THE GILLCABLE STEREO TELEVISION TESTS

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ABSTRACT

As an aid to its internal evaluation of possible technologies for delivering stereo television, Gillcable ran technical comparison tests of broadcast television (BTSC), FM and Studioline formats under actual system operating conditions. This paper details the results of those tests.

BACKGROUND

The advent of broadcast stereo television has presented the cable industry with technical and marketing challenges of very serious proportion[1, 2, 3]. A full discussion of the issues is beyond the purpose of this paper, however the principal concerns are:

- incompatibility with existing scrambling systems

- incompatibility with baseband converters

- possible degradation of stereo separation in a cable system as a function of signal processing equipment

- degradation of signal to noise in a cable system due to cascaded transmission system noise and reduced aural carrier levels

- miscellaneous other issues including compatibility with microwave transmission equipment, adjacent channel interference, etc.

In response, manufacturers of cable equipment have proposed solutions including both equipment modifications to better handle the broadcast (or BTSC) format and equipment to allow operators to handle stereo sound via various out-of-channel schemes.

The FCC, faced with evidence of very high retrofit costs decided not to rule at this time on the issue of whether cable operators would have to carry broadcast stereo in the transmitted format. Their stated intent is to monitor the development of stereo in the marketplace with an eye to later rulings if necessary[4]. The recent ruling of the DC Court of Appeals overturning the must-carry rules in their entirety may make the FCC issue moot, however there is still to be heard the issue of whether stereo content of a broadcast signal may be modified in format without violating the integrity of the copyrighted product.

THE SCTE STEREO SEMINAR

In January of this year, many of the industry's best authorities in the field gathered at a national SCTE-sponsored seminar to discuss both BTSC and alternate stereo technologies. Although attendees were exposed to many alternative strategies, there was also a distinct lack of field experience, largely unsupported conjecture on subscriber reactions and a lack of real apples-to-apples format comparisons. Based on the limited data available, there were also strongly differing opinions on the probable technical performance of various formats. Gillcable personnel, at least, felt that we did not have sufficient information to make an informed decision on a strategy for our company.

THE GILL FIELD TESTS-PURPOSE

As a first step towards making that decision, Gill determined to run a carefully controlled comparison test including BTSC, FM multiplex and at least one of the advanced formats available. The test was to include both technical performance and subjective listening data. Included within the second would be questions of cost and operating and equipment complexity associated with various schemes as those are very important to the ultimate need to sell the technology to our customers. This report will be limited to the results of the technical tests.

EQUIPMENT

The test configuration was designed for as much flexibility as possible and to provide a variety of equipment so that a particular format might not be judged on the basis of a single sample. To that end, the following were provided:

Signal Sources-Video:
VH-1 video
Video test patterns from a Tektronix model 149A generator
Video from a Zenith model VR-4000 VHS video tape recorder

Signal Sources-Audio:
VH-1 digital audio from a Wegener model 1739-03 demodulator
HI-FI audio from the Zenith VCR
Compact digital disk audio (Realistic model CD-1000)
Pink noise from a Heathkit model AD-1309 generator
Precision audio tones from a Sound Technology model 1410A oscillator

Audio Distribution Amplifier:
ROH model 202B

Transmitters:
Scientific Atlanta model 6350 modulator
Scientific Atlanta model 6380 BTSC encoder
Wegener model 1691A FM modulator
Leaming model FMT615C FM modulator
Leaming model FMT652 Studioline modulator

Receivers:
Zenith BTSC adaptor for Z-TAC premium decoder (prototype)
Zenith model CV524 BTSC adaptor for VCR
Sony model MLV1100 BTSC television adaptor
Realistic model STA110 FM receiver
W&S model SM2001 tracking FM stereo tuner
Studioline receiver

Measurement Equipment:
Sound Technology model 1710A audio distortion analyzer
TFT model 850 BTSC analyzer
Heathkit model AD1308 audio spectrum analyzer

The original intent to have multiple BTSC encoders available had to be scrapped as the Wegener unit was withdrawn from the test.

All sources were connected to a common audio distribution amplifier, then fed to the individual modulators. This allowed maximum flexibility in interchanging audio sources. At the receiving end, RF splitters and attenuators were used to feed RF to all equipment. All decoders were connected to an external switching box, then to the auxiliary input of the Realistic FM receiver. For subjective listening purposes, it was felt that this eliminated factors related to the amplification and speaker equipment. Technical data was generally taken at the output of the passive switching box to eliminate any possible noise contributions from the preamplification stages of the receiver.

TEST CONDITIONS

In the Gill system, the earth station receiving site and laboratories are located approximately five miles from the headend. A transportation trunkline of ten amplifiers length connects them. For this test, the subcarriers of VH-1 were carried on a separate, dedicated Catel model VFMS2000 video FM link. This allowed the deviation to be increased for maximum signal to noise without interaction with the video signal. VH-1 was chosen initially because of its superior format for satellite link transmission of audio.

The test point in the laboratories is located 12 amplifiers deep in the transmission system. The measured carrier-to-noise ratio on the special video channel set up for the tests was 47 dB. This allowed tests to be made at various C/N ratios up to that level.

The aural carrier with BTSC encoding was at the normal 15 dB below the luminance carrier. FM multiplex transmission was carried 10 dB below video as is the standard at Gill. The Studioline transmission was carried 15 dB below video, even though the manufacturer claims satisfactory performance should be attainable with carriage 25 dB down. We felt that there was no point in needlessly degrading performance unless system loading factors required it.

Back-to-back tests were made with certain combinations of equipment to determine measurement capabilities. The results will be mentioned with the discussions of individual tests, where relevant.

TEST RESULTS

Signal to Noise

Since expected signal to noise performance was the area that engendered the greatest disagreement among the SCTE seminar participants, a great deal of attention was paid to these measurements[5, 6]. Data was taken for all combinations of equipment under conditions of varying carrier-to-noise ratios.

In the case of BTSC, data was taken with various video conditions to measure the effect of buzz components on overall audio noise. This was done because the EIA's earlier reported test results had shown significant noise increase in the presence of video, multipath and video transmitter incidental carrier phase modulation (ICPM)[7].

The measurement method used was to insert a 1 kHz tone into a given channel at a level sufficient to produce full modulation. After measurement of the recovered audio level, the tone was removed and the level of the remaining broadband noise was measured. We recognize that in systems using active noise reduction circuitry (both BTSC and Studioline) this method does not measure instantaneous signal to noise but rather dynamic range, however we lacked equipment to do the more complex notched carrier noise measurements required for true signal to noise measurements under those conditions. It should also be noted that our measurement method sums together both gaussian noise and discreet noise components (such as buzz components related to video) and should therefore be characterized as "signal-to-crud" ratio. This was felt to be acceptable since any audible spurious noise degrades the quality perception to a listener.

In all cases, measurements were made separately on left and right channels, averaged, and the results rounded to the nearest whole decibel.

TABLE 1-AUDIO SIGNAL TO NOISE RATIOS

	Video Carrier/Noise Ratio *		
	47dB	41dB	35dB
Studioline	82dB	82dB	80dB
FM-W&S Receiver	59dB		
FM-Realistic Receiver	57dB	49dB	43dB
BTSC-Zenith Z-TAC Stereo Adapter			
Blank Black Screen	52dB		
Active Video	55dB		
"Buzz Pattern"	52dB		
BTSC-Zenith VCR Stereo Adapter			
Blank Black Screen	61dB		
Active Video	63dB	60dB	58dB
"Buzz Pattern"	58dB		
BTSC-Sony TV Stereo Adapter			
Blank Black Screen	57dB		
Active Video	57dB	53dB	46dB
"Buzz Pattern"	53dB		

*Other test carriers were varied accordingly

The measurement test limit, determined by connecting the audio source through the distribution amplifier to the audio analyzer was 94 dB.

Several observations can be made about the test results. First, of course, is that the Studioline format performed very well in all cases. The lack of degradation as the carrier-to-noise ratio was decreased would seem to be an indication that internal Studioline equipment noise sources, rather than distribution system noise, is the limiting factor. This is borne out by the lack of significant change between back-to-back equipment connection (measured at 84 dB) and that through the 12 amplifier cascade.

Second, the BTSC, quality in general, also degraded more slowly than carrier-to-noise ratio. This would, again, seem to indicate that significant contributions to overall noise are internal to the equipment. The TFT Model 850 BTSC Monitor measured a transmitted S/N ratio of 65 dB for the Scientific Atlanta BTSC encoder.

Third, the FM multiplex signal degraded dB for dB with the decrease in system noise margin. This was the expected result, but caused FM to perform comparatively worse than BTSC in a noisy system. Results were not significantly different between the two FM receivers, nor between the two available modulators.

Subjectively, the differences in noise level between the BTSC and FM (at 47 dB C/N) were difficult to detect during active music programming of the type transmitted by VH-1. During quiet passages, however, both had detectable noise. In evaluating relative noise levels of these two formats, it should be kept in mind that during the test sequences the video modulation level was carefully controlled. Should video modulation exceed normal levels, significant sync buzz occurs in the BTSC signal (just as it now occurs in monaural sound) while the other formats are free from video side-effects.

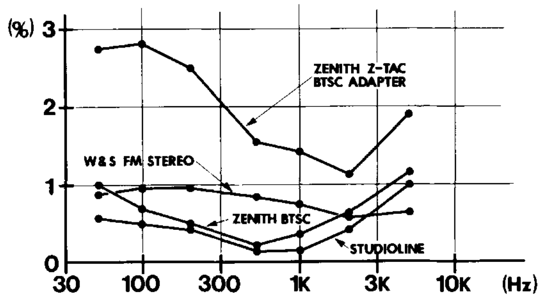
Looking to the future, notice should be taken of the proposed improved system for FM broadcasting proposed by the CBS Technology Center at the recent Chicago ICCE show. This technology holds the promise for an improvement in FM signal-to-noise ratio of 15 dB or more and would clearly give this format an advantage over BTSC[8].

Harmonic Distortion

The second area in which measurements were taken was harmonic distortion of the audio signal in passing through the entire system. Measurements were taken with the audio analyzer and, in the case of BTSC also with the TFT analyzer. In the former case the instrumentation limit was below 0.25% (generally below 0.15%) from 50-20,000 Hz. Video content during these measurements was active VH-1 video. As with noise measurements, data was taken for left and right channels and averaged.

Figure 1 shows the data taken with the audio analyzer for some of the equipment. As can readily be seen, selected samples of all formats achieved a distortion generally below 1%. For unknown reasons, the Zenith stereo adapter for the Z-TAC descrambler exhibited somewhat higher distortion.

Figure 1:



HARMONIC DISTORTION

Other combinations of FM modulators and tuners exhibited similar results with maximum distortion numbers under 1.5% in all cases. The Sony BTSC demodulator, though not plotted, had distortion numbers in the 1-2% range. Transmitted BTSC harmonic distortion was below 1% at all frequencies and below 0.5% from 200-2000 Hz. In general, no clear pattern of preference for a particular format is obvious from our data. It appears that differences in individual equipments was more important than transmission type.

At the suggestion of one of the participants, BTSC total harmonic distortion was measured at 1 kHz as a function of video content with the following results:

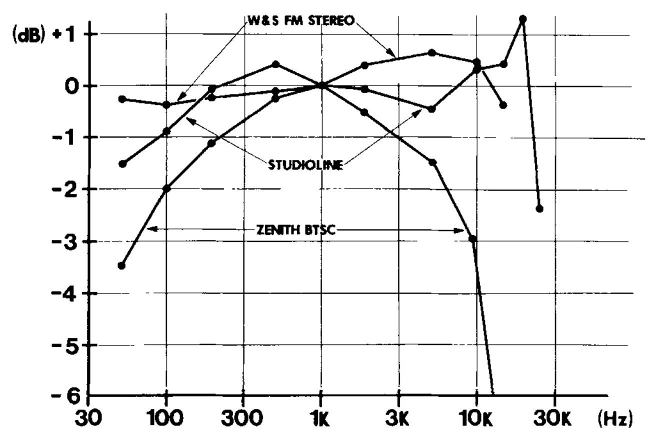
	BTSC STEREO ADAPTER		
VIDEO MODULATION:	SONY TV	ZENITH VCR	ZENITH Z-TAC
BLACK SCREEN	1.6%	0.6%	1.5%
50 IRE GRAY SCREEN	1.6%	1.0%	1.5%
WHITE SCREEN	2.8%	2.5%	2.5%
COLOR BARS	2.0%	0.8%	2.0%

It appears that all of the tested decoders exhibited a degradation as a function of video content and level. Insertion of a 400 Hz high-pass filter in the measurement loop substantially decreased the readings in all cases, indicating that low frequency components were a major contributor.

Frequency Response

Overall system gain as a function of frequency was measured for all systems using the distortion analyzer and precision oscillator. In the case of BTSC, the transmitted response was also plotted using the TFT analyzer. The test instrumentation was flat within 0.5 dB to 10 kHz, rolling off to 1.15 dB at 25 kHz. Figure 2 is a plot of several of the systems.

Figure 2:



FREQUENCY RESPONSE

In the case of BTSC, the upper and lower 3 dB points are very similar for the Sony equipment. The Zenith VCR adapter is similar, except for less low-end rolloff. Interestingly enough, the transmitted BTSC signal was quite flat with no low-end rolloff and only 0.8 dB at 10 kHz. At 15 kHz, the transmitted signal was down 5.8 dB. It would seem, therefore, that the principal contributor to the relatively poor frequency response of the BTSC equipment was decoders rather than the encoder.

If this kind of suppressed low-frequency response is typical of BTSC decoders (perhaps in an attempt to diminish sync buzz), it perhaps offers an explanation of the "subjective loss of bass response" that was reported by the NCTA's observers in the Chicago tests last year.

The Realistic receiver was similar to the W&S receiver except for a 1.6 dB rolloff at 50 Hz and rapid rolloff after 10 kHz to 6 dB at 15 kHz.

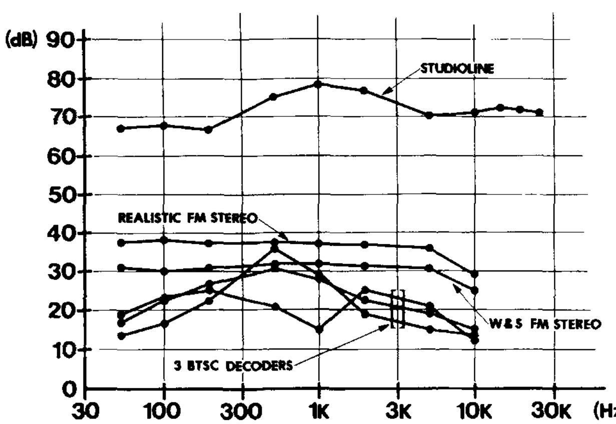
In general, the FM proponents were superior to the BTSC and very similar to the Studioline except for that system's superior high end response.

Stereo Separation

Stereo separation is what differentiates stereo from monophonic transmission, although there is disagreement about how much separation is required or useful. The primary tool used for making separation measurements was the Sound Technology Analyzer. Point-to-point measurements were made for a range of frequencies on each channel with the deviation set to 100% in each case. The channels were averaged and rounded to the nearest dB for the data presented below. In the case of BTSC, data was also taken with the TFT analyzer so that the transmitted separation could be measured independent of any decoder degradation.

Figure 3 below is a graph of the significant results. The very high measured separation of the Studioline system was expected since that format uses independent RF carriers for the left and right channels. The graphed FM separation was taken using the Wegener FM modulator. Separation measured using the Realistic receiver and the Leaming modulator was degraded by approximately 13 dB compared with that measured using the Wegener modulator.

Figure 3:



STEREO SEPARATION

The most widely varying results were obtained using the various BTSC equipment. While the decoders agreed within reasonable limits at low and high audio frequencies, differences of the order of 15 dB were found in the critical mid-ranges, and the results were generally poor compared with either of the other formats tested. Such variations presumedly result from phase and amplitude errors in the decoders either adding to or partially cancelling similar errors in the encoder. When the transmitter was measured with the TFT BTSC Analyzer, the separation was found to be a uniform 21-24 dB from 50-1000 Hz, falling smoothly to 15 dB at 10 kHz and a little over 9 dB at 15 kHz.

In defense of manufacturers of both BTSC encoders and decoders, there has been very little standard measuring equipment on the market to use in factory alignment of their products until the last few months. Hopefully the advent of the TFT and similar products will result in more consistent results in the future.

Nevertheless, the relatively poor showing of the BTSC contenders points out the weakest element in the BTSC system: the companding which is applied only to the L-R signal components in the encoding process. Any relative gain or phase errors between L+R and L-R portions of the aural signal between the encoder and decoder quickly degrade separation. Such errors can result from audio, IF, or RF filtering or any horizontal line rate signals adding to the pilot, for instance.

Finally, it should be pointed out that there is certainly an upper limit of usefulness in stereo separation, just as there is an upper limit of usefulness in S/N performance. Certainly there is a psychoacoustic limit beyond which the human mind cannot detect further improvement, but more importantly, most television viewers will be listening to television through loudspeakers rather than headphones. In that environment, speaker quality, physical separation, room acoustics and listener location all act to limit achievable separation. A discussion of a reasonable electronic separation is beyond the scope of this paper, but readers are urged to review the materials published by such groups as the Audio Engineering Society for further information.

Baseband Converters

Certainly, existing baseband converters are not compatible with BTSC stereo signals if they use audio demodulation and remodulation in order to achieve volume control and mute functions. Without giving up those functions or adding prohibitively to the cost by incorporation BTSC decoders and encoders, the usual approach to stereo is to add an external BTSC decoder whose baseband audio outputs feed external sound amplification equipment[9].

Given that some systems or some customers may elect not to add the additional adapter, it is important to know what happens if a BTSC encoded signal is fed through a normal baseband converter and to a stereo television. Since the audio bandpass of the baseband converter may or may not pass the stereo pilot, but will surely not pass all of the L-R sideband, it would be expected that the result would not be identified as quality stereo.

We found that the Z-TAC decoder used for our tests passed a sufficient quantity of the pilot to light the stereo light on the Sony decoder. The resultant sound, compared to monaural sound was nearly identical in our case, except for a slightly audible degradation in S/N. It would be dangerous, however, to draw conclusions about how other decoders or converters would act under similar circumstances.

High-Level Sweep Interference

Given that many cable systems still use high-level interfering system sweep testing, the effect of such signals on the various contenders seemed relevant. Based on subjective judgments, the amount of "pop" audible in BTSC and FM systems was comparible and somewhat objectionable just as it is now in standard monaural television sound and simulcast FM. The Studioline system also reacted to the sweep, but its amplitude seemed to be lower and the duration somewhat longer. No conclusion was reached as to which result represented the highest degree of subscriber irritation. Certainly, in evaluating other high-quality sound systems, such as digital, such interference and its effects should be evaluated. Perhaps the error correction schemes in digital systems will completely eliminate the audible effects.

FINALLY

Carefully constructed subscriber listening tests will be conducted using this equipment under the auspicies of ATC's market research department to determine the reactions of non-expert observers to the various formats under various conditions. Those will be reported separately by ATC at some future time. Nevertheless, our panel of technical observers made a few subjective observations under conditions of live programming which may be of interest.

First, under high-average-modulation-level conditions with typical VH-1 music programming, differences in S/N ratio were not obvious. When pauses in program audio occurred, though, the noise level in both FM and BTSC were noticeable and significantly higher than Studioline. Our observers did not note significant differences between FM and BTSC in this regard. Thus, while the relatively noisier formats may be adequate for popular music formats, only further tests will detect whether movie programming, for instance, will find listeners equally unaware of the differences.

Second, most observers were aware of a quality degradation when switching between either of the other formats and BTSC. It was variously described as a lack of "sharpness", "depth" and/or "crispness." Whether it was due to the lower separation or the inferior frequency response or some other factor could not be determined.

Third, none of the differences between formats was dramatic to a casual listener using loudspeakers. In all cases there was a significant loss of spacial feeling when switching to monaural, even using the same amplifier and speakers. Also, as expected, there was a significant improvement using the external audio system compared to the internal television speaker in the monaural mode.

As expected, the Studioline system far outperformed all other contenders in technical performance and seems to be a very durable system from the standpoint of distribution system degradation. FM simulcasting appears to have an advantage over BTSC, at least at this time, in stereo separation and the resistance of that separation to degradation. BTSC would seem to have a S/N advantage over FM under degraded signal conditions, however widespread adoption of the new CBS technique for improved FM transmission would give FM a significant edge in the future.

The Gill stereo tests are certainly not a comprehensive test of even the three formats represented. Only one BTSC encoder was used, for instance, and a limited sampling of equipment for other formats. Also, the tests considered only the relative technical merits of these formats. The upcoming ATC listening tests will complement the technical data by adding subscriber subjective reactions. Finally, the ATC engineering department intends to run tests concentrating on the BTSC format and will add useful information on such areas as specific degradations of BTSC due to various cable equipment. Engineers called upon to make choices of stereo format for their systems should review all the available literature carefully.

ACKNOWLEDGEMENTS

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thanks should go to Wegener, Leaming, Studioline, Scientific Atlanta, Zenith, TFT, W&S Systems and Bay Area Interconnect for the loan of equipment and particularly to the engineering personnel of those participants who spent the time to get the equipment to us and make sure it was running correctly. Walt Reames and his crew and Bill Kostka of the Gill Engineering department contributed many hours to construction, coordination and taking of data. Finally, a special note of thanks is owed to Walt Colquitt of ATC and to Frank McClatchie for lending their time and expertise to the project.

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APPENDIX I - INDIVIDUAL TEST DATA

TEST INSTRUMENTATION - MEASURED AT AUDIO D/A OUTPUTS

FREQUENCY	LEFT LEVEL	RIGHT LEVEL	LEFT % DISTORTION	RIGHT % DISTORTION
10 Hz	-1.40 dB	-1.40 dB		
20 Hz	-0.10 dB	-0.10 dB	0.35 %	0.37 %
50 Hz	0.00 dB	0.00 dB	0.07 %	0.04 %
100 Hz	0.00 dB	0.05 dB		
200 Hz	0.00 dB	0.05 dB		
500 Hz	0.00 dB	0.00 dB	0.055%	0.03 %
1 kHz	0.00 dB	0.00 dB	0.055%	0.03 %
2 kHz	0.00 dB	0.00 dB		
5 kHz	-0.05 dB	-0.05 dB	0.12 %	0.08 %
10 kHz	-0.20 dB	-0.20 dB	0.14 %	0.13 %
15 kHz	-0.45 dB	-0.50 dB	0.22 %	0.14 %
20 kHz	-0.80 dB	-0.80 dB	0.21 %	0.14 %
25 kHz	-1.20 dB	-1.10 dB		

Signal to noise with 400 Hz HPF and 30 kHz LPF: Left Channel: 93.5 dB
Right Channel: 95.0 dB

BTSC MEASUREMENTS

TRANSMITTED BTSC SIGNAL

EQUIPMENT: Scientific Atlanta Model 6380 BTSC Encoder
TFT Model 850 BTSC Analyzer
Sound Technology Model 1410A Oscillator

	RELATIVE LEVEL		DISTORTION @ 100% MODULATION		S/N RATIO		SEPARATION	
FREQUENCY	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT
50 Hz	0.0 dB	0.0 dB	0.88 %	0.59 %			23.7 dB	23.2 dB
100 Hz	0.1 dB	0.0 dB	0.67 %	0.58 %			23.3 dB	24.1 dB
200 Hz	0.1 dB	0.0 dB	0.54 %	0.50 %			23.2 dB	24.0 dB
500 Hz	-1.1 dB	-1.2 dB	0.30 %	0.27 %			23.2 dB	23.5 dB
1 kHz	0.0 dB	0.0 dB	0.34 %	0.33 %	65.3	65.2	21.1 dB	20.8 dB
2 kHz	-0.1 dB	-0.7 dB	0.51 %	0.52 %			15.9 dB	15.9 dB
5 kHz	-0.3 dB	-1.5 dB	0.93 %	0.90 %			13.9 dB	14.3 dB
10 kHz	-0.3 dB	-1.3 dB					14.6 dB	15.1 dB
15 kHz	-4.8 dB	-6.8 dB					9.3 dB	9.4 dB

ZENITH Z-TAC STEREO ADAPTER

EQUIPMENT: Scientific Atlanta Model 6380 BTSC Encoder
Sound Technology Model 1410A Oscillator
Sound Technology Model 1710A Distortion Analyzer

	RELATIVE LEVEL		DISTORTION @ 100% MODULATION		S/N RATIO		SEPARATION	
FREQUENCY	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT
50 Hz	-1.7 dB	-1.4 dB	2.75 %	2.75 %			19.4 dB	19.3 dB
100 Hz	-1.0 dB	-0.7 dB	2.85 %	2.70 %			23.0 dB	23.0 dB
200 Hz	-0.7 dB	-0.5 dB	2.50 %	2.50 %			24.5 dB	23.0 dB
500 Hz	-0.4 dB	-0.3 dB	1.55 %	1.55 %			20.2 dB	20.0 dB
1 kHz	0.0 dB	0.0 dB	1.10 %	1.25 %	57.0	54.0	15.0 dB	17.5 dB
2 kHz	-0.15dB	+0.2 dB	1.20 %	1.05 %			26.5 dB	24.7 dB
5 kHz	-0.6 dB	-0.3 dB	2.0 %	1.80 %			21.5 dB	20.6 dB
10 kHz	-3.0 dB	-2.7 dB					12.0 dB	12.0 dB
15 kHz	-32.0 dB	-31.6 dB						

NOTE: **

ZENITH VCR STEREO ADAPTER

EQUIPMENT: Scientific Atlanta Model 6380 BTSC Encoder
Sound Technology Model 1410A Oscillator
Sound Technology Model 1710A Distortion Analyzer
Zenith VCR Stereo Adapter with VR-4000 VCR

	RELATIVE LEVEL		DISTORTION @ 100% MODULATION		S/N RATIO		SEPARATION	
FREQUENCY	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT
50 Hz	-3.4 dB	-3.2 dB	1.3 %	0.90 %			17.4 dB	17.6 dB
100 Hz	-2.0 dB	-1.8 dB	0.7 %	0.7 %			22.6 dB	22.0 dB
200 Hz	-1.1 dB	-1.0 dB	0.6 %	0.5 %			27.5 dB	25.8 dB
500 Hz	-0.2 dB	-0.2 dB	0.2 %	0.17 %			31.0 dB	30.0 dB
1 kHz	0.0 dB	0.0 dB	0.35%	0.30 %	64.6	64.0	26.5 dB	29.0 dB
2 kHz	-1.15dB	-0.3 dB	0.7 %	0.65 %			21.5 dB	23.5 dB
5 kHz	-1.5 dB	-1.4 dB	1.2 %	1.20 %			18.2 dB	19.9 dB
10 kHz	-3.25dB	-3.3 dB					14.5 dB	15.8 dB
15 kHz	-36.0 dB	-36.0 dB						

NOTE: **

SONY STEREO TELEVISION ADAPTER

EQUIPMENT: Scientific Atlanta Model 6380 BTSC Encoder
Sound Technology Model 1410A Oscillator
Sound Technology Model 1710A Distortion Analyzer
Sony Stereo Television Adapter with Sony KV1976R Television

	RELATIVE LEVEL		DISTORTION @ 100% MODULATION		S/N RATIO		SEPARATION	
FREQUENCY	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT
50 Hz	-3.2 dB	-3.4 dB	1.3 %	2.0 %			12.5 dB	12.8 dB
100 Hz	-1.2 dB	-1.25dB	1.7 %	1.95%			16.8 dB	17.0 dB
200 Hz	-0.55dB	-0.6 dB	1.8 %	1.9 %			21.2 dB	22.3 dB
500 Hz	-0.2 dB	-0.25dB	1.75%	1.6 %			35.0 dB	37.0 dB
1 kHz	0.0 dB	0.0 dB	1.45%	1.5 %	57.7	58.5	30.5 dB	27.3 dB
2 kHz	-0.55dB	-0.6 dB	1.1 %	1.1 %			19.5 dB	20.1 dB
5 kHz	-2.0 dB	-2.2 dB	1.5%	1.5 %			15.0 dB	15.4 dB
10 kHz	-3.0 dB	-3.4 dB					12.6 dB	13.7 dB
15 kHz	-30.0 dB	-34.7 dB						

NOTE: **

BTSC S/N AS A FUNCTION OF VIDEO CONTENT

EQUIPMENT: Same as above, except that, instead of active video, specified patterns from the Tektronix waveform generator were used.

SONY STEREO TELEVISION ADAPTER

PATTERN	SIGNAL/NOISE NO FILTER	SIGNAL/NOISE 400 Hz LPF	TOTAL HARMONIC DISTORTION NO FILTER	TOTAL HARMONIC DISTORTION 400 Hz LPF
0 IRE Flat Field	57.0 dB	59.0 dB	1.60 %	1.45 %
50 IRE Flat Field	55.5 dB	58.0 dB	1.60 %	1.45 %
100 IRE Flat Field	54.0 dB	55.6 dB	2.80 %	1.60 %
Color Band	53.0 dB	55.0 dB	2.00 %	1.60 %

ZENITH Z-TAC STEREO ADAPTER

PATTERN	SIGNAL/NOISE NO FILTER	SIGNAL/NOISE 400 Hz LPF	TOTAL HARMONIC DISTORTION NO FILTER	TOTAL HARMONIC DISTORTION 400 Hz LPF
0 IRE Flat Field	52.0 dB	57.7 dB	1.55 %	1.20 %
50 IRE Flat Field	52.5 dB	57.5 dB	1.55 %	1.20 %
100 IRE Flat Field	52.0 dB	57.0 dB	2.40 %	1.25 %
Color Band	51.7 dB	56.0 dB	2.00 %	1.35 %

ZENITH VCR STEREO ADAPTER

PATTERN	SIGNAL/NOISE NO FILTER	SIGNAL/NOISE 400 Hz LPF	TOTAL HARMONIC DISTORTION NO FILTER	TOTAL HARMONIC DISTORTION 400 Hz LPF
0 IRE Flat Field	60.6 dB	64.7 dB	0.60 %	0.26 %
50 IRE Flat Field	60.2 dB	64.3 dB	1.00 %	0.34 %
100 IRE Flat Field	58.2 dB	62.5 dB	2.50 %	0.60 %
Color Band	58.0 dB	59.0 dB	0.85 %	0.55 %

FM MEASUREMENTS

REALISTIC RECEIVER/WEGENER TRANSMITTER

EQUIPMENT: Wegener Model 1691 SW FM Modulator
Sound Technology Model 1410A Oscillator
Sound Technology Model 1710A Distortion Analyzer
Realistic Model STA 110 FM Receiver

FREQUENCY	RELATIVE LEVEL LEFT	RELATIVE LEVEL RIGHT	DISTORTION @ 100% MODULATION LEFT	DISTORTION @ 100% MODULATION RIGHT	S/N RATIO LEFT	S/N RATIO RIGHT	SEPARATION LEFT	SEPARATION RIGHT
50 Hz	-1.2 dB	-1.4 dB	0.36 %	1.15 %			37.8 dB	36.8 dB
100 Hz	-0.6 dB	-0.60dB	0.67 %	0.87 %			37.0 dB	38.6 dB
200 Hz	-0.40dB	-0.4 dB	1.8 %	1.05 %			35.6 dB	38.4 dB
500 Hz	-1.2 dB	-1.2 dB	1.6 %	0.94 %			33.8 dB	40.2 dB
1 kHz	0.0 dB	0.0 dB	1.1 %	1.15 %	57.0	57.0	35.8 dB	36.8 dB
2 kHz	+0.35dB	+0.3 dB	0.85 %	0.90 %			37.4 dB	38.4 dB
5 kHz	+0.4 dB	+0.4 dB	0.90 %	0.91 %			34.4 dB	36.8 dB
10 kHz	-0.7 dB	-0.7 dB					28.2 dB	29.2 dB
15 kHz	-6.2 dB	-6.6 dB						

NOTE: **

REALISTIC RECEIVER/LEAMING FM TRANSMITTER

EQUIPMENT: Leaming Model FMT 615C FM Modulator
Sound Technology Model 1410A Oscillator
Sound Technology Model 1710A Distortion Analyzer
Realistic Model STA 110 FM Receiver

	RELATIVE LEVEL		DISTORTION @ 100% MODULATION		S/N RATIO		SEPARATION	
FREQUENCY	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT
50 Hz	-1.5 dB	-1.75dB	0.95 %	0.44 %			18.8 dB	17.6 dB
100 Hz	-0.75dB	-0.85dB	0.90 %	0.97 %			22.2 dB	21.6 dB
200 Hz	-0.3 dB	-0.6 dB	1.20 %	1.70 %			23.6 dB	24.0 dB
500 Hz	0.0 dB	-0.3 dB	1.3 %	1.5 %			23.95dB	24.0 dB
1 kHz	0.0 dB	0.0 dB	0.97 %	1.15 %	57.5	59.0	23.6 dB	24.8 dB
2 kHz	-0.35dB	+0.3 dB	0.82 %	0.87 %			23.6 dB	24.1 dB
5 kHz	0.0 dB	+0.75dB	0.85 %	0.88 %			23.5 dB	24.5 dB
10 kHz	-0.7 dB	0.0 dB					22.4 dB	24.2 dB
15 kHz	-6.2 dB	-5.3 dB						

NOTE: **

W&S SYSTEMS FM RECEIVER/WEGENER FM TRANSMITTER

EQUIPMENT: Wegener Model 1691 SW FM Modulator
Sound Technology Model 1410A Oscillator
Sound Technology Model 1710A Distortion Analyzer
W&S SM 2001 Tracking FM Stereo Receiver

	RELATIVE LEVEL		DISTORTION @ 100% MODULATION		S/N RATIO		SEPARATION	
FREQUENCY	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT
50 Hz	-0.3 dB	-0.2 dB	1.0 %	0.68 %			31.0 dB	31.7 dB
100 Hz	-0.2 dB	-0.5 dB	1.0 %	0.82 %			28.2 dB	31.2 dB
200 Hz	-0.15dB	-0.1 dB	1.05 %	0.86 %			30.3 dB	31.1 dB
500 Hz	-0.1 dB	-0.1 dB	0.83 %	0.77 %			30.9 dB	32.2 dB
1 kHz	0.0 dB	0.0 dB	0.78 %	0.63 %	59.7	59.0	30.7 dB	31.3 dB
2 kHz	+0.3 dB	+0.3 dB	0.65 %	0.58 %			30.3 dB	31.1 dB
5 kHz	+0.7 dB	+0.6 dB	0.68 %	0.63 %			30.5 dB	29.9 dB
10 kHz	+0.3 dB	-0.2 dB					28.5 dB	28.5 dB
15 kHz	-0.9 dB	-0.9 dB						

NOTE: **

STUDIOLINE SYSTEM MEASUREMENTS

TRANSMITTER/RECEIVER BACK-TO-BACK MEASUREMENTS

EQUIPMENT: Leaming Model FMT 652 Studioline Modulator
Sound Technology Model 1410A Oscillator
Sound Technology Model 1710A Distortion Analyzer
Studioline Tracking Stereo Receiver

	RELATIVE LEVEL		DISTORTION @ 100% MODULATION		S/N RATIO	
FREQUENCY	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT
50 Hz	-2.1 dB	-1.9 dB				
100 Hz	-1.5 dB	-1.0 dB				
500 Hz	-0.9 dB	+0.4 dB				
1 kHz	-0.3 dB	0.0 dB	0.15 %	0.27 %	83.0	85.0
2 kHz	0.0 dB	+0.4 dB				
4 kHz	-0.7 dB	+0.3 dB				
6 kHz	-0.6 dB	+0.2 dB	0.65 %	0.72 %		
8 kHz	-0.4 dB	+0.2 dB				
10 kHz	-0.1 dB	+0.1 dB				
15 kHz	+0.9 dB	0.0 dB				
20 kHz	+0.6 dB	-0.8 dB				
25 kHz	-3.4 dB	-4.2 dB				

NOTE: **

STUDIOLINE SYSTEM TESTS

EQUIPMENT: Leaming Model FMT 652 Studioline Modulator
Sound Technology Model 1410A Oscillator
Sound Technology Model 1710A Distortion Analyzer
Studioline Tracking Stereo Receiver

	RELATIVE LEVEL		DISTORTION @ 100% MODULATION		S/N RATIO		SEPARATION	
FREQUENCY	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT
50 Hz	-1.4 dB	-1.6 dB	0.6 %	0.58 %			63.0dB	70.0dB
100 Hz	-0.8 dB	-1.0 dB	0.53 %	0.52 %			66.0dB	70.0dB
200 Hz	-0.7 dB	-0.8 dB	0.48 %	0.36 %			65.0dB	68.0dB
500 Hz	+0.9 dB	-0.6 dB	0.25 %	0.25 %			81.0dB	67.0dB
1 kHz	0.0 dB	0.0 dB	0.18 %	0.19 %	83.5*	81.0*	78.0dB	79.0dB
2 kHz	0.0 dB	0.0 dB	0.45 %	0.41 %			78.0dB	75.0dB
5 kHz	-0.2 dB	-0.6 dB	1.0 %	1.05 %			70.0dB	69.0dB
10 kHz	+0.5 dB	-0.2 dB					73.0dB	70.0dB
15 kHz	-0.2 dB	+0.3 dB					73.0dB	70.5dB
20 kHz	-1.0 dB	+0.15dB					73.0dB	70.5dB
25 kHz	-3.9 dB	-3.0 dB					71.0dB	69.9dB

* Lowering the Studioline carriers by 10 dB to 25 dB below video changed the measured S/N to: 82 dB on the left channel and 81.9 dB on the right channel.

NOTE: **

SIGNAL/NOISE AS A FUNCTION OF RF CARRIER/NOISE - ALL FORMATS

NOTE: For this test, the level of the channel 33 video and aural carrier, the level of the FM simulcast signal and the level of the Studioline carriers were all varied the same amount while all other channels on the system were held constant. VH-1 active video was present during the tests.

	AUDIO SIGNAL/NOISE (dB)			
	BTSC		FM	
EQUIVALENT VIDEO CARRIER/NOISE	ZENITH CV-524	SONY MLV 1100	REALISTIC STA 110	STUDIOLINE
47 dB	62	56	56.5	81.5
41 dB	60	53	49	81.5
35 dB	58.5	46	43	79.5

** FOR RESPONSE MEASUREMENTS, LEVEL SET FOR 100% MODULATION AT 15 kHz, THEN LEFT CONSTANT. DISTORTION AND SEPARATION MEASURED WITH MODULATION SET AT 100% AT EACH FREQUENCY. S/N RATIO MEASURED WITH ACTIVE VH-1 VIDEO PRESENT, 30 kHz LPF ON AUDIO.