NRSC REPORT

NATIONAL RADIO SYSTEMS COMMITTEE

NRSC-R31
Subjective Evaluation of Audio Degraded by Noise and Undesired FM Signals
November 17, 1982

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FOREWORD

NRSC-R31, Subjective Evaluation of Audio Degraded by Noise and Undesired FM Signals, documents two studies on human perception of the quality of degraded audio signals. These studies were conducted in response to the FCC's decision to re-open Docket 80-90 to consider the results of these and other studies as to their impact on the FM allocations planning process.

The NRSC is jointly sponsored by the Consumer Electronics Association and the National Association of Broadcasters. It serves as an industry-wide standards-setting body for technical aspects of terrestrial over-the-air radio broadcasting systems in the United States.

SUBJECTIVE EVALUATION OF AUDIO DEGRADED BY NOISE AND UNDESIRED FM SIGNALS

A Report by the Technical Subgroup
of the Advisory Committee
on Radio Broadcasting

Lawrence C. Middlekamp
National Association of Broadcasters

November 17, 1982

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Executive Summary

Two studies on human perception of the quality of degraded audio signals were conducted. First, the signal to noise (S/N) ratios of five separate quality "grades" were established by listener-controlled adjustments of the ratios of a wide range of recorded audio material. The second study assessed the quality grades of recorded audio output from an FM receiver for specific RF ratios (those used by the FCC and the CCIR for FM protection) of desired and undesired signals. Ten experienced listeners participated in both tests.

Results (the mean values) of the first study (S/N) show a decade relationship (60, 50, and 40 dB) between "imperceptible", "slightly annoying", and "very annoying" (grades 5, 3, and 1) respectively. Of particular interest, the mean value of S/N for annoyance level 3,"slightly annoying", was found to be approximately 50 dB; an annoyance analagous to the TASO grade 3 indicating "passable" picture quality.[1]

The results of the second study show that the mean value of the subjective quality of the audio output from an FM receiver

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[1]See Report to the Federal Communications Commission, Television Allocations Study Organization ("TASO"), March 1959. TASO Grade 3 was found to be approximately 30 dB video S/N. This turned out to be the same factor which had been employed as a fundamental planning factor in the FCC's system of television allocations. The clear implication is that 50 dB stereophonic S/N should be utilized as a fundamental planning factor in FM radio allocations.

for RF ratios producing a 30 dB audio signal to interference (S/I) ratio was approximately Grade 2 (annoying) interference. Similarly, the subjective quality for a 50 dB audio S/I ratio was Grade 4 (perceptible, but not annoying) interference. The actual grade differences between the two S/I ratios were 1.6, 2.0, and 1.8 levels for co-channel, 1st adjacent channel and 2nd adjacent channel FM interference respectively.

This study clearly demonstrated that expert listeners find the present 30 dB stereophonic S/I an unacceptable criterion on which to base a system of FM allocations. To the contrary, the 50 dB criterion employed in most other parts of the world has been shown to be more appropriate since it conforms to reception standards judged by listeners to be "perceptible, but not annoying" whereas 30 dB was found to be "annoying" or worse.

Generally, in both tests, the perceived subjective quality of 30 dB aural S/N was judged to be much worse than that for a 50 dB aural S/I.

Introduction

1. Chronology of Events

In March, 1980, the Commission began a rulemaking proceeding with the objective of changing the technical standards utilized in allocating FM broadcast stations.[2] The comment period closed March 2, 1981. On July 12, 1982, the Subgroup on Technical Matters of the Advisory Committee on Radio Broadcasting[3] petitioned the FCC (1) to reopen the record in Docket 80-90 "to allow acceptance of three completed studies and additional studies being prepared and (2) to initiate a further rulemaking proceeding affording the opportunity for public comment on all these submissions."[4] On August 5, 1982, the Chief of the Broadcast Bureau issued an Order accepting for public comment the three completed studies, one of which, among other things, recommended "that studies be undertaken immediately to establish (1) the relationship between audio S/N and subjective listening quality; and (2) the appropriate value of audio S/N which should be utilized

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[2]Notice of Proposed Rulemaking in BC Docket 80-90 (FCC 80-108), 45 Fed. Reg. 17602 (March 19, 1980).

[3]The Advisory Committee and its subgroups on Technical Matters and Radio Spectrum Allocations were created by Memorandum Opinion and Order issued by the Commission on September 22, 1980 (FCC 80-537).

[4]Petition for Reopening of the Record and for Issuance of a Further Notice of Proposed Rule Making, Subgroup on Technical Matters of the Advisory COmmittee on Radio Broadcasting, July 12, 1982 at 1.

within the FM allocations planning process".[5] This study provides answers to these questions.

2. Need for Research

The FCC's FM allocations technical standards are based, to a large degree, on a co-channel signal-to-interference ratio of 20 dB. This ratio was established approximately 40 years ago when the only FM transmission mode was monophonic. A 20 dB RF signal-to-interference ratio yields a monophonic audio signal-to-interference ratio of approximately 50 dB. However, for stereophonic transmission, a 20 dB signal-to-interference ratio yields an aural signal-to-interference ratio of only 30 dB.[6] In short, while the mode of transmission and reception of FM broadcast stations changed, the allocation standards utilized by the Commission did not. Moreover, the international standard for quality FM stereo broadcasting differs from that which is used domestically. CCIR believes a 50 dB stereophonic S/I ratio is necessary to provide a quality FM broadcasting service.[7] A need was therefore perceived for research into the Commission's assumptions regarding public expectation of quality stereo sound.

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[5] FM Broadcasting Receiver Characteristics and Protection Criteria: A Report by the Technical Subgroup to the Advisory Committee on Radio Broadcasting, July 7, 1982, at Appendix C.

[6] Id. at 1.

[7] Recommendations and Reports of the CCIR; XIVth Plenary Assembly, Kyoto, 1978, Volume X, Rec. 412-2.

Design of Listening Tests

Attempts to locate definitive studies on the public desirability of stereo 30 dB or 50 dB S/I were unsuccessful. Moreover, no studies dealing with either perception of an acceptable audio S/I ratio or the subjective quality of audio degraded by noise and undesired FM signals could be found. It is, however, reasonable to assume that the two ratios would yield substantially different results.

Two studies were designed and conducted: 1) listening tests to determine qualitative perception of noise added to processed audio program material; and 2) subjective assessment of a recorded tape of the audio output from an FM receiver with desired program material degraded by undesired FM signals. Co-channel, first adjacent (+/- 200 kHz), and second adjacent channel (+/- 400 kHz) undesired FM signals were utilized, supplied at RF levels which produced audio ratios of 30 dB and 50 dB stereo S/I using the CCIR method.

The listening tests were conducted by Bronwyn L. Jones, Staff Scientist, at the CBS Technology Center, Stamford, Connecticut. In the first test, random noise with FM spectral contouring characteristics constituted the interfering audio, while the second test used highly processed modulated rock music -- a worst case condition -- as the degrading audio. Subjective evaluations were carried out by ten experienced listeners using the CCIR five point annoyance scale:

Annoyance Scale

1. Very annoying
2. Annoying
3. Slighty annoying
4. Perceptible but not annoying
5. Imperceptible

It should be recognized that the annoyance can be due to interfering noise or other interfering undesired audio, such as that occuring in the output of an FM receiver when an undesired FM signal is also being received.

The purpose of the first test (with noise degraded audio) was to determine "the relationship between audio S/N and subjective listening quality".[8] The purpose of the second test was to obtain the listener's opinions on which S/I audio ratio is necessary for acceptable FM listening. For this report we shall refer to the first test as signal to noise (S/N) and the second test as signal to interference (S/I).

Test #1

SUBJECTIVE SIGNAL TO NOISE TEST

1. Description.

For this test, listeners assigned specific values of S/N to each of the five annoyance levels. Each listener was seated

[8]July 7, 1982 Technical Subgroup Report at Appendix C. See n. 5, supra.

in an audio listening room at the CBS Technology Center. The listener adjusted FM weighted noise with a 40 dB attenuator to produce, in his/her judgement, a specific level of audio quality as represented on the CCIR scale -- i.e. a listener would adjust the noise to be "annoying" (level 2), and that might turn out to be equivalent to a 45 dB S/N. Similarly, another listener might judge "annoying" to be equivalent to a 40 dB S/N, and "slightly annoying" (level 3) to be 50 dB S/N. The results shown in Figure 1 and Table 1 are averages of each listener's attenuator (S/N) adjustments for each selection of program material.

The desired audio recording consisted of five one minute segments representing a wide variation of program material, both speech and music. Noise levels for each program segment and each annoyance level, the listener's response "mark", and a calibration were recorded on a strip chart. Explicit instructions were read and discussed; the listener could repeat any section of the tape.

2. Results.

Results of this test are given in Table 1 and Figure 1. (p.8 and p.9). Table 1 presents the sample mean and the sample standard deviation of the S/N ratios from each listener for each program segment and for each of the five annoyance levels. In addition, the "total" means and "total" standard deviations are provided.

TABLE 1

Subjective Audio Quality, Noise Degraded
(N=10)

Program Excerpts	Signal To Noise Ratios (dB)									
	Impercept.		Percept.		SL. Annoying		Annoying		Very Annoying	
	$\overline{X}$	S	$\overline{X}$	S	$\overline{X}$	S	$\overline{X}$	S	$\overline{X}$	S
Samisen	56.5	4.0	53.1	4.2	50.4	3.8	44.4	4.7	39.6	5.0
Poem	62.2	3.2	58.4	2.7	52.2	3.5	48.8	3.6	42.1	4.7
M. Jackson	50.4	5.3	44.2	4.6	38.5	3.7	35.3	4.0	31.9	2.9
Piano	65.6	2.1	59.6	2.8	55.7	3.9	51.5	4.4	44.1	5.0
Haydn	61.1	4.5	57.9	3.9	51.3	5.3	47.0	4.9	40.6	6.2
All five	59.2	5.9	54.6	6.3	49.6	6.5	45.4	6.5	39.7	4.7

$$\text{Sample mean} = \overline{X} = 1/N \sum_{1}^{N} X_i$$

$$\text{Sample standard deviation} = S = \left[(1/N-1) \sum_{1}^{N} (\overline{X} - X_i)^2 \right]^{\frac{1}{2}}$$

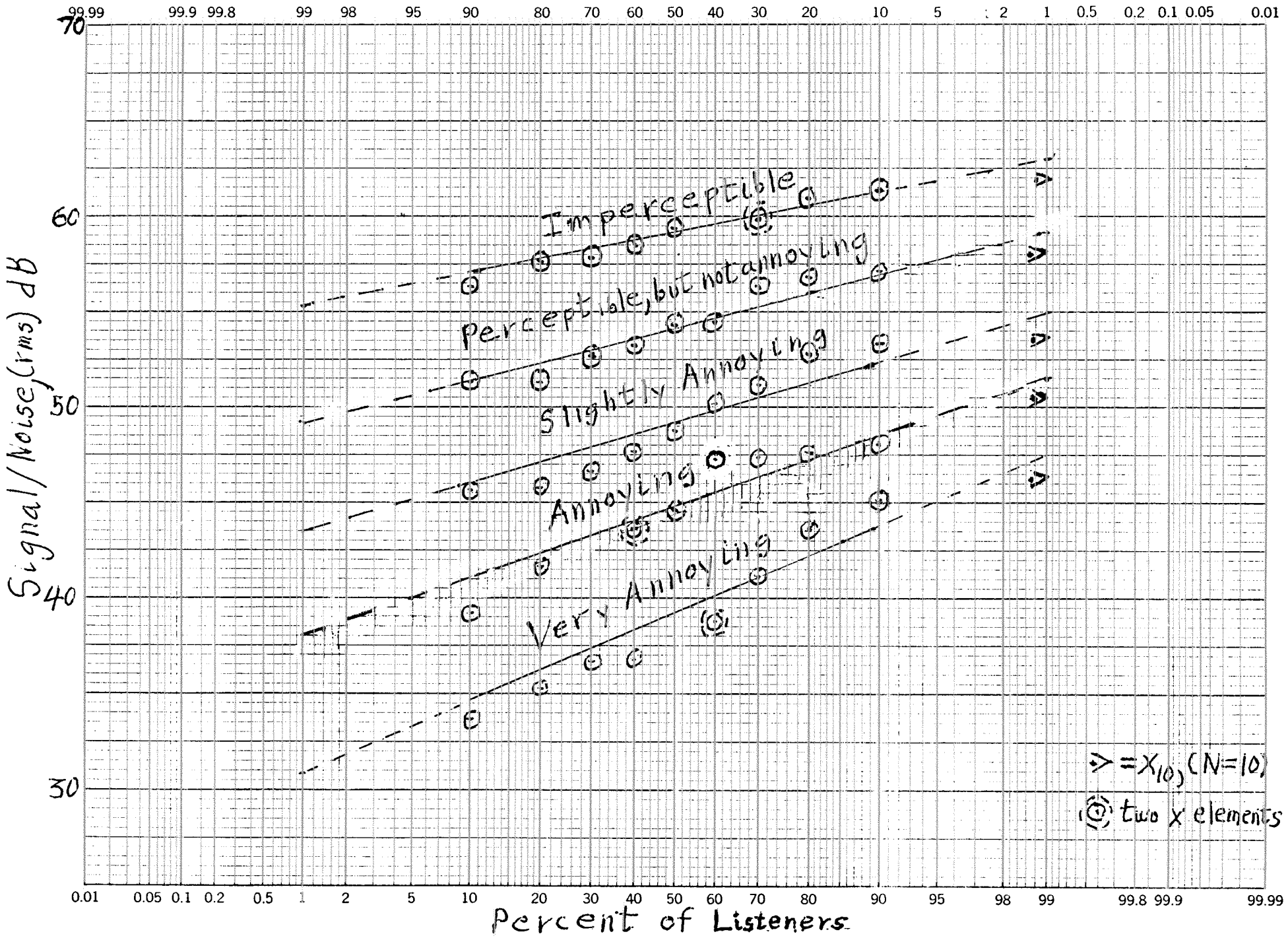

FIGURE 1: Subjective Audio Quality - Annoyance (Noise)

Figure 1 is a plot of the data obtained in the signal to noise test. Each listener made separate adjustments of the S/N ratios for each of the five one minute program material segments and repeated those adjustments for each of the five separate audio qualities. The mean values of the S/N ratios determined by each listener for the five segments were then obtained. These values were then plotted on cumulative probability paper, resulting in five curves representing the five annoyance levels. Because there were ten listeners, a solid line is plotted from 10 to 90 percent representing the actual sample data. Dashed linear extensions indicate where no sample points were available. These plots are similar in nature and analagous to the TASO plots of subjective TV picture quality.

Additional details are given in Appendix A.

Test #2

SUBJECTIVE SIGNAL TO INTERFERENCE TEST

1. Description

As in the signal to noise test, a listener was seated in the audio listening room of the CBS Technology Center. This time, however, he/she was asked to make a subjective assessment of a 30 dB and a 50 dB S/I ratio (non-integer values were acceptable). This assessment was made on four thirty second segments of program material -- representing desired audio degraded by undesired, highly processsed audio.

The S/I recording was prepared at the laboratory of the

National Association of Broadcasters (NAB) in Washington, D.C. The lab recorded the stereo output of an FM receiver whose RF input consisted of (1) a desired audio program signal and (2) an undesired audio program signal. Each signal was independently generated. The desired signal level was that existing at the receiver's terminals when located at the 1 mV/m contour.[9] The undesired levels (FM co-channel, 1st adjacent, and 2nd adjacent), determined by CCIR methods, were designed to produce a 30 dB and a 50 dB signal to interference ratio. These ratios are the criteria used by the FCC (30 dB) and recommended by the CCIR (50 dB) for use in establishing FM protection ratios. (See Appendix B).

Each listener made thirty-six separate assessments: four types of desired program material; three different frequency relations of the desired and undesired FM signals; and two different RF desired to undesired ratios.

2. Results

The results of this test are presented in Table 2 (p. 12). For each of three D/U frequency relations, the mean values from the 10 listeners for each of the recorded program segments are presented. Additionally, for each frequency relation, the "total" means are provided.

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[9]This level was calculated to be -47.1 dBm. See Appendix C.

TABLE 2

Subjective Audio Quality, Undesired Audio Degraded
(FM Protection Ratios)

Program Excerpts	$\bar{X}$(N=10) of Quality Grades (5-1)					
	FM Co-channel		FM First Adjacent		FM Second Adjacent	
	(30 dB)	(50 dB)	(30 dB)	(50 dB)	(30 dB)	(50 dB)
Female Voice	1.8	4.3	1.5	4.3	1.7	4.1
Guitar	1.5	2.7	1.3	2.4	1.2	2.5
Vocal & Ochestra	3.0	4.0	3.3	4.6	2.3	4.2
Silence	1.9	3.9	1.6	4.1	1.7	3.2
All four	2.1	3.7	1.9	3.9	1.7	3.5

ANNOYANCE SCALE

1. Very annoying
2. Annoying
3. Slightly annoying
4. Perceptible but not annoying
5. Imperceptible

Conclusion

Although the CCIR method for FM protection ratios was specifically designed to produce 50 dB S/I audio ratios, no studies had been found to show subjective equivalence between 50 dB S/N audio and that from an FM receiver subjected to the RF levels of the protection ratios. Tests 1 and 2 of this report provide such a comparison.

One conclusion is inescapable. Protection ratios providing a stereophonic 50 dB S/I audio ratio are strongly preferred to those which yield only 30 dB. The mean subjective assessments with the ratios for 50 dB S/I were that the interference was only "perceptible", while those for 30 dB S/I were "annoying". These assessments differ by two grades, with the 30 dB annoyance considered one grade lower than acceptable.

Primarily these studies provide the first known data for (1) the relationship between audio S/N and subjective listening quality; and (2) the appropriate value of audio S/I which should be utilized within the FM allocations planning process.

The test procedures and results used the CCIR annoyance scale; i.e., the greatest annoyance (very annoying) is Grade 1. This is confusing to many since the best audio quality is usually considered Grade 1; e.g., TASO picture quality. We believe that it would be desirable that "annoyance" be changed to "audio quality" grades 1 to 5, analagous to the TASO picture grades, with 1 representing the highest quality.

Recommendations for Further Research

If further research is contemplated by other interested parties, the following suggestions are recommended:

1) Tapes depicting 30 and 50 dB S/I ratios should be employed with as many receivers as possible.

2) A larger number of listeners would lend greater statistical accuracy to results.

3) Further efforts should be made to reduce the potential effect of tape "hiss" on the test results.

Acknowledgements

The following people and companies have contributed their time and resources to seeing the successful completion of this study:

Engineering

Mr. Rex Nathanson.....CBS Technology Center

Mr. Jon Grosjean.....Consultant

Mr. Tom Mock.....Electronics Ind. Asso.

Equipment

Belar Electronics Labs, Inc.....Modulation Monitors

Orban Associates, Inc.....Stereo processor/Generator

General Electric Company.....Psophometer, White Noise Generator, and CCIR Weighting Filter

Appendix
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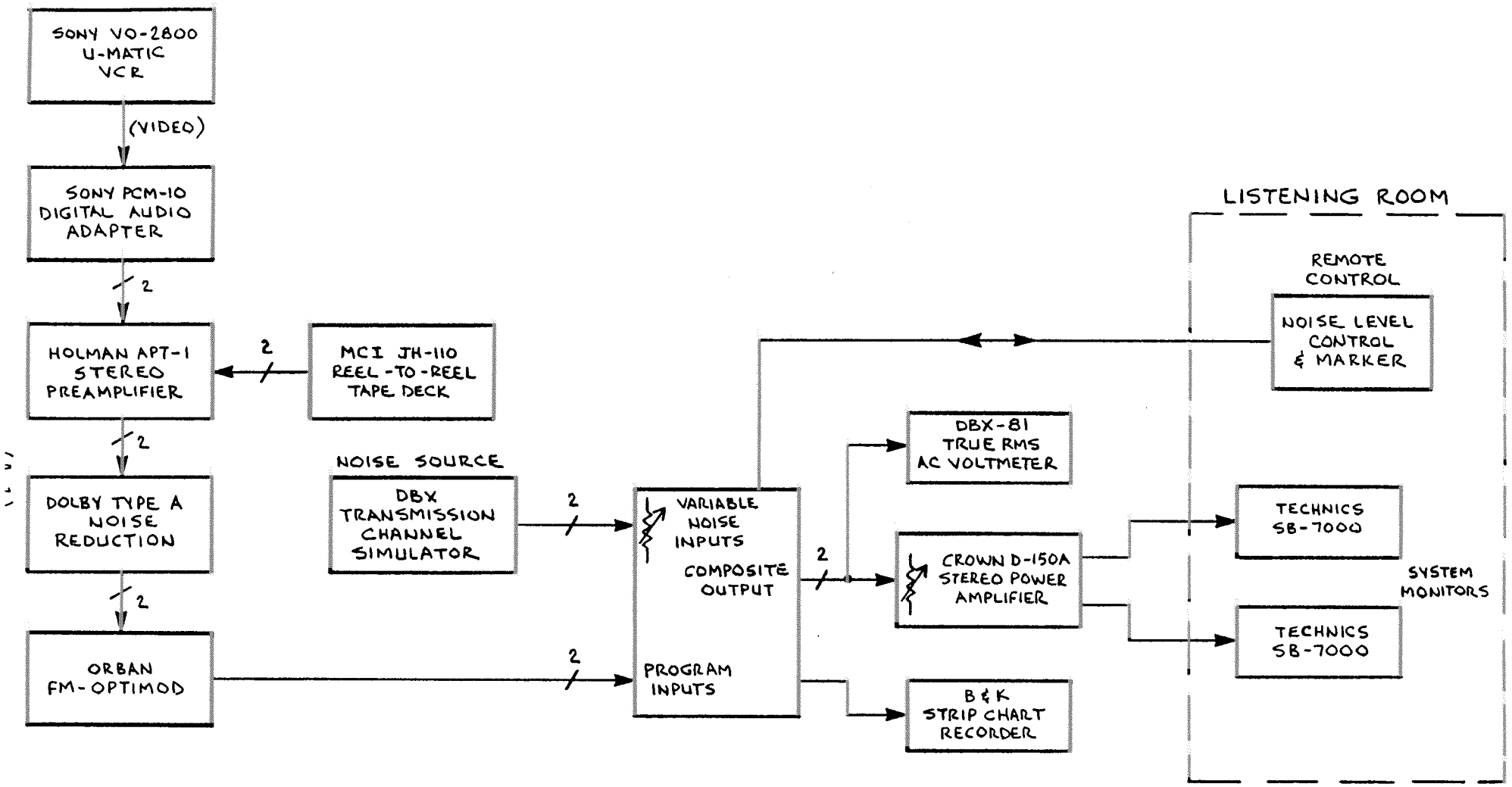


CBS

NAB FM PROTECTION RATIO STUDY
SYSTEM DIAGRAM

EIA TEST #2 - Evaluation of Annoyance Levels

A. Auxi on Holman Preamp

B. Turn on Dolby A

1. Disconnect inputs to input matrix
2. Switch "reference" on selector
3. Switch box into #2 position
4. EIAJ FM B- noise
5. Switch Technics preamp (amplifiers noise) to "source"
6. B&K strip chart recorder settings
   a. Fastest writing speed
   b. 0.3 mm/s paper speed
7. dbx meter connected to left channel input of 12 box using y adaptor
8. Calibration levels

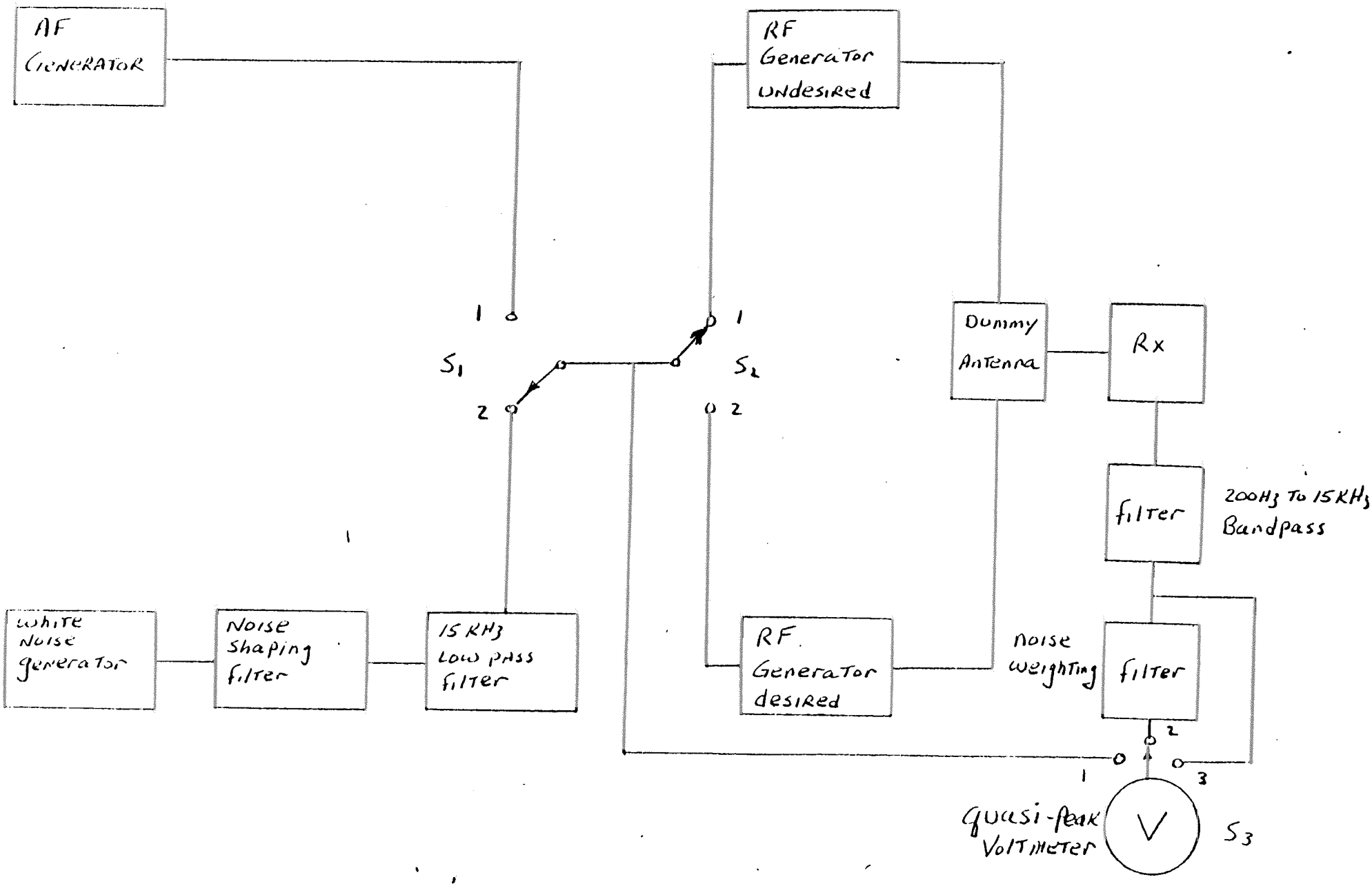
-30	-52.5
-32.5	-55
-35	-57.5
-40	-60
	-62.5
-45	-68.65
-47.5	Mark
-50	

FM Protection Radio - NAB Tape

1. Turn off Dolby A
2. Select Tape 1 input on Holman Preamp
3. Turn noise "Off" on simulator panel
4. Switch box into #1 pos
5. Reinstall input cables
6. Technics preamp "Tape"

CBS Listening Panel

The listening panel was made up of ten experienced male and female listeners. Four had been hired as expert listeners by the EIA for compander evaluation studies already in progress at the CBS Technology Center. Six were chosen from the CTC professional staff. The approximate age range was 25-50 years. All had normal hearing as determined either by a hearing screen run at 30 dB (250 Hz - 8 kHz) or by report.



(R-1)

Equipment Set-up Used by CCIR
for Determining FM Protection Ratios

51.1. 51. Method of measurement using noise modulation.

The unwanted signal, instead of being modulated with 1 kHz, shall be modulated by a noise signal which is obtained from a gaussian white noise generator, passing the signal through a weighting filter as specified in Fig 11 followed by a low-pass filter having a cut-off frequency of 15 kHz and a slope of 60 dB/octave, and then through a pre emphasis network (50 μs or 75 μs).
The audio-frequency amplitude/frequency characteristic of the modulation stage of the signal generator should not vary by more than 2 dB up to the cut-off frequency of the low-pass filter.

The accuracy of the measurement depends very much on the precision with which frequency deviation of the signal generator can be set; this is especially true for the unwanted transmitter. The line-up procedure therefore should be carried out very carefully.
The deviation of the signal shall be measured by means of the arrangement shown in Fig.12. The meter V shall be a quasi-peak voltmeter. (See Appendix A). To obtain the required deviation conditions, the switches S1, S2 and S3 are placed in position 1 and the modulation at 500 Hz of the a.f. generator adjusted to ± 32 kHz (± 21.3 kHz) deviation. The meter reading is noted. The switch S1 is then placed in position 2 and the noise modulation adjusted to give the same reading on the quasi-peak meter.

51.2.

For the determination of the reference level, the wanted signal is frequency modulated, using a sinusoidal tone of 500 Hz with the rated maximum system deviation.

Therefore the switches are set as follows: S1 in position 1, S2 in position 2 and S3 in position 3. The reading of the meter V indicates the reference level.

51.3 The noise voltmeter used to measure the wanted and interfering signals at the output of the receiver consists of the quasi-peak voltmeter with defined dynamic characteristics and an added filter which modifies the levels of the interfering frequencies according to their subjective interference effect as specified in Appendix A.

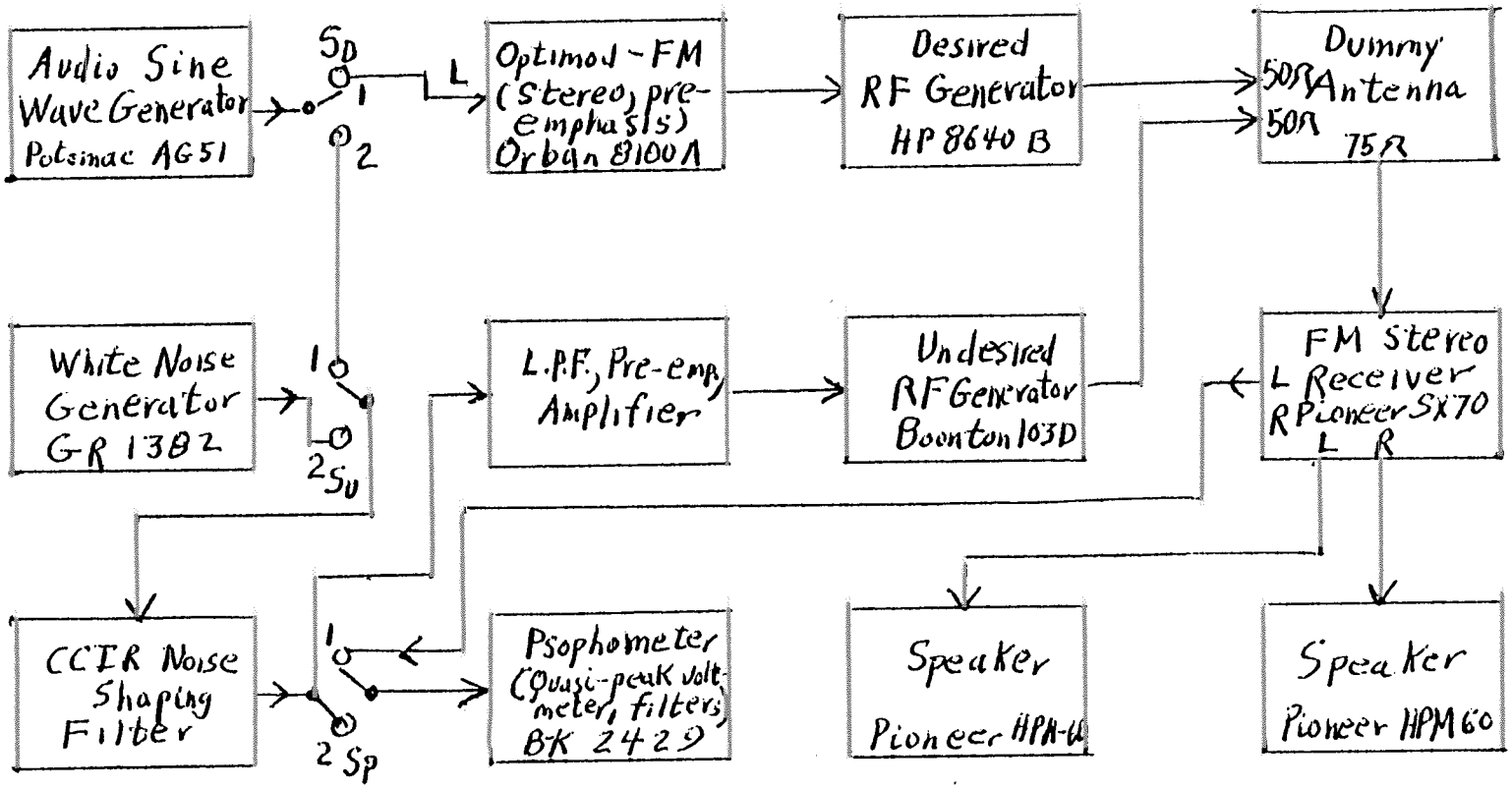
51.4 The audio-frequency signal-to-interference ratio should be measured at the low-level audio-frequency output of the receiver. If this is not possible, the tone-controls shall be in a position to ensure a flat audio frequency response (see clause 7.12 h).

The level of the unwanted signal is adjusted to obtain an a.f. signal-to-interference ratio of 50dB at the a.f. output of the receiver, the value of 50dB being chosen in this case to correspond with CCIR Rec. 412-1. In this case, the weighting network at the quasi-peak voltmeter shall be switched in (switch 3 in position 2). The ratio between the r.f. levels of the wanted and unwanted signals is the required r.f. wanted-to-interfering signal ratio.

FOOTNOTE: These characteristics correspond with those given in CCIR Rec. 468-1.

52. Presentation of the results.

Curves are plotted with the audio-frequency signal-to-interference ratio and the wanted input signal level as parameters. The frequency difference between the wanted and unwanted signals is plotted linearly as abscissa and the radio-frequency signal-to-interference ratio expressed in decibels linearly



N.A.B. Block Diagram 1
Equipment Set-up
for
Determining RF Protection
Ratios (CCIR Method)

RF Protection Ratios
(Stereo on D (Desired); Mono on U (Undesired))

1. Refer to Block Diagram 1;
2. Adjustment of Optimod-FM as detailed in its operating manual;
3. Set frequencies of D, U, and FM Receiver to 97.900 MHz, using self contained frequency counters of generator for tuning receiver;
4. Set D output to -47.1 dBm as given by its output attenuators and level meter. (See "Calculations" for the derivation and justification of this level). U carrier off;
5. Switch S_D, S_U, and Sp all to position 1;
6. Modulate D at 100% (75 kHz) total* with "L" input to Optimod a 500 Hz signal from the sine wave generator and 9% pilot (stereo);
7. Record the level of the left channel output from the receiver on the Psophometer, unweighted filtering. (This is the 0 dB reference level);
8. D carrier off, U carrier on, U level at -47 dBm;
9. S_D to 2, S_U at 1, Sp at 2;
10. Modulate U to 32 kHz deviation* (IEC publication 315.4) with a 500 Hz signal from the sine wave generator;
11. Record level of Psophometer, unweighted filter;
12. S_U to 2. Adjust White Noise Generator for same level of Psophometer unweighted filter, as recorded in step 11;
13. Sp to 1, D carrier on. Adjust U level to give -30 dB and -50 dB reading on the Psophometer (Radio II filter) with respect to the level recorded in step 7. Record these levels;
14. Protection ratios for the two S/N parameters, 30 and 50 dB, are given by the D/U ratio;
15. Repeat step 13 (and 14, if wanted) with U at 97.700 MHz and at 97.500 MHz;
16. Steps 13 and 15 produce the U levels for audio S/N ratios of 30 and of 50 dB for co-channel, lower first adjacent channel, and lower second adjacent channel, and lower second adjacent channel with respect to a D signal of -47.1 dBm for this receiver;
17. (Note that the 2 signal dummy antenna results in a 7.8 dB loss, so that the actual D power at the receivers terminals are -54.9 dBm (65.1 dBfW).

Note:

*Use modulation meter and modulation control devices provided on the signal generators.

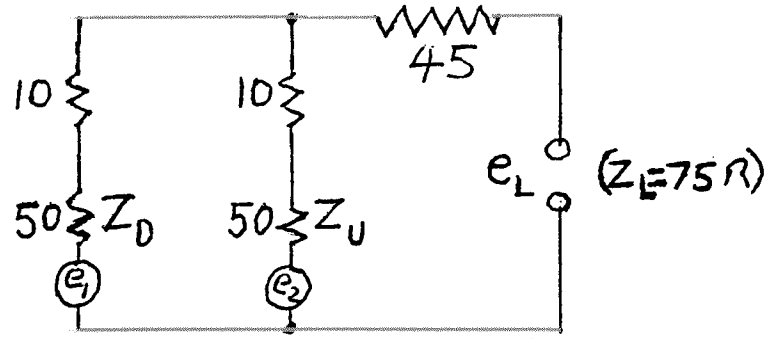
Calculations

Desired signal level, e_D, or P_D on 98 MHz for 1 mV/m field

E_0 = field strength contour level = 1 mV/m
λ(98 MHz) = 300/98 = 3.06 m
V_M = voltage across 73 Ω matched dipole resistance = $E_0\lambda/2\pi$

V_M = 1 X 3.06/2π = .487 mV
V_{75} = desired voltage across 75Ω receiver = V_M X (75/73)1/2 = .494 mV

To match two 50Ω signal generators, D and U, to the 75Ω receiver, the following dummy antenna is used:



If e_1, e_2 are open circuit voltages, then $e_L = \frac{e_1 + e_2}{4}$

But level output meters are calibrated as match terminated $e_M = 2e_L = 2(V_{75})$ and $e_D = e_M$, therefore e_D = 2 X.494mV = .988 mV.

For mW (Ω) meter readings, P_M (50Ω) = (988 X 10-6)2/50 = P_M (50Ω) = 19.52 nW = -47.1 dBmW= P_D

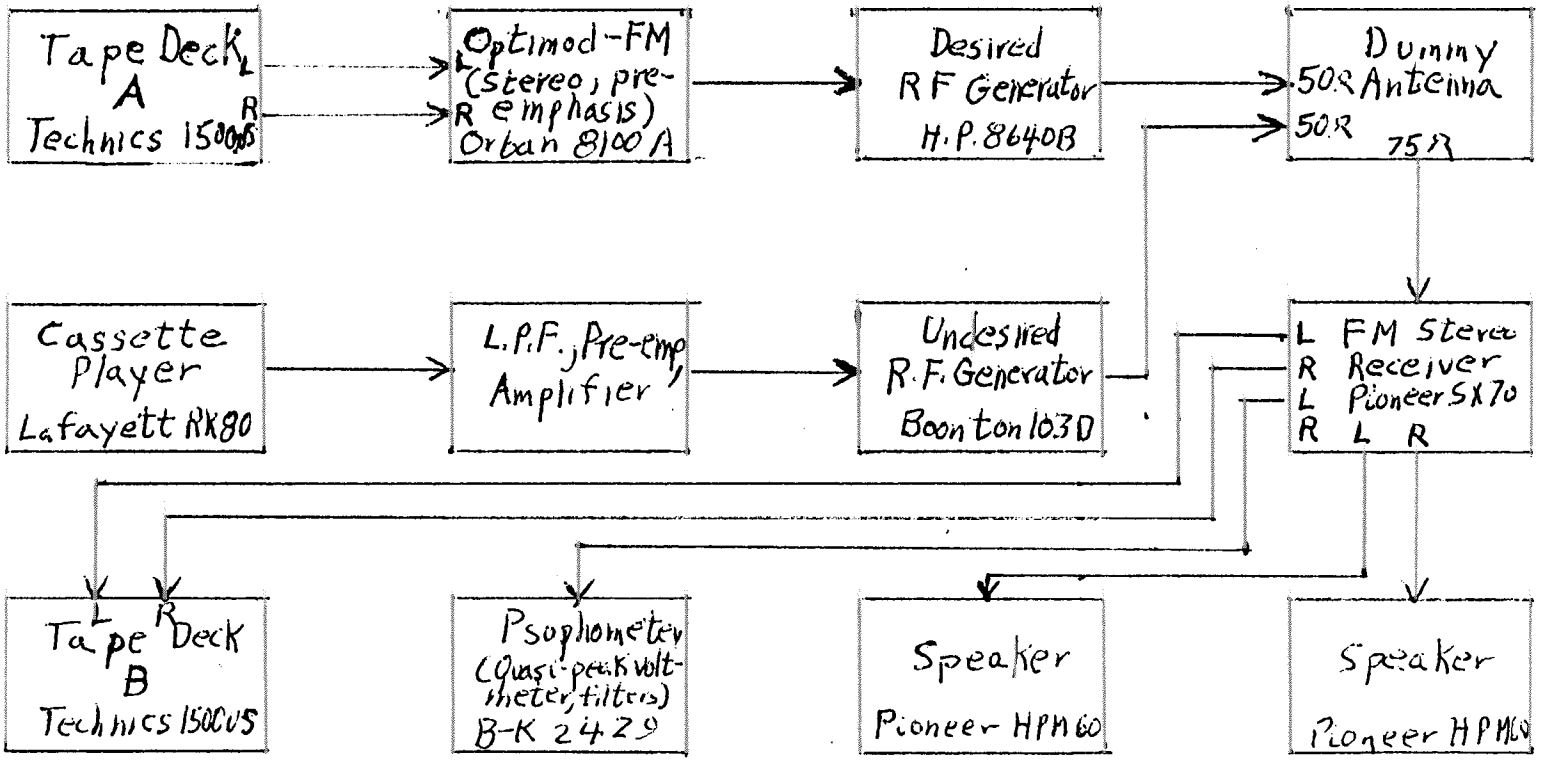
Receiver desired signal power is given by P_R = (.494 X 10-3)2/75 = $\frac{244 \text{ X } 10\text{-}9 \text{ W}}{75}$ = 65.1 dBfW

Results
Test Procedure, FM Protection Ratios
for Audio Taping

Receiver: Pioneer SX 780
D = -47.1 dBm on 97.900 MHz
D (rcvr.) = -54.9 dBm = 65.1 dBfW

Reference 0 dB audio level.....350.0 mV
Minimum (stereo) receiver noise.....0.42 mV
Maximum audio S/N for D = -47.1 dBm.....58.4 dB
Audio level of -30 dB.....11.1 mV
Audio level of -50 dB.....1.11 mV

U Frequency Re:D	Audio S/N in dB	U Level in dBm	D/U in dB
Co-channel	30	-73	26
	50	-94	47
D-200 KHz	30	-55	8
	50	-76	29
D-400 KHz	30	+2	-49
	50	-17	-30
D+200 KHz	30	-53	6
	50	-73	26
D+400 KHz	30	+2	-49
	50	-15	-32



(Used to pre-monitor desired and undesired FM generators' signals.) ← FM Modulation Monitor Belar FMM-1

N.A.B. Block Diagram 2
Equipment Set-up
for
FM Audio Taping

Taping Procedure for FM Audio

Tape Deck A: desired audio source
Tape Deck B: record of receiver output
D: desired signal generator
U: undesired signal generator

1. D and U at 97.900 MHz;
2. D level at -47 dBm, DMOD at AC, U level at -73 dBm, U carrier "off";
3. Start A at 0002, start B from 0000 in recording mode;
4. At "cue" tone after voice announcement and test tones, turn U carrier "on";
5. At next "cue", switch U level to -94 dBm;
6. At next "cue", turn U carrier "off";
7. At next "cue", stop A and B;
8. Set U to 97.700 MHz, U level to -76 dBm, U carrier "on";
9. Start A and B;
10. At next "cue", U carrier "off";
11. At next "cue", U level to -55 dBm, U carrier "on";
12. At next "cue", stop A and B, received A to 0348;
13. Set U to 97.500 MHz, U level to +2 dBm, U carrier "off";
14. Start both A and B;
15. At next "cue", U carrier "on";
16. At next "cue", U level to -17 dBm; and
17. At next "cue", stop A and B.

Tape Contents

Description	Approx. Tape Count Min. Sec.
Tone	00 02
Tone 100 Hz, 0 VU	00 09
Tone 1 KHz, -2 VU	00 29
Tone 2 KHz, -5 VU	00 49
Tone 1 KHz	00 13
Voice announcement	01 48
Tone 100 Hz	02 18
Tone 1 KHz	02 38
Tone 10 KHz	02 58
Silence	03 18
"Cue" tone	03 46
Start of Desired Program (D.P.)	
Voice	03 50
Guitar	04 20
Vocal	04 53
Silence	05 47
"Cue" tone	05 47
End of Desired Program	
D.P. repeat	05 50 - 07 48
D.P. repeat	07 51 - 09 49
D.P. repeat	09 53 - 11 52
D.P. repeat	11 55 - 13 50
D.P. repeat	13 55 - 15 50
D.P. repeat	15 55 - 17 50
D.P. repeat	17 55 - 19 50
D.P. repeat	19 55 - 21 50

NRSC Document Improvement Proposal

If in the review or use of this document a potential change appears needed for safety, health or technical reasons, please fill in the appropriate information below and email, mail or fax to:

National Radio Systems Committee
c/o Consumer Electronics Association
Technology & Standards Department
1919 S. Eads St.
Arlington, VA 22202
FAX: 703-907-4190
Email: standards@ce.org

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PROBLEM AREA (ATTACH ADDITIONAL SHEETS IF NECESSARY): a. Clause Number and/or Drawing: b. Recommended Changes: c. Reason/Rationale for Recommendation:	
ADDITIONAL REMARKS:	
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