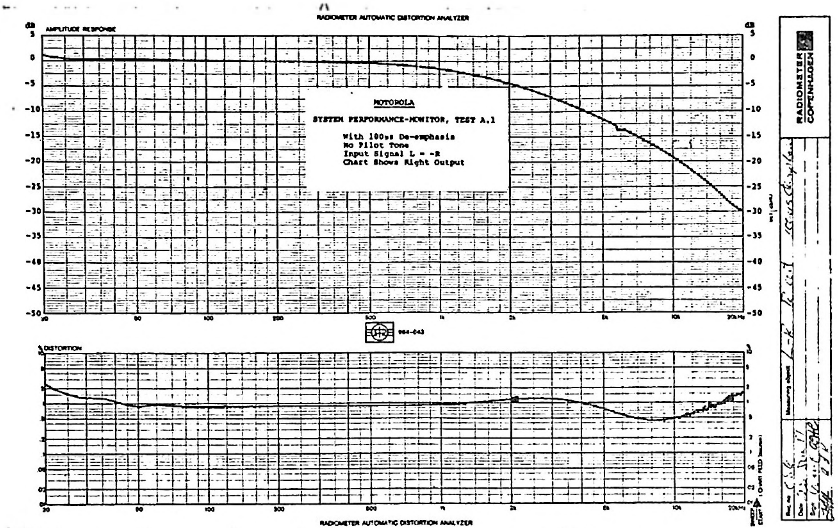
SYSTEM PERFORMANCE-MONITOR, TEST A.1

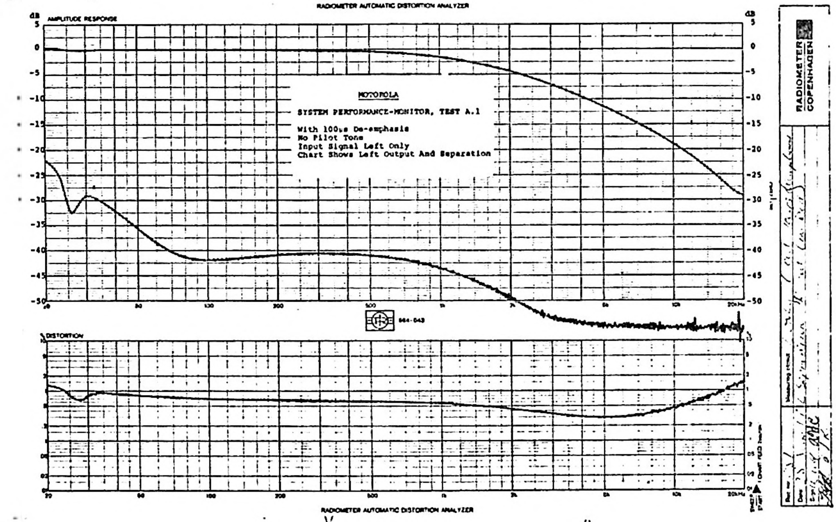
With 100µs De-emphasis
No Pilot Tone
Input Signal L = R
Chart Shows Right Output

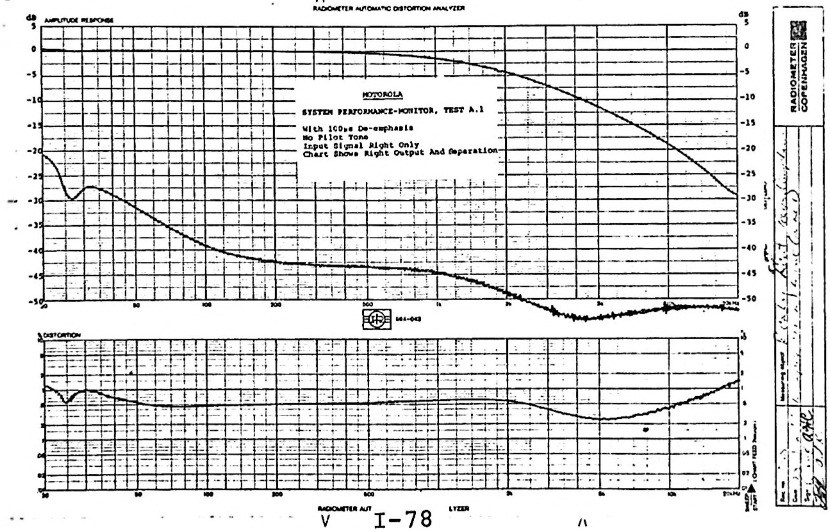

MOTOROLA

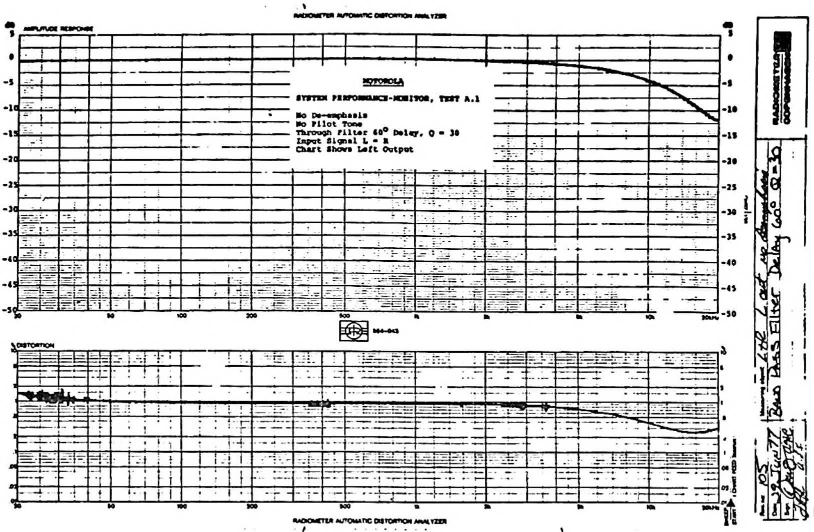
SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100µs De-emphasis
No Pilot Tone
Input Signal L = -R
Chart Shows Left Output


RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
20
50
100
200
500
1k
2k
5k
10k
20kHz
964-043
DISTORTION
RADIOMETER COPENHAGEN
MOTOROLA
SYSTEM PERFORMANCE-MONITOR, TEST A.1
With 100µs De-emphasis
No Pilot Tone
Input Signal L = -R
Chart Shows Right Output


RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
20
50
100
200
500
1k
2k
5k
10k
20kHz
964-043
DISTORTION
RADIOMETER COPENHAGEN
MOTOROLA
SYSTEM PERFORMANCE-MONITOR, TEST A.1
With 100µs De-emphasis
No Pilot Tone
Input Signal Left Only
Chart Shows Left Output And Separation


RADIOMETER AUTOMATIC DISTORTION ANALYZER
AMPLITUDE RESPONSE
dB
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
20
50
100
200
500
1k
2k
5k
10k
20kHz
964-043
DISTORTION
RADIOMETER COPENHAGEN
MOTOROLA
SYSTEM PERFORMANCE-MONITOR, TEST A.1
With 100µs De-emphasis
No Pilot Tone
Input Signal Right Only
Chart Shows Right Output And Separation

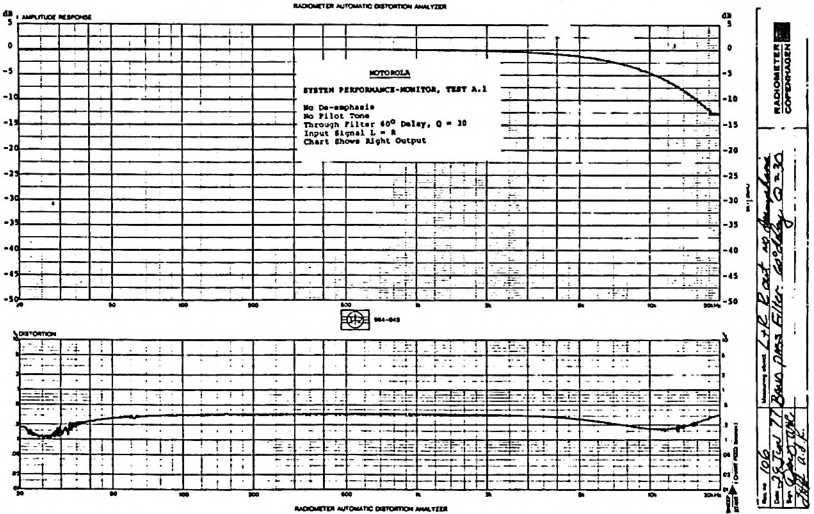


MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
No Pilot Tone
Through Filter 60° Delay, Q = 30
Input Signal L = R
Chart Shows Left Output

105
29 Jun 77
L+R L out no Deemphasis
Band Pass Filter Delay 60° Q=30

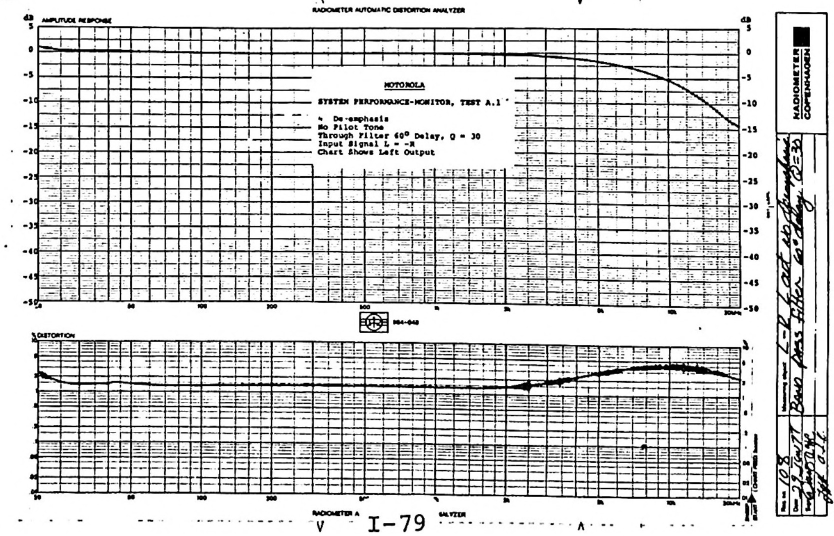


MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
No Pilot Tone
Through Filter 60° Delay, Q = 30
Input Signal L = R
Chart Shows Right Output

106
29 Jun 77
L+R R out no Deemphasis
Band pass Filter 60° delay Q=30

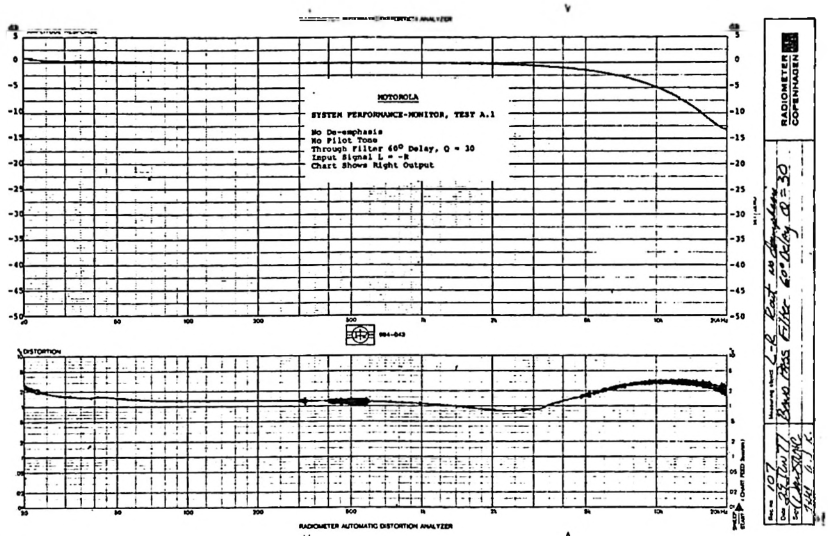


MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

4 De-emphasis
No Pilot Tone
Through Filter 60° Delay, Q = 30
Input Signal L = -R
Chart Shows Left Output

108
29 Jun 77
L-R L out no Deemphasis
Band pass Filter 60° delay Q=30

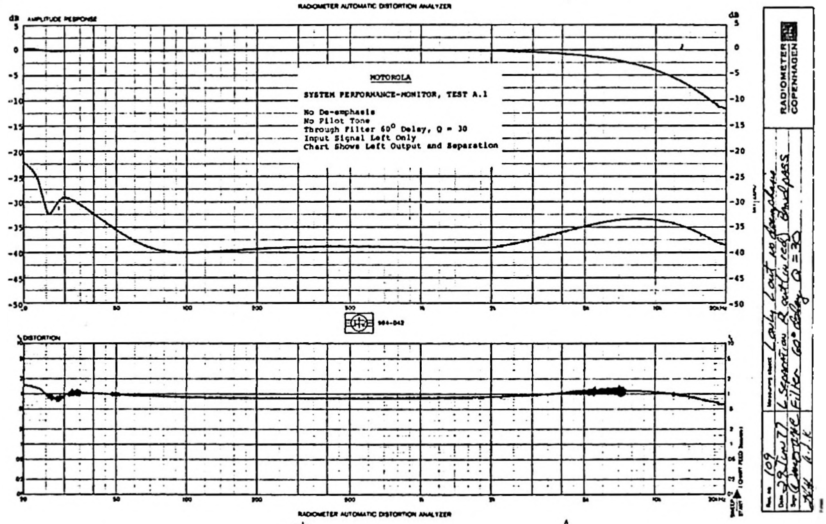


MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
No Pilot Tone
Through Filter 60° Delay, Q = 30
Input Signal L = -R
Chart Shows Right Output

107
29 Jun 77
A.J.K.
L-R Rout no deemphasis
Band Pass Filter 60° Delay Q = 30

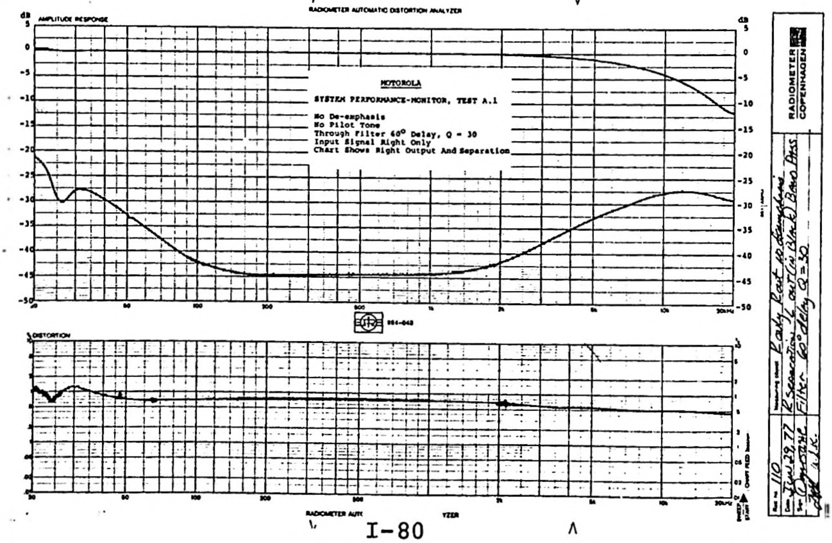


MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
No Pilot Tone
Through Filter 60° Delay, Q = 30
Input Signal Left Only
Chart Shows Left Output and Separation

109
29 Jun 77
A.J.K
L only Lout no deemphasis
L separation R out (in red) Bandpass
Filter 60° delay Q = 30

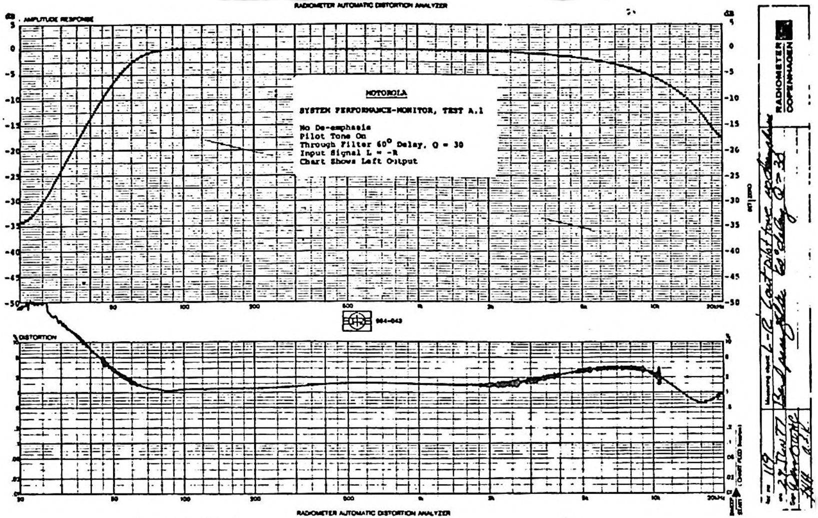


MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
No Pilot Tone
Through Filter 60° Delay, Q = 30
Input Signal Right Only
Chart Shows Right Output And Separation

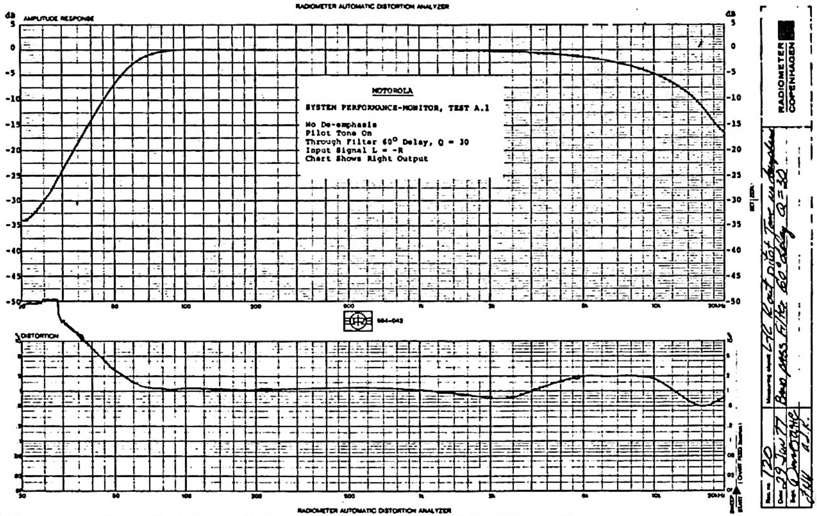
110
Jun 29, 77
A.J.K.
R only Rout no deemphasis
R separation L out (in black) Band Pass
Filter 60° delay Q = 30



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

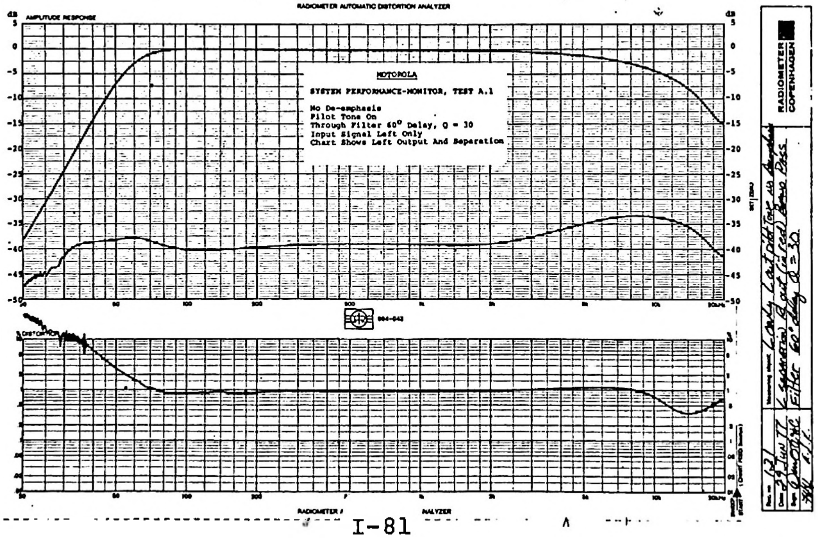
No De-emphasis
Pilot Tone On
Through Filter 60° Delay, Q = 30
Input Signal L = -R
Chart Shows Left Output



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

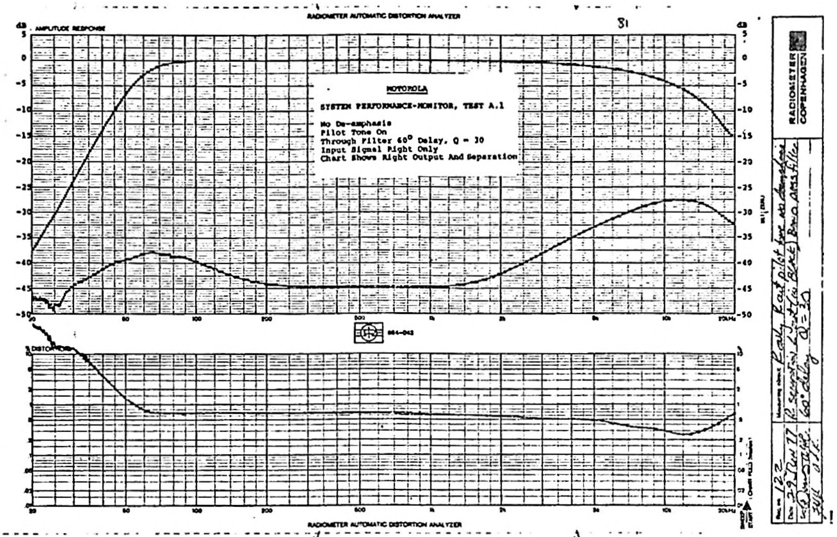
No De-emphasis
Pilot Tone On
Through Filter 60° Delay, Q = 30
Input Signal L = -R
Chart Shows Right Output



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
Pilot Tone On
Through Filter 60° Delay, Q = 30
Input Signal Left Only
Chart Shows Left Output And Separation

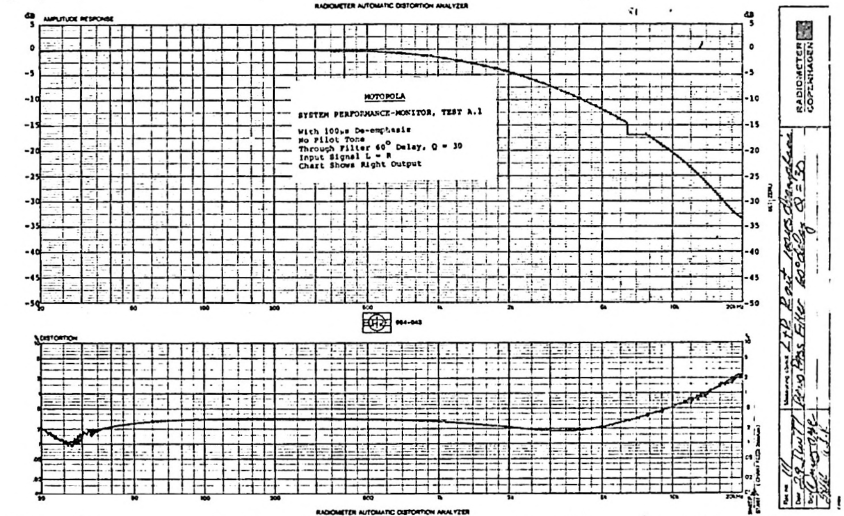


MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
Pilot Tone On
Through Filter 60° Delay, Q = 30
Input Signal Right Only
Chart Shows Right Output And Separation

Rec. no. 122
Date 29 JUN 77
Measuring object R only R out pilot tone no deemphasis
R separation L out (in BLACK) Band pass filter
60° delay Q = 30

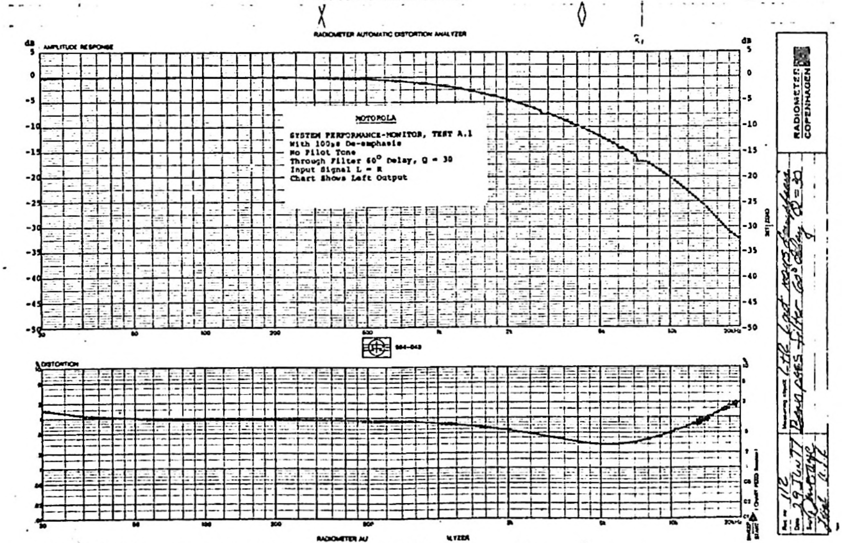


MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100µs De-emphasis
No Pilot Tone
Through Filter 60° Delay, Q = 30
Input Signal L = R
Chart Shows Right Output

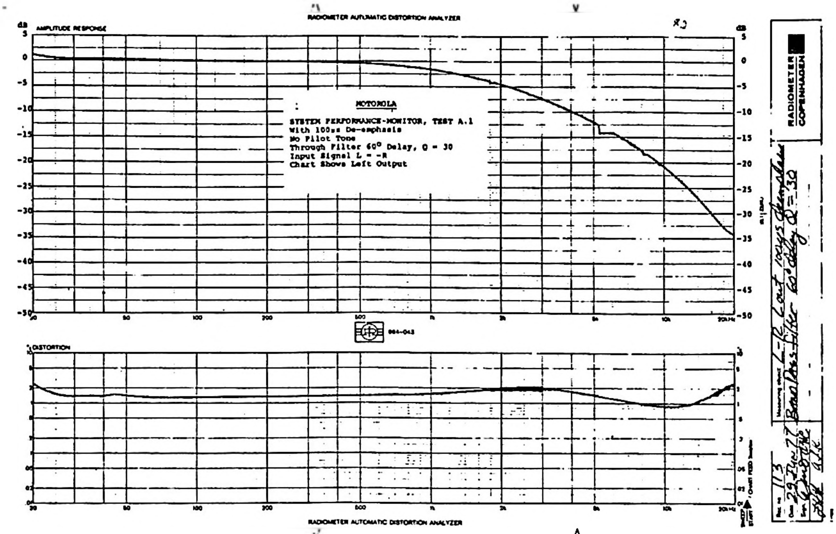
Rec. no. 111
Date 29 JUN 77
Measuring object L+R R out 100µs deemphasis
Band Pass Filter 60° delay Q = 30



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1
With 100µs De-emphasis
No Pilot Tone
Through Filter 60° Delay, Q = 30
Input Signal L = R
Chart Shows Left Output

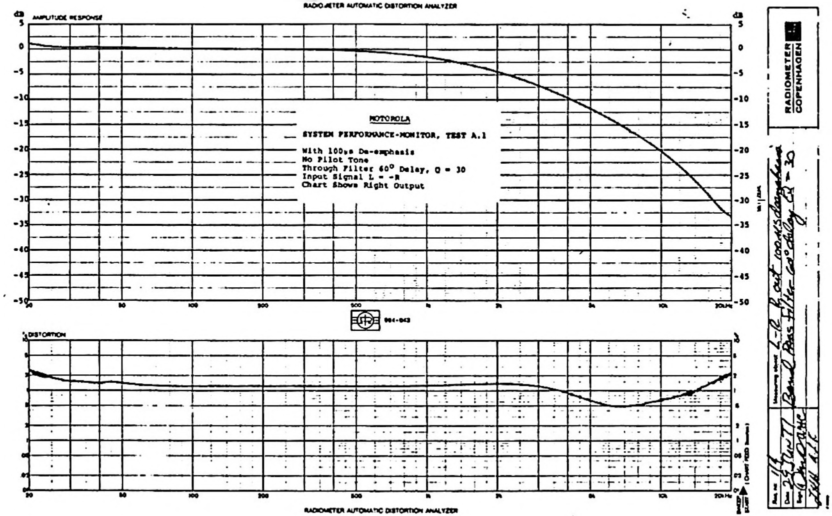
Rec. no. 112
Date 29 JUN 77
Measuring object L+R L out 100µs deemphasis
Band pass filter 60° delay Q = 30



MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1
With 100µs De-emphasis
No Pilot Tone
Through Filter 60° Delay, Q = 30
Input Signal L = -R
Chart Shows Left Output

Rec. no 113
Date 29 Jun 77
Sign. Quadrature
JKH A.K.
Measuring object L-R, L out 100µs deemphasis
Band Pass Filter 60° delay Q = 30

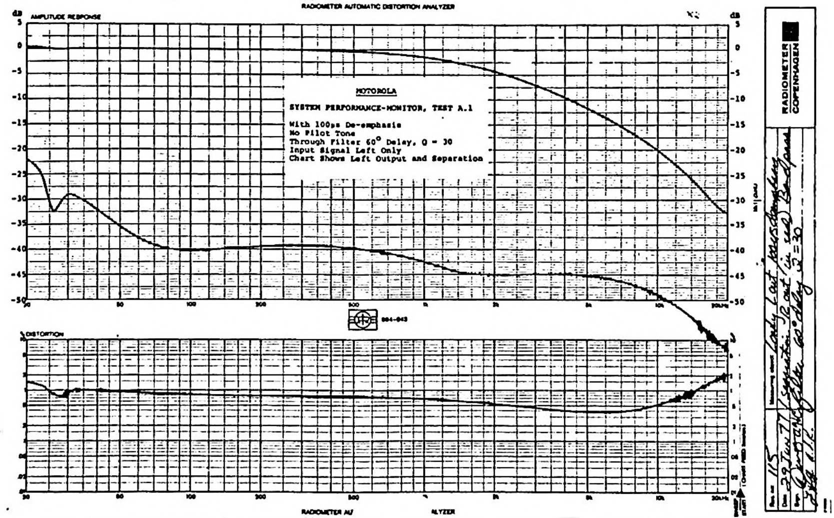


MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100µs De-emphasis
No Pilot Tone
Through Filter 60° Delay, Q = 30
Input Signal L = -R
Chart Shows Right Output

Rec. no 114
Date 29 Jun 77
Sign. Quadrature
JKH A.K.
Measuring object L-R R out 100µs deemphasis
Band Pass Filter 60° delay Q = 30

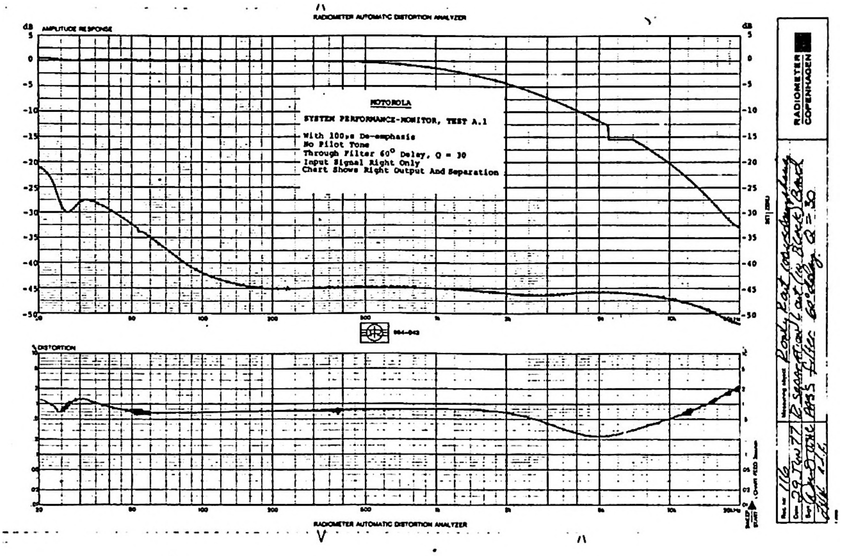


MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100µs De-emphasis
No Pilot Tone
Through Filter 60° Delay, Q = 30
Input Signal Left Only
Chart Shows Left Output and Separation

Rec. no 115
Date 29 Jun 77
Sign. Quadrature
JKH A.K.
Measuring object Only L out 100µs deemphasis
Separation (R out in red) Bandpass
filter 60° delay Q = 30

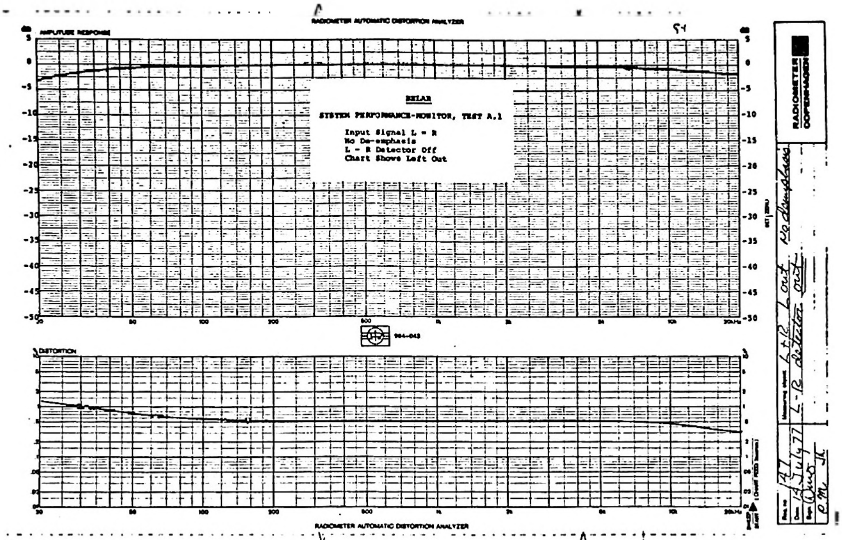


MOTOROLA

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100μs De-emphasis
No Pilot Tone
Through Filter 60° Delay, Q = 30
Input Signal Right Only
Chart Shows Right Output And Separation

Rec. no 116
Date 29 Jun 77
Measuring object Right Out (w/ deemphasis
R separation L out (in Black) Band
PASS filter 60° delay Q = 30

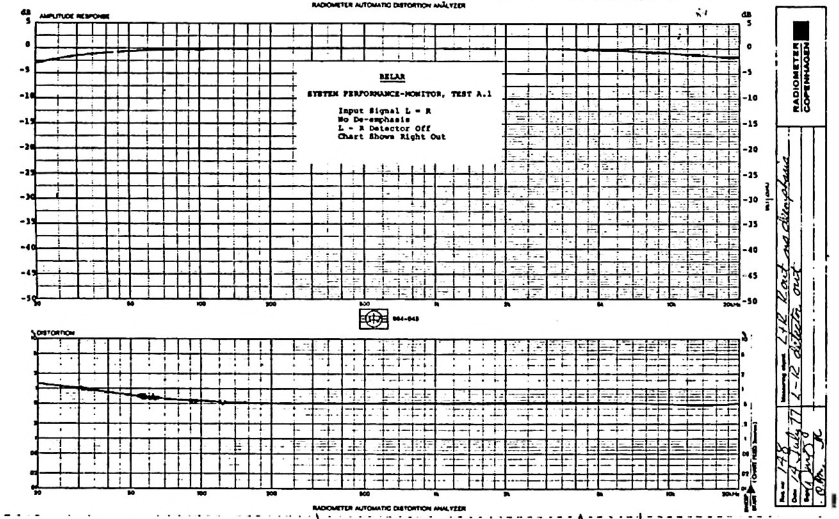


BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

Input Signal L = R
No De-emphasis
L - R Detector Off
Chart Shows Left Out

Rec. no 147
Date 14 July 77
Measuring object L+R L out No deemphasis
L-R detector out

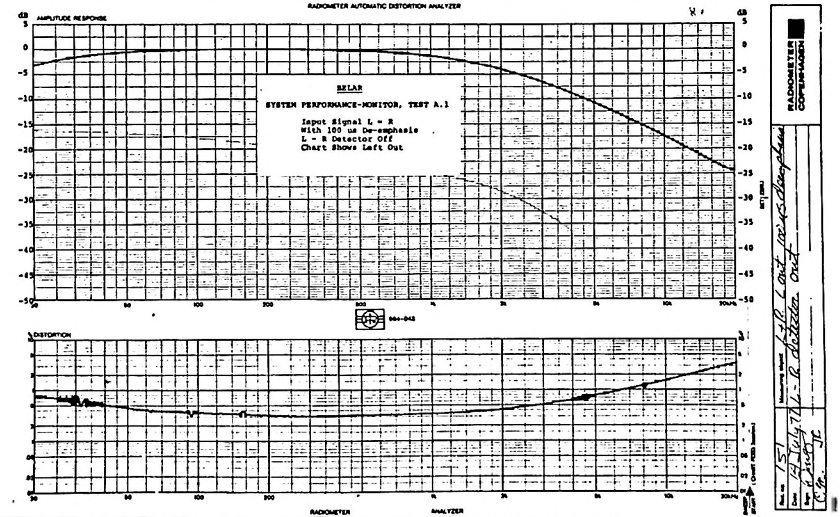


BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

Input Signal L = R
No De-emphasis
L - R Detector Off
Chart Shows Right Out

Rec. no 148
Date 14 July 77
Measuring object L+R R out no deemphasis
L-R detector out

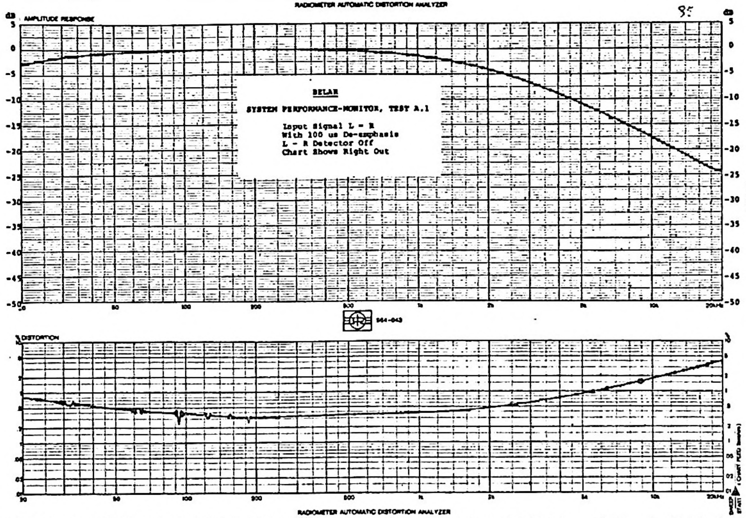


BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

Input Signal L = R
With 100 us De-emphasis
L - R Detector Off
Chart Shows Left Out

Rec. no 151
Date 14 July 77
Measuring object L+R L out 100 µs deemphasis
L-R detector out



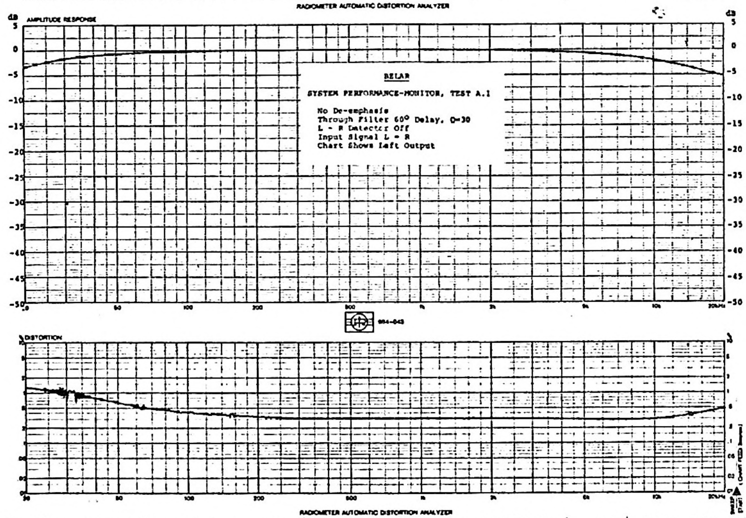
BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

Input Signal L - R
With 100 us De-emphasis
L - R Detector Off
Chart Shows Right Out

Rec. no 52
Date 14 July 77
C.m. JC
Measuring object L+R Rout 100μS Deemphasis
L-R detector out

RADIOMETER COPENHAGEN



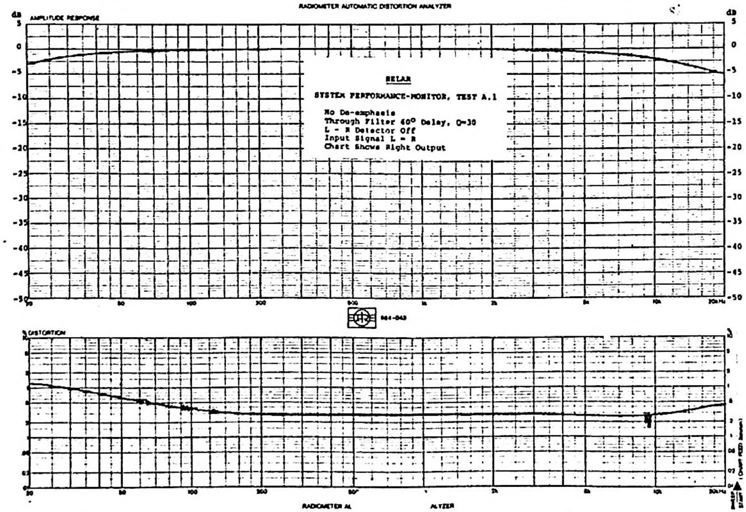
BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
Through Filter 60° Delay, Q=30
L - R Detectcr Off
Input Signal L = R
Chart Shows Left Output

Rec. no 160
Date 14 July 77
C.m. JC
Measuring object L+R Lout no deemphasis
Band pass network 60° delay Q=30
L-R detector out

RADIOMETER COPENHAGEN



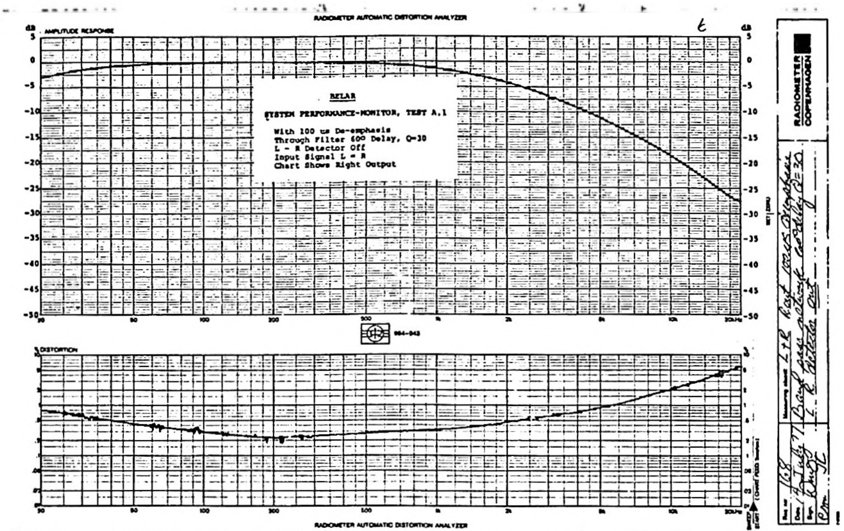
BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
Through Filter 60° Delay, Q=30
L - R Detector Off
Input Signal L = R
Chart Shows Right Output

Rec. no 159
Date 14 July 77
C.m. JC
Measuring object L+R Rout no deemphasis
Band pass network 60° delay Q=30
L-R detector out

RADIOMETER COPENHAGEN

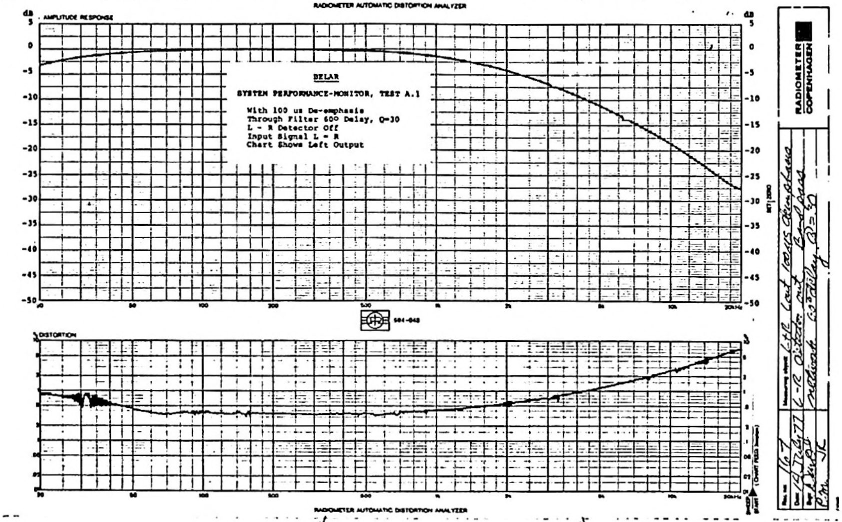


BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100 us De-emphasis
Through Filter 60° Delay, Q=30
L - R Detector Off
Input Signal L = R
Chart Shows Right Output

1.8
14 July 77
L+R Right 100 µS De-emphasis
Band pass network 60° delay Q=30
L-R Detector out

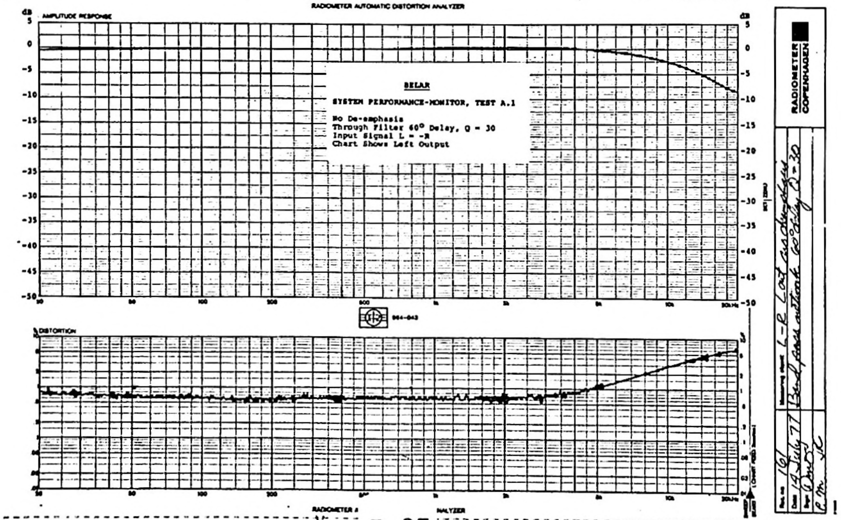


BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

With 100 us De-emphasis
Through Filter 60° Delay, Q=30
L - R Detector Off
Input Signal L = R
Chart Shows Left Output

1.7
14 July 77
L+R Left 100 µS De-emphasis
L-R Detector out Band pass
network 60° delay Q=30

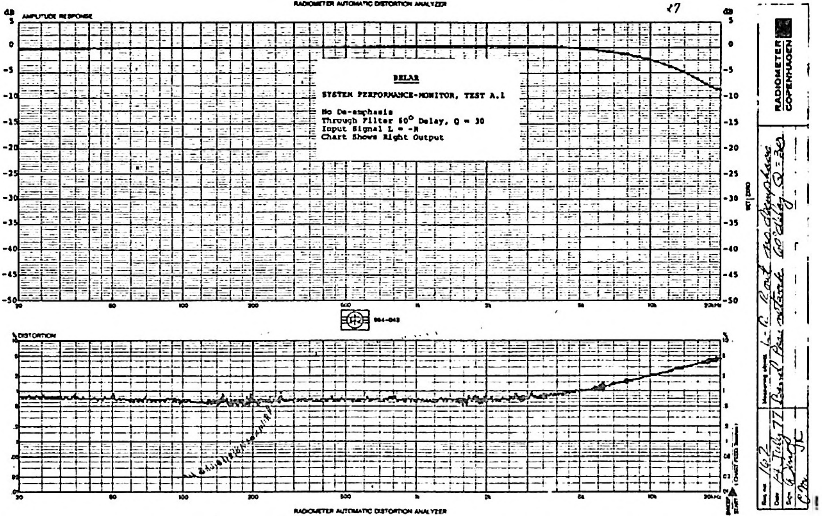


BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal L = -R
Chart Shows Left Output

1.9
14 July 77
L-R Left no de-emphasis
Band pass network 60° delay Q=30

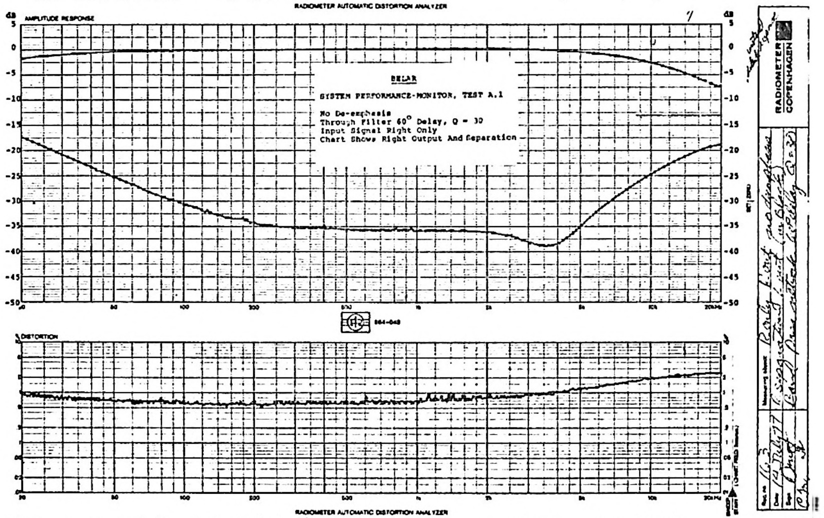


BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal L = -R
Chart Shows Right Output

Rec. no. 162
Date 14 July 77
Sign. D.Ding JC
C.Mn.
Measuring object: L-R Rout no de-emphasis
Band Pass network 60° delay Q = 30

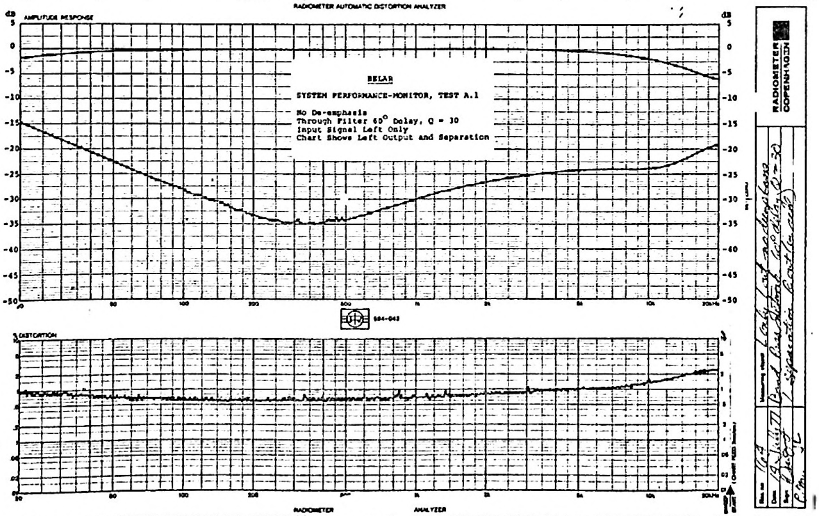


BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal Right Only
Chart Shows Right Output And Separation

Rec. no. 163
Date 14 July 77
Sign. D.Ding JC
C.Mn.
Measuring object: Right Lout no de-emphasis
L separation Lout (in black)
Band pass network 60° delay Q = 30

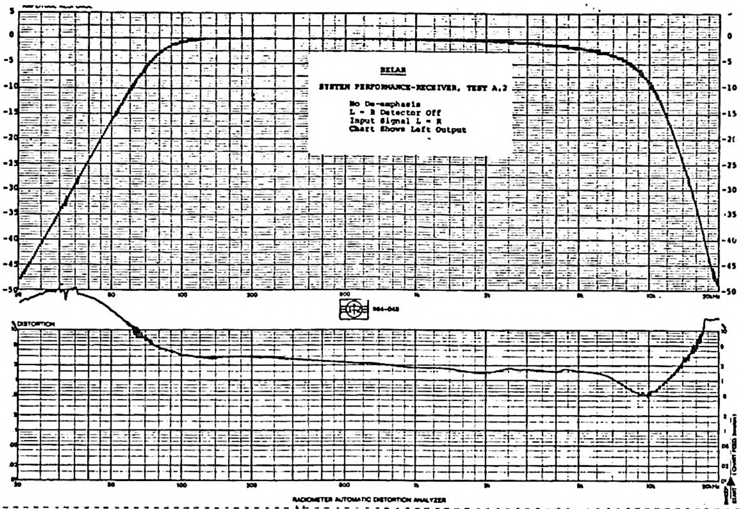


BELAR

SYSTEM PERFORMANCE-MONITOR, TEST A.1

No De-emphasis
Through Filter 60° Delay, Q = 30
Input Signal Left Only
Chart Shows Left Output and Separation

Rec. no. 164
Date 14 July 77
Sign. D.Ding JC
C.Mn.
Measuring object: Left Lout no de-emphasis
Band pass network 60° delay Q = 30
L separation Rout (in red)



BELAR

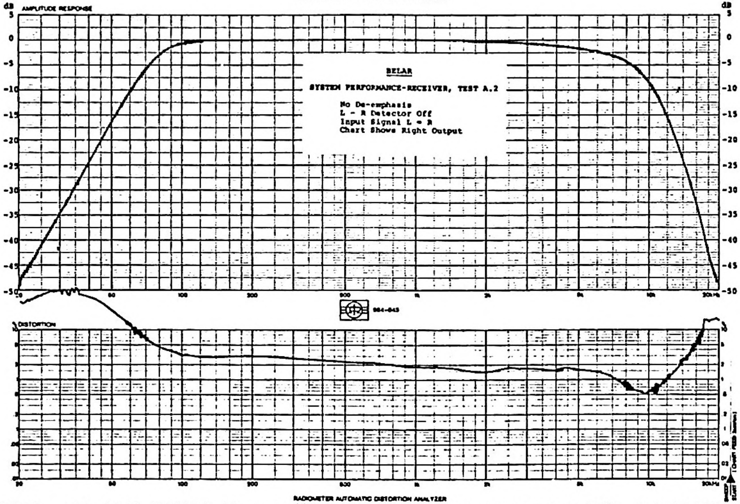
SYSTEM PERFORMANCE-RECEIVER, TEST A.2

No De-emphasis
L - R Detector Off
Input Signal L = R
Chart Shows Left Output

RADIOMETER COPENHAGEN

Rec. no 174
Date 18 July 77
Sign. ADP
RDS PJN JL

Measuring object L+R L out no deemphasis
L-R Detector out



BELAR

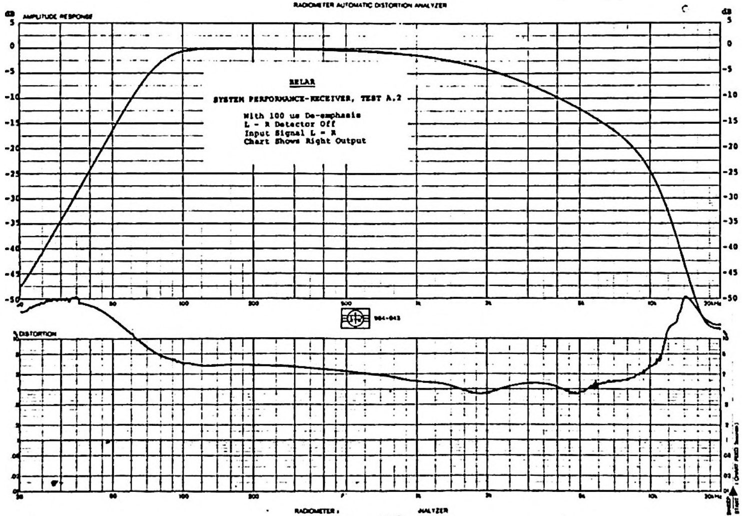
SYSTEM PERFORMANCE-RECEIVER, TEST A.2

No De-emphasis
L - R Detector Off
Input Signal L = R
Chart Shows Right Output

RADIOMETER COPENHAGEN

Rec. no 175
Date 18 July 77
Sign. ADP
RDS PJN JL

Measuring object L+R Rout no deemphasis
L-R detector out



BELAR

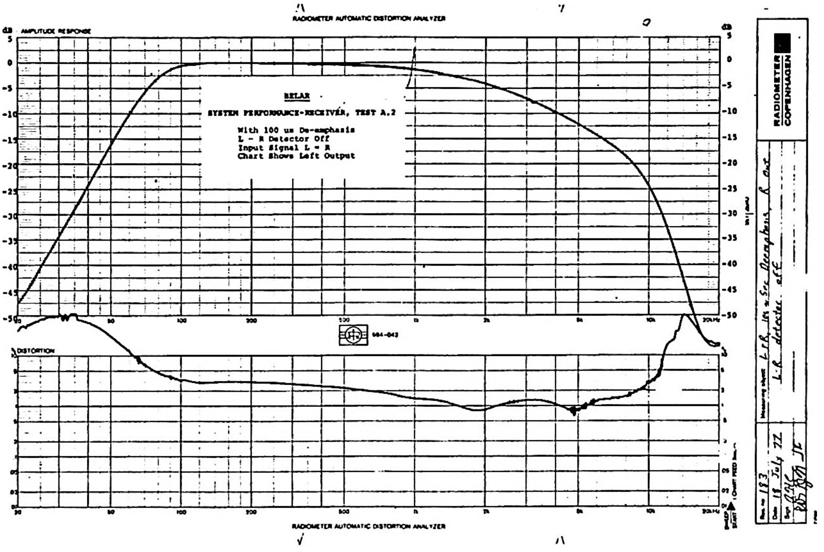
SYSTEM PERFORMANCE-RECEIVER, TEST A.2

With 100 us De-emphasis
L - R Detector Off
Input Signal L = R
Chart Shows Right Output

RADIOMETER COPENHAGEN

Rec. no 182
Date 18 July 77
Sign. ADP
RDS PJN JL

Measuring object L+R, 100 usec Deemphasis, L out
L-R Detector OFF



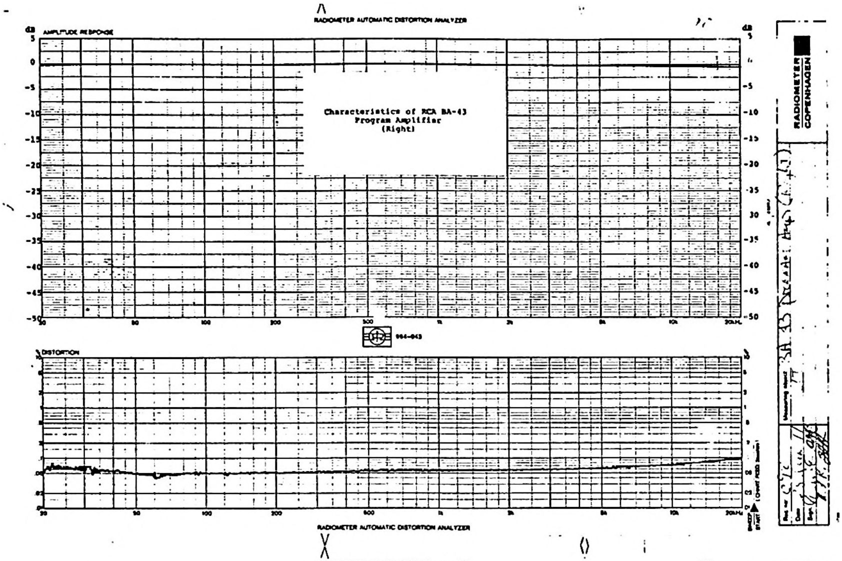
BELAR

SYSTEM PERFORMANCE-RECEIVER, TEST A.2

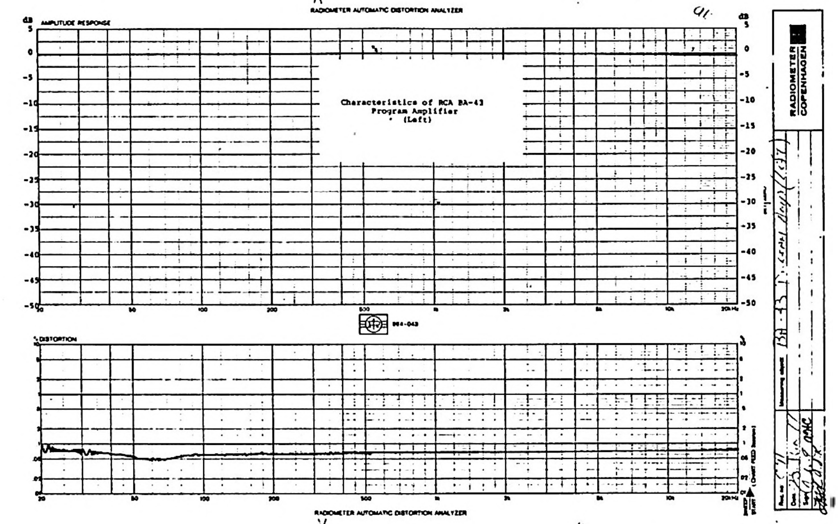
With 100 us De-emphasis
L - R Detector Off
Input Signal L = R
Chart Shows Left Output

Measuring object: L+R, 100 u Sec Deemphasis, R out
L-R detector off

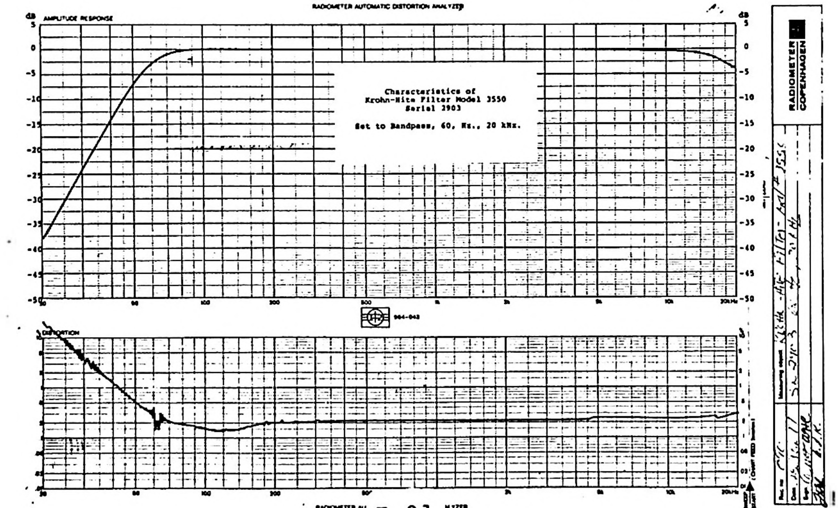
Rec. no. 183
Date 18 July 77



Characteristics of RCA BA-43
Program Amplifier
(Right)



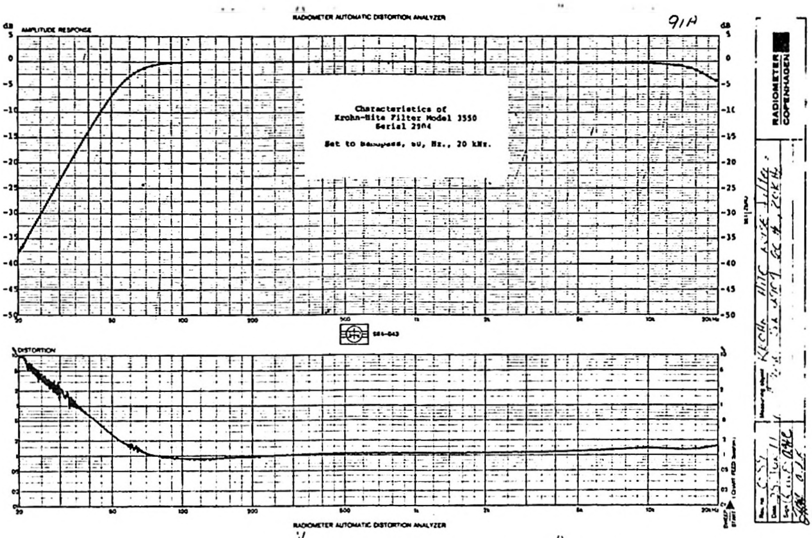
Characteristics of RCA BA-43
Program Amplifier
(Left)



Characteristics of
Krohn-Hite Filter Model 3550
Serial 2903

Set to Bandpass, 60, Hz., 20 kHz.

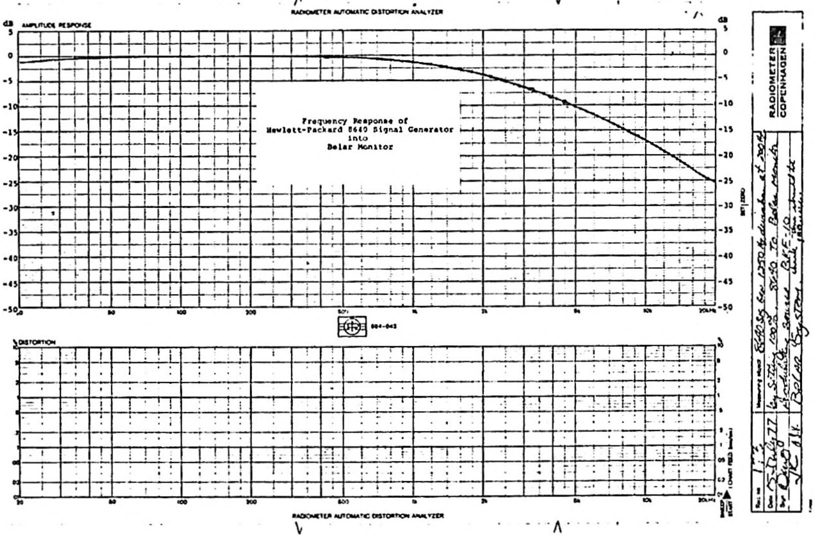
91A



Characteristics of
Krohn-Hite Filter Model 3550
Serial 2904

Set to Bandpass, 50, Hz., 20 kHz.

Rec. no. C55
Date 25 Jun 11
Sign [illegible]
Measuring object KROHN HITE [illegible] filter, [illegible] 50 Hz, 20 kHz



Frequency Response of
Hewlett-Packard 8640 Signal Generator
into
Belar Monitor

Rec. no. 1
Date 15 July 77
Sign [illegible]
Measuring object 8640 Sig Gen 1250 Hz deviation at 300 Hz by setting 100%. 8640 to Belar monitor. Modulating source BKF-10. Belar System. [illegible]

HARRIS

COMMUNICATION AND
INFORMATION PROCESSING

Dear Broadcaster:

The growth of FM stereo has created a serious challenge for the AM broadcaster. AM stereo can answer that challenge. The FCC is currently evaluating five AM stereo systems, and Chairman Ferris has committed the Commission to act within the first quarter of 1980.

Two of the major issues with which I am concerned are coverage and the ability to provide a competitive quality stereo signal. Only the Harris V-CPM system insures no reduction in mono listener coverage; and stereo coverage exceeds 90% of mono. Combine this with the fact that AM stereo will not suffer from multipath and line-of-sight reception problems, and you have met the competitive challenge of FM stereo!

However, the quality of the AM signal must be maintained. Harris has the only system that considers the future quality of AM mono and stereo receivers. V-CPM can be used with current receivers, and is the only system that can be used with advanced synchronous receivers now being introduced in the market.

With synchronous receivers, reception is less plagued with noise and interference, and the rasping distortion heard on skywave signals and in directional antenna nulls is completely eliminated. Furthermore, synchronous stereo receivers will provide better fringe area reception, both in stereo and in mono.

If you share my concern over these key issues, let the FCC know by writing, on your station letterhead, to:

Secretary
Federal Communications Commission
Docket 21313
1919 M Street, N.W.
Washington, D.C. 20554

Remember, your voice counts in this important matter. Write today concerning the future of your industry.

Sincerely,

Dan Maase

Dan Maase
Vice President-Engineering

fls

HARRIS CORPORATION Broadcast Products Division P. O. Box 4290, Quincy, Illinois 62301 217/222-8200