

The Technical Performance of Typical Home Color Television Receivers

By ILMAR MUNAK and MICHAEL GOURGON

Technical performance data for typical home television receivers is not generally available although knowledge of receiver characteristics is important to the broadcast engineer. The Canadian Broadcasting Corp. has undertaken to meet this need by measuring the performance of 11 color TV receivers of 11 different manufacturers. Measurements were made of the video, audio, RF, and acoustical performance. The study discovered very large spreads of performance within the sample of receivers for any given parameter. Broadcasters can draw on these test results to establish the performance profile of a "standard" TV receiver for use in setting their broadcast system standards. The level of performance of this "standard" receiver should be based on the performance of the better receivers. Major deteriorating parameters were: resolution limitations, ringing and edging effects, audio bandwidth limitations, audio channel periodic noise, scanning nonlinearity, and black level shift with average-picture-level changes.

Introduction

Knowledge of the technical performance of the home TV receiver, as part of the television broadcasting system, is important to the broadcast engineer. For example, the transmitter engineer needs to know the signal strength required to operate typical home receivers for optimum performance; the television systems engineer needs to know the severity of the impairments to picture and sound in home receivers so that he can apportion tolerance to the appropriate technical parameters for studios, networks, and transmitters.

Technical performance data for typical home TV receivers is not, however, readily available. The CBC has, therefore, undertaken a program of work to measure the performance of several home color TV receivers of popular make. Altogether eleven TV receivers representing eleven different manufacturers were purchased from normal consumer sales outlets. Prices ranged from \$400 to \$674 (Canadian). In this work measurements were made of the video, audio, RF, and acoustical performance. The results of these measurements are presented below.

Experimental Procedure

Performance of the receivers was measured in the factory adjusted state, as delivered. Only external user-adjustable controls were utilized, in testing, to optimize receiver performance.

In both the electrical and acoustical testing the signal source was a high quality modulator (channel 4, 66-72 MHz) to NTSC stan-

dards. This enabled the various test signals, outlined in the tables below, to be introduced to the receiver at its antenna terminals (Fig. 1). Included also in the tables below, is the test point for each parameter measured. Exceptions to this procedure are noted below. These parameters represent a partial listing of the total number that were measured for the study. In particular, a large bulk of data representing color decoding and color rendition has not been included in this report.

For the measurements in Fig. 1, the carrier level from the modulator was adjusted for noise free reproduction of the test waveform by each receiver. In addition, the receiver automatic frequency control was on during measurement of all video characteristic parameters.

The test setup for the measurement of kinescope display characteristic (Fig. 2) was identical to that for video characteristics. All measurements were based on screen observations.

In measuring audio channel electrical characteristics (Fig. 3), all parameters except periodic noise were measured according to International Electrotechnical Commission television receiver testing standards.* Audio channel periodic noise due to intermodulation and internal video-to-audio crosstalk from the color bar test waveform

was measured relative to 400 Hz at a 30% modulation level. The speaker, in all cases, was substituted by a resistor of the proper value, and measurements were taken at this point.

For RF and IF bandwidth testing (Fig. 4), the modulator was not used and the RF sweep generator was introduced directly to the VHF or UHF antenna terminals of the receiver, as required. A 30-dB video (post-detection) signal-to-noise ratio was judged as the minimum value for an acceptable picture. A 50-dB audio signal-to-noise ratio (relative to 400 Hz at a 30% modulation level) was the minimum ratio which could be met by all receivers. RF parameters of adjacent channel rejection and image rejection as well as the traditional UHF "taboos" were not investigated.

All acoustic measurements of the receiver's speaker output (Fig. 5) were taken at the recognized standard viewing distance of five times screen height. Volume controls were uniformly set among the receivers so as to produce a comfortable listening level for average program material, and acoustic level measurements insured uniformity of this setting. The video test waveform for all acoustic measurements was 75% color bars.

Conclusions

In general the study discovered very large spreads of performance, within the sample of receivers, for any given parameter. Broadcasters such as CBC, can draw upon these test results to establish the performance profile of a "standard" television receiver for use in setting their broadcast system standards. The level of performance of this "standard" receiver should be based on the performance of the better receivers.

As discussed in more detail below, major deteriorating parameters were: resolution limitations, ringing and edging effects, audio bandwidth limitations, audio channel periodic noise, scanning nonlinearity, and black level shift with APL changes.

Video Characteristics

The test results for video characteristics have been compared, where applicable, to

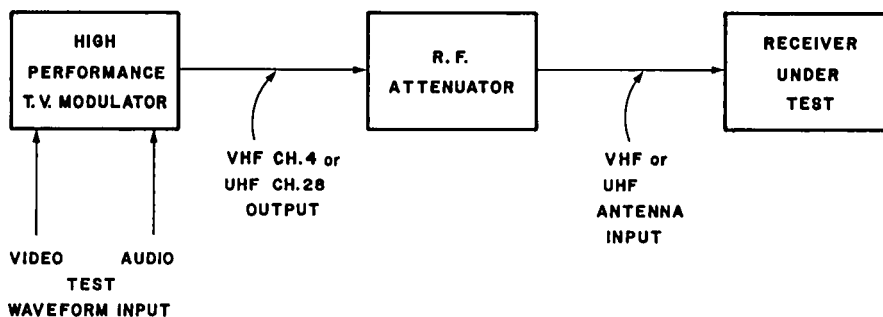


Fig. 1. Arrangement of equipment for television receiver measurements.

Presented on 14 November 1978 during the General Conference of the Commonwealth Broadcasting Association held in Mauritius, an Indian Ocean island nation within the British Commonwealth. The paper was read for the authors by Norman R. Grover of CBC Engineering. The authors, Ilmar Munak and Michael Gourgon, are with the Operations Development Department at the Engineering Headquarters of the Canadian Broadcasting Corp., 7925 Côte St. Luc Road, Montreal, Quebec, Canada, H4W 1R5. This paper was received on 7 March 1979. Copyright © 1979 by the Society of Motion Picture and Television Engineers, Inc.

Parameter Measured	Test Waveform Utilized	Test Point
Differential gain and phase	Modulated Stairstep	Detector buffer amplifier
2T pulse "K" factor	Pulse (2T and 12.5T) and bar	Luminance driver
Pulse-to-bar ratio	Pulse (2T and 12.5T) and bar	Luminance driver
Luminance waveform tilt	Pulse (2T and 12.5T) and bar	Luminance driver
Luminance-Chrominance timing error	Pulse (2T and 12.5T) and bar	Color difference stage inputs
Luminance channel bandwidth	Video sweep	Luminance driver
Chroma channel bandwidth	Video sweep	Color decoder input
APL effect on luminance channel	Variable APL stairstep	Luminance driver

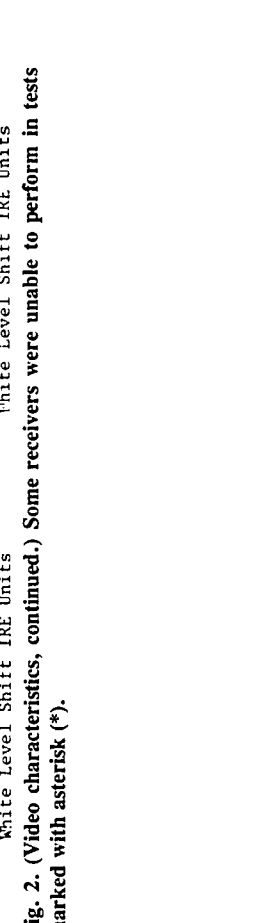
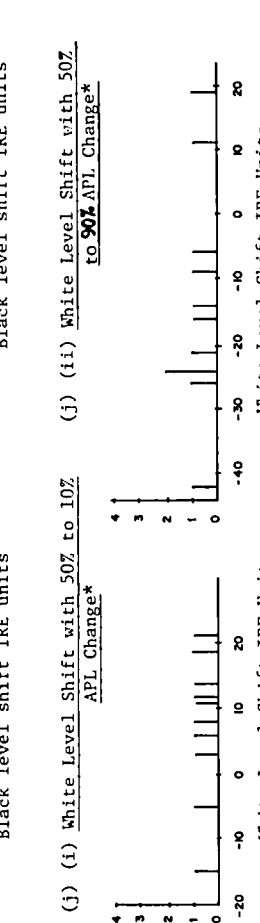
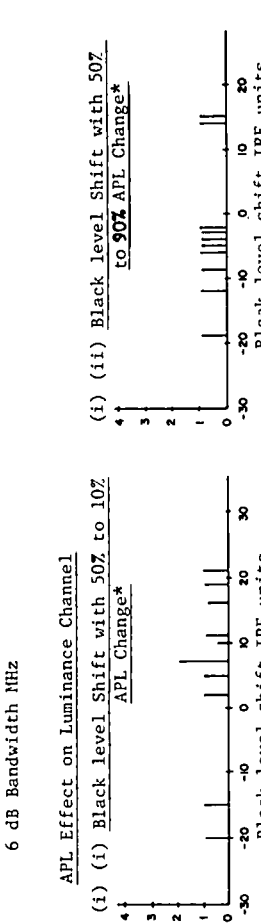
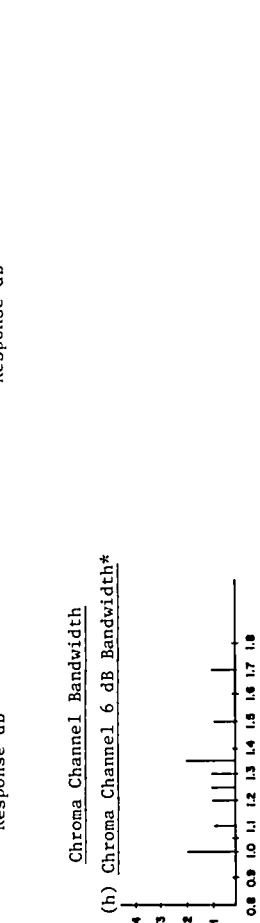
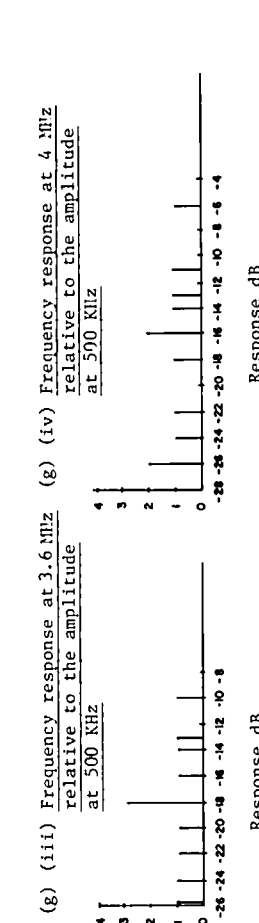
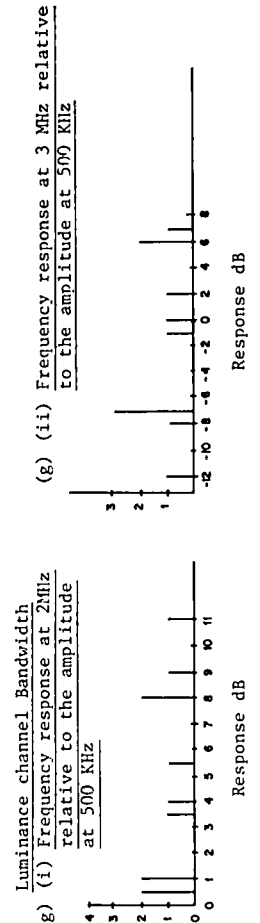
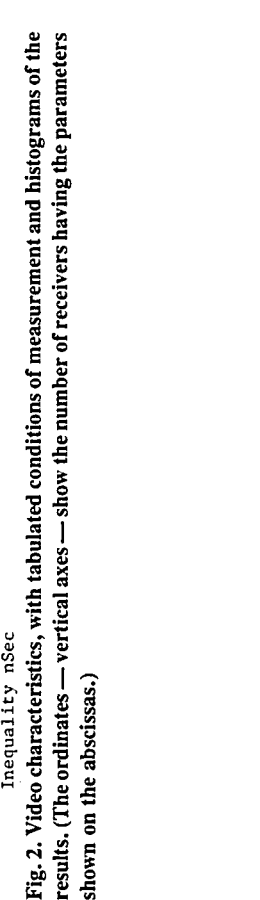
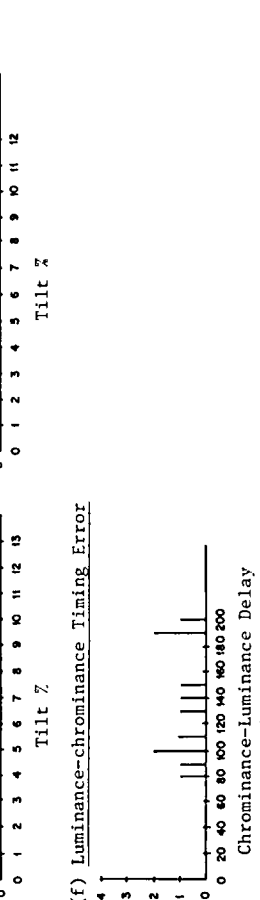
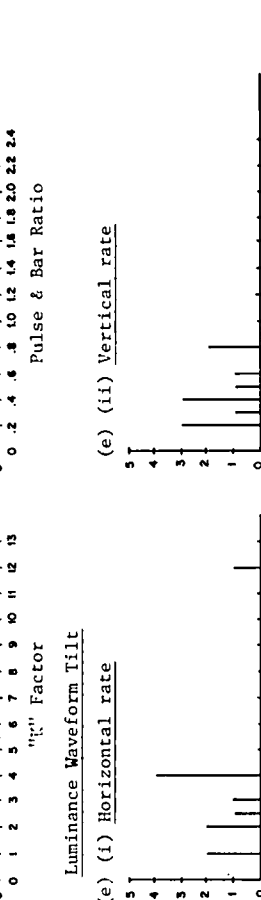
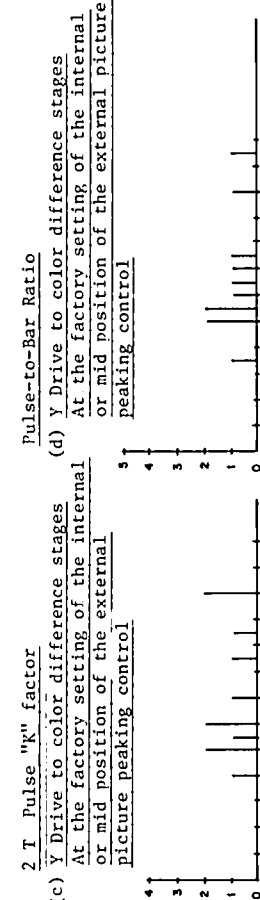
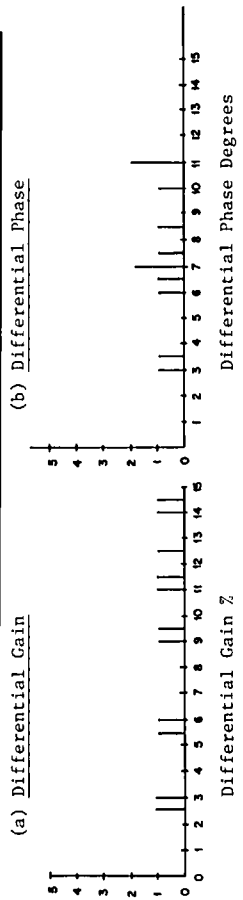


Fig. 2. Video characteristics, with tabulated conditions of measurement and histograms of the results. (The ordinates — vertical axes — show the number of receivers having the parameters shown on the abscissas.)

Parameter Measured	Test Waveform Utilized
Audio channel bandwidth	Sinusoidal audio tones
Distortion at low frequency cutoff	Sinusoidal audio tones
Power output for 3% distortion	Sinusoidal audio tones
Periodic noise	75% color bar

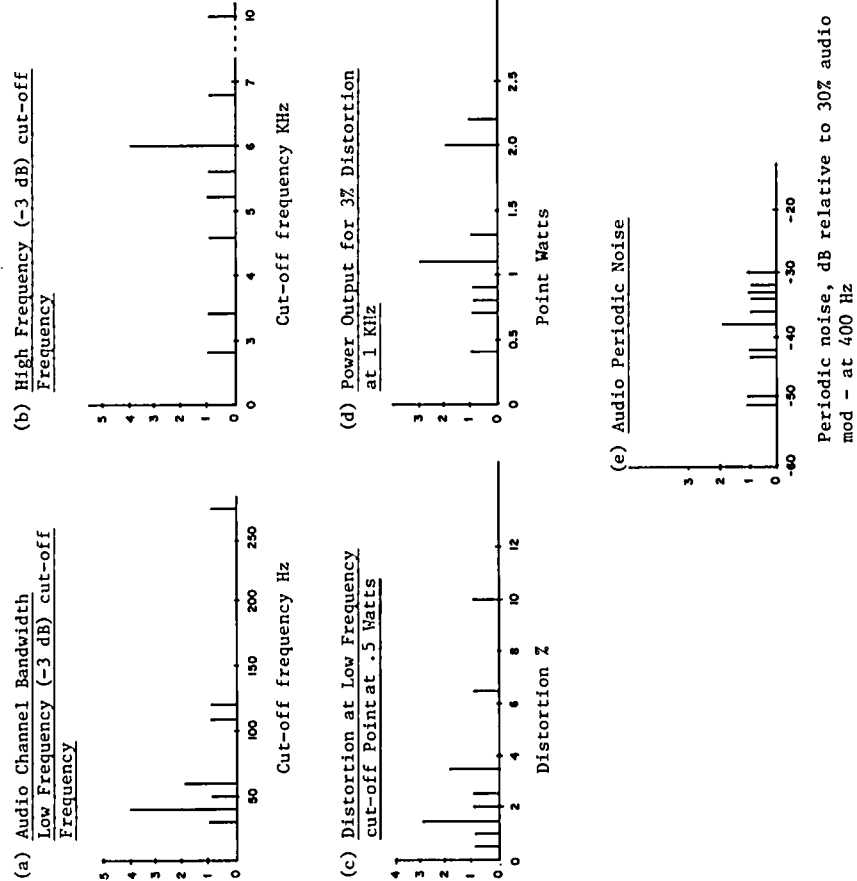


Fig. 4. Audio channel electrical characteristics.

Parameter Measured	Test Waveform Utilized
Horizontal scanning nonlinearity	Cross hatch
Vertical scanning nonlinearity	Cross hatch
Picture overscan	Cross hatch
Geometric distortion	Cross hatch
Convergence error	Cross hatch
Size variation with brightness change from maximum focused luminance to maximum usable luminance	Cross hatch
Maximum focused luminance	White field
Shading (maximum)	White field
Luminance transfer characteristics	White field

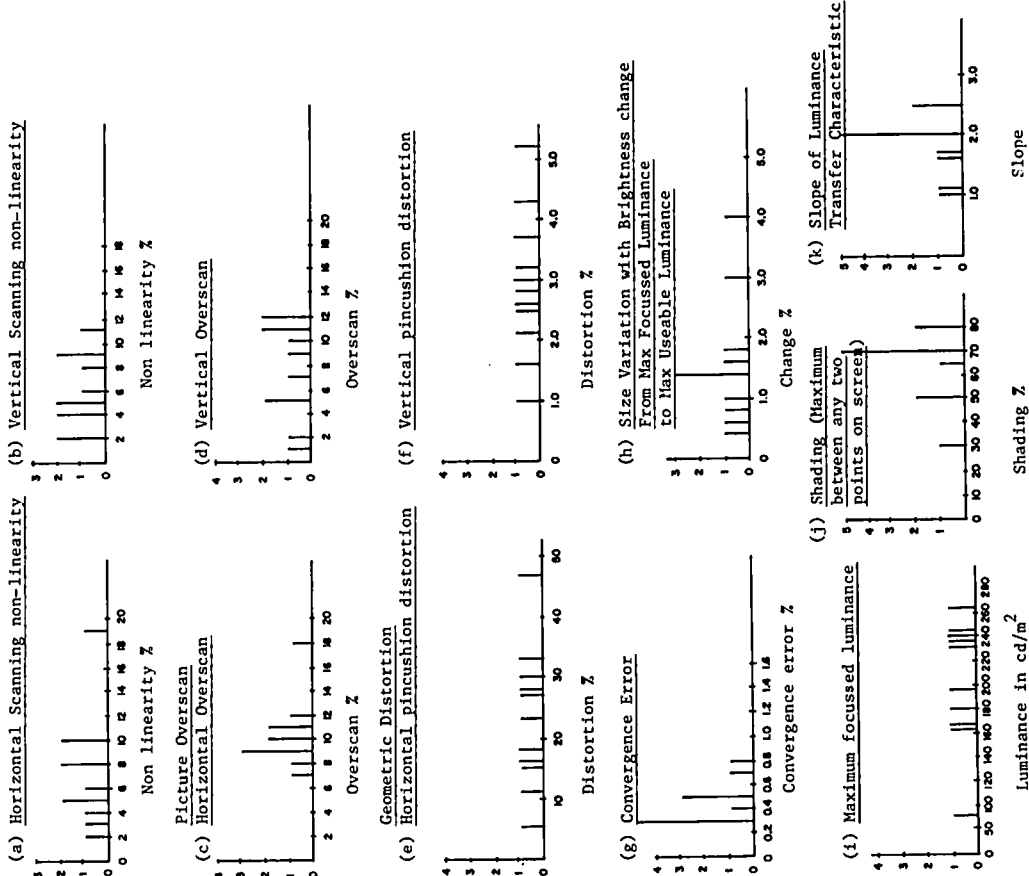


Fig. 3. Kinescope display characteristics, with conditions and results.

Parameter Measured	Test Waveform Utilized	Test Point
RF and IF 6-dB bandwidth	RF sweep	Video Detector
RF level for 30-dB video SNR	Pulse and bar	Luminance driver and chroma decoder output (blue channel)
RF level for 50-dB audio SNR	75% color bar	Output to speaker

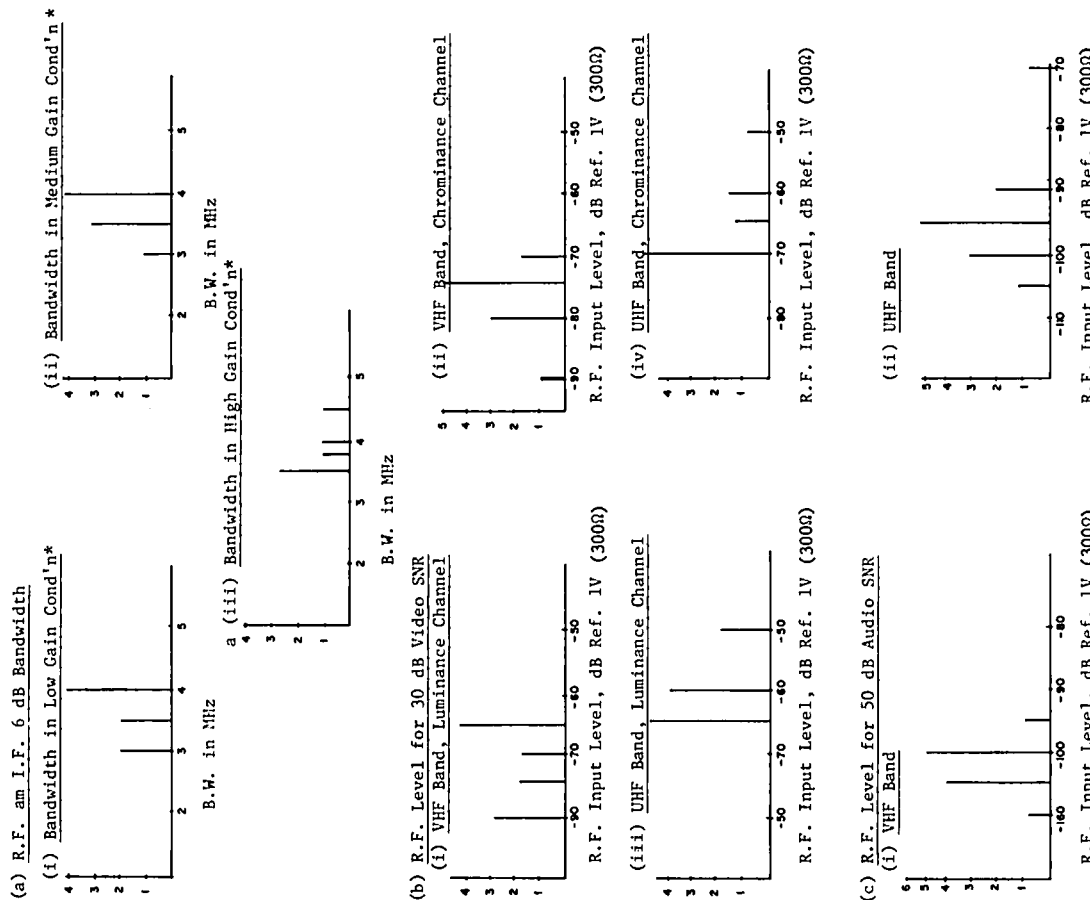


Fig. 5. RF and IF characteristics. Some receivers were unable to perform in tests marked with asterisk (*).

Parameter Measured	Test Waveform Utilized
Anechoic on-axis frequency response	Sinusoidal audio tone sweep
Dispersion characteristics	Sinusoidal audio tone
Harmonic distortion	Sinusoidal audio tone

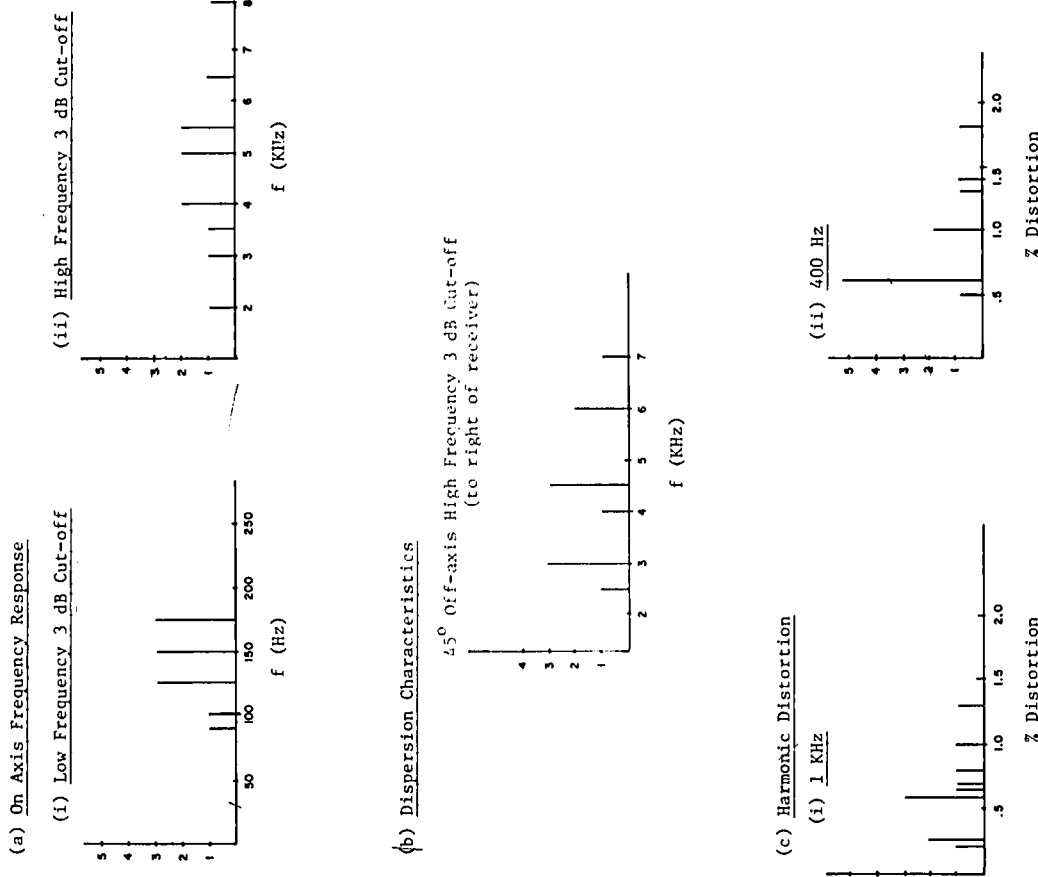


Fig. 6. Acoustic characteristics.

Table I. CBC tentative delivery system specifications.

Parameter	Stations		
	Group 1	Group 2	Group 3
K-Factor (%)	7	8	12
Weighted signal to noise (dB)	42	40	36
Chrom/lum gain inequality ($\pm\%$)	22	25	35
Chrom/lum delay inequality (\pm ns)	130	175	250
Differential phase (\pm deg)	10	13	18
Differential gain (%)	15	20	30
Compliance— all parameters (%)	99.5	99.5	80

Group 1 - Main stations

Group 2 - All other network connected stations

Group 3 - Rebroadcast stations (worst case)

The delivery system is considered as the path from camera encoder through network distribution to transmitter demodulator output.

the CBC tentative delivery system specifications (Table I).

The mean findings of 7% for 2T pulse 'K' factor and 1.3 for the pulse-to-bar ratio were approximately equal to CBC specifications for main station delivery systems (including professional demodulator). However, this performance level manifested itself in most sample receivers as severe ringing and edging effects.

Black level shift with APL change from 10% to 90% was 40- to 50-IRE units for the worst case. This amount of shift results in objectionable variation of tonal values with changes in scene content. This defect restricts the broadcastable range of low-key and high-key scenes if viewer inconvenience is to be avoided.

Luminance channel frequency response limitations manifest themselves as reduced limiting resolution which is, at best, 250 lines.

All other results were found to give subjective impairments of much less severity.

Kinescope Display Characteristics

Receivers displaying the worst-case results for scanning nonlinearity are approximately five times worse than a high quality camera, and this causes variations in the shape of objects moving in a scene. The measured average picture overscan of 10% is useful information for determining the maximum useable area for titling and scene composition. The average slope of the luminance transfer characteristic of the entire re-

ceiver (not just kinescope) was 2 rather than the theoretical ideal of 2.5. The average maximum focused luminance of the sample receivers was 233 cd/m² (65 ft-L).

Remaining parameter findings were judged to have little or no degrading effect upon receiver performance.

RF Characteristics

On the average, UHF tuner sensitivities were 10 to 20 dB lower than those of the VHF tuners in the sample receivers. Typically, to obtain a 30-dB luminance video signal-to-noise ratio, it was necessary to apply -70 dBV or about 300 μ V (with a 300- Ω input impedance) at the VHF antenna terminals while -60 dBV or 1000 μ V (300- Ω impedance) was needed at the UHF tuner input.

Audio Channel Electrical and Acoustic Characteristics

Large variations occurred among receivers in frequency response performance. Low frequency cutoff varied from 25 Hz to 275 Hz and high frequency cutoff varied from 2 kHz to 10 kHz. Maximum power output also showed variation from 0.4 W to 2.25 W. Periodic noise findings (audio buzz) additionally produced objectionable performance degradation in the sample receivers. The average level was 38 dB below 400 Hz at 30% modulation. Other parameters were judged as not degrading receiver audio performance.

Low Bit-Rate System for Digital Coding of the Television Picture

By P. RAINGER and P. A. RATLIFF

System design of bit-rate reduction equipment for digital television involves striking a compromise between hardware cost and the cost of transmission or storage of the digital signal. This paper is concerned with "cascadable" systems, in which there is a small but definable loss of quality when the signal is first coded though there is no increase in degradation as it passes through further stages of digital coding. Bit-rate economy is sought by reducing the sampling frequency and the number of bits per sample; degradation due to analog to digital conversion is ignored and — for the sake of simplicity — the system input and output are assumed to be linear pulse-code-modulated signals of 8 bits per sample. Experimentation with various alternative systems has shown that for various reasons differential pulse code modulation (DPCM) is to be preferred, although in some cases its advantage is small. The discussion is in terms of the 625-line PAL signal, but many of the points made are applicable to other television standards. The effectiveness of DPCM coding is considered for the cases of 1-D, 2-D, and 3-D prediction, and the cascadability of such a system is considered in detail. Sub-Nyquist sampling is examined as an important bit-rate reduction system, and the necessary requirements of cascadability are studied in an attempt to identify the principles involved so that the technique may be extended. Experience gained with a system sampling at twice color subcarrier and using a 2-D system of filtering was employed to develop the theory of a 3-D system.

Presented on 3 February 1979 at the Society's Television Conference in San Francisco by Peter Rainer (who read the paper) and P. A. Ratliff. Both authors are with the BBC, Mr. Rainer at Broadcasting House, London, W1A 1AA, England, and Mr. Ratliff at the Research Department, Kingswood Warren, Tadworth Surrey KT20 6NP, England. This paper was first published in unedited form in the SMPTE book *Digital Video 2*, copyright © 1979 by the Society of Motion Picture and Television Engineers, Inc.

Introduction

It is generally accepted that a bit-rate of about 100 Mbit/s is required for digital coding of high quality television signals, using conventional linear PCM. Although such simple coding has many advantages in the television studio, it is grossly inefficient in terms of information-carrying capacity, and

once the digital video signal leaves the studio, for distribution to local-area transmitters for example, it will have to compete with all manner of other digital signals in tomorrow's world of all-digital communications. The concept of universal, digital communication highways is fine, but the video signal is a greedy companion in comparison with the major occupant of these highways, the telephone signal. Similarly, such video signals are gluttonous for the digital storage media which will soon play a major role in studio-signal processing, and thus it is important to look at methods of coding them more efficiently. Of course, the final solution involves striking a balance between the cost of hardware required to effect a bit-rate economy and the cost of transmission or storage of the digital signal.

Ideally, the picture quality given by the digital coding should be so high that the system is effectively transparent to the signal; then any number of separate systems may be connected in cascade without causing a progressive degradation of the signal. In practice, some loss of transparency may be tolerated where the impairment introduced is so small as to be virtually undetectable under conditions of critical assessment.