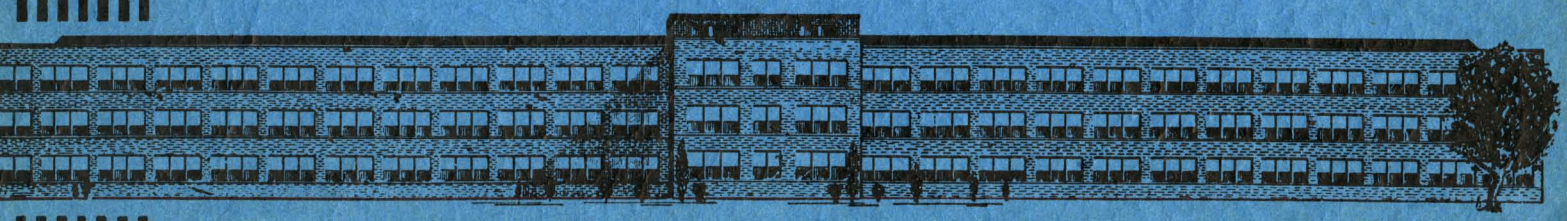
LCK

A STUDY OF CO-CHANNEL AND ADJACENT CHANNEL INTERFERENCE OF TELEVISION SIGNALS

PART II

RADIO CORPORATION OF AMERICA
RCA LABORATORIES DIVISION



RADIO CORPORATION OF AMERICA
RCA LABORATORIES DIVISION
PRINCETON, N. J.

E W ENGSTROM
VICE PRESIDENT IN CHARGE OF
RESEARCH

January 30, 1950.

Mr. T. J. Slowie, Secretary
Federal Communications Commission
Washington 25, D. C.

Re: Docket Nos. 8736, 8975,
9175 and 8976
Part II

Dear Sir

Under date of January 17, we filed copies of a bulletin entitled, "A Study of Co-Channel and Adjacent-Channel Interference of Television Signals, Part I." A bulletin covering the second phase of this study under the same title, but Part II, is filed herewith. One hundred copies of this eighth* bulletin are submitted. Copies will be mailed to the list of persons and organizations attached to Mr. Robert Zeller's letter of October 26, 1949.

Very truly yours,

E. W. Engstrom

E. W. Engstrom

*See attachment

*Bulletins previously filed and distributed:

"A 15 by 20-Inch Projection Receiver for the RCA Color Television System" (letter dated October 20, 1949)

"Synchronization for Color D ot Interlace in the RCA Color Television System" (letter dated October 31, 1949)

"A Two-Color Direct-View Receiver for the RCA Color Television System" (letter dated Novemb er 9, 1949)

"An Experimental UHF Television Tuner" (letter dated December 12, 1949)

"A Three-Color Direct-View Receiver for the RCA Color Television System" (letter dated January 9, 1950)

"An Experimental Determination of the Sideband Distribution in the RCA Color Television System" (letter dated January 17, 1950)

"A Study of Co-Channel and Adjacent-Channel Interference of Television Signals, Part I" (letter dated January 17, 1950)

A Study of Co-Channel and Adjacent Channel Interference of Television Signals

Part II

Radio Corporation of America

January 1950

Contents

	Page
Introduction	1
Method and Apparatus used for the Determination of Adjacent Channel Interference Ratios	1
Classification of Types of Adjacent Channel Interference	2
Discussion of Experiments	3
Conclusion	7

List of Illustrations

Page

Fig 20 – Frequency-response characteristic of the vestigial sideband fi ter 1

Fig 21 – Frequency characteristic of RCA receiver, Model 9T246, on Channel 3 2

Fig 22 – Frequency characteristic of RCA receiver, Model 9T246, on Channel 4 2

Fig 23 – Threshold values of lower adjacent channel interfering signals, as a function of the percentage of observers requiring ratios greater than the ordinate values Desired signal is standard monochrome viewed on standard monochrome receiver See Table V for undesired signals 3

Fig 24 – To erable values of lower adjacent channel interfering signals, as a function of the percentage of observers requiring ratios greater than the ordinate values Desired signal is standard monochrome viewed on standard monochrome receiver See Table V for undesired signals 3

Fig 25 – Threshold values of upper adjacent channel interfering signals, as a function of the percentage of observers requiring ratios greater than the ordinate values Desired signal is standard monochrome viewed on standard monochrome receiver See Table VI for undesired signals 5

Fig 26 – Tolerable values of upper adjacent channel interfering signals, as a function of the percentage of observers requiring ratios greater than the ordinate values Desired signal is standard monochrome viewed on standard monochrome receiver See Table VI for undesired signals 5

Fig 27 – Threshold and tolerable values of upper adjacent channel interfering signals, as a function of the percentage of observers requiring ratios greater than the ordinate values The desired signal is dot-sequentia color and the interfering signal is standard monochrome See Table VII 5

Fig 28 – Threshold and tolerable values of lower adjacent channel interfering signals, as a function of the percentage of observers requiring ratios greater than the ordinate values The desired signal is dot-sequential color and the interfering signal is standard monochrome See Table VIII 5

Fig 29 – Threshold and tolerable values of upper adjacent channel interfering signals, as a function of the percentage of observers requiring ratios greater than the ordinate values The desired signal is field-sequential color See Table VII for the undesired signals 7

Fig 30 – Threshold and tolerable values of ower adjacent channel interfering signals, as a function of the percentage of observers requiring ratios greater than the ordinate values The desired signal is field-sequential color See Table VIII for the undesired signa s 7

A Study of Co-Channel and Adjacent Channel Interference of Television Signals

Part II

Introduction

Certain observations and conclusions bearing on the allocation of television stations were reported in Part I of "A Study of Co-Channel and Adjacent Channel Interference of Television Signals" as a consequence of an extensive study of co-channel interference conducted by RCA Laboratories Part II of the study is the concluding section and summarizes the work with adjacent-channel interference

Method and Apparatus Used for the Determination of Adjacent Channel Interference Ratios

The approach to the problem was made through the use of subjective visual observations of a limited number of observers The choice of personnel for the test group was made from laboratory employees with the intent of approximating a fair cross-section of the population by 15 observers All observers were accustomed to the viewing of television pictures and had some previous acquaintance with the types of adjacent-channel interference ordinarily experienced in standard monochrome television

Included in the tests were signals characteristic of the three proposed color television systems the field-sequential system as proposed by the Columbia Broadcasting System, the line-sequential system as proposed by Color Television Inc and the dot-sequential system as proposed by the Radio Corporation of America A standard monochrome signal was paired with the color systems for certain tests to represent the co-existence of color and monochrome television on adjacent channels

All signals were generated by low-power transmitters operating on Channels 3 and 4 within the laboratory Attenuation of the lower sideband of an interfering signal on the upper adjacent channel was provided by a vestigial sideband filter with attenuation characteristics as shown in Fig 20 Synchronizing waveforms for the interfering and desired signals were generated by independent synchronizing generators not locked to a common power supply

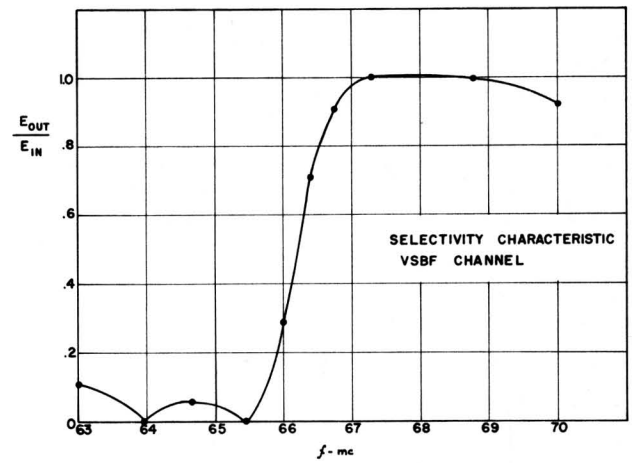


Fig 20 - Frequency-response characteristic of the vestigial sideband filter

Significant details of the observer tests of adjacent channel interference correspond to the conditions for co-channel interference tests as set forth in Part I of this study namely

Receiver	RCA Model 9T246 Video output supplied signals for monochrome and color observations.
Picture Size	As stated in Part I
Desired Picture	Stationary slide, band leader and band (see Fig 12, Part I)
Interfering Picture	Test pattern
High-light Brightness	15 foot-lamberts
Ambient Room Illumination	Up to 4 foot-candles

Observer tests of co-channel interference may ordinarily be conducted without regard for

the selectivity characteristics of the receiver used since the spectrums of both desired and interfering signals correspond and are treated equally by the receiver On the contrary, conclusions drawn from observations of adjacent-channel interference must take account of the selectivity characteristic of the television receiver since the spectrums of the desired and interfering signals are displaced by six megacycles

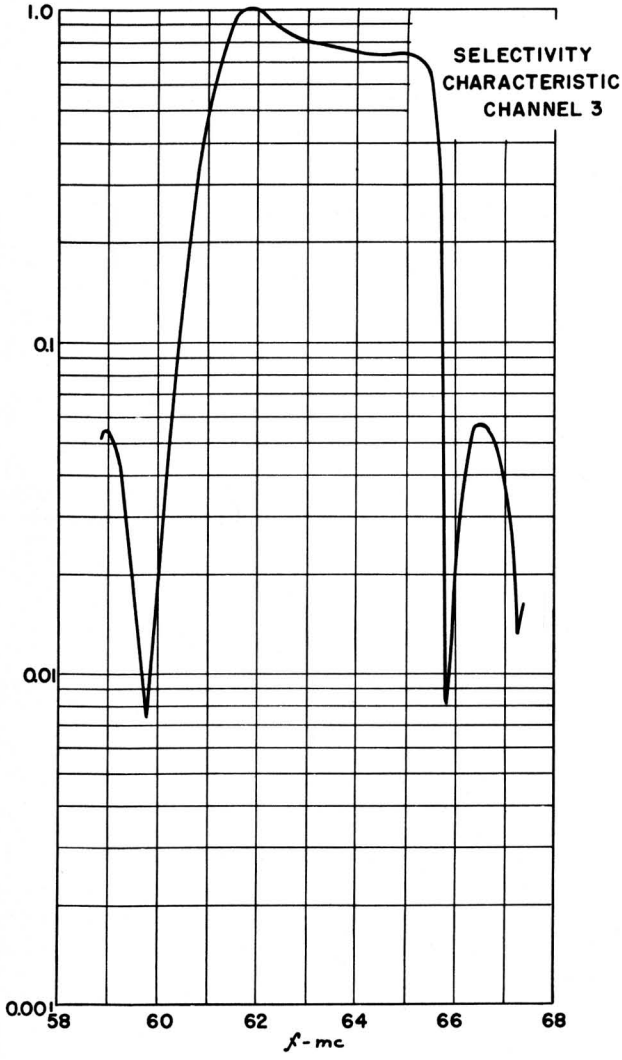


Fig 21 – Frequency characteristic of RCA receiver, Model 9T246, on Channel 3

The overall selectivity characteristics of the receiver used in tests at RCA Laboratories are displayed in Figs 21 and 22

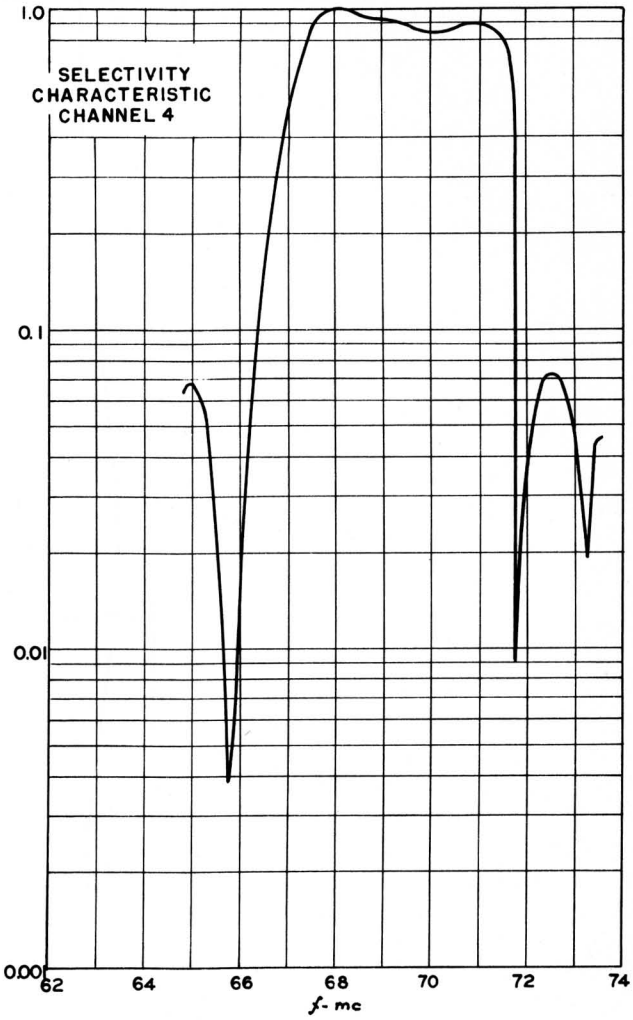


Fig 22 – Frequency characteristic of RCA receiver, Model 9T246, on Channel 4.

Classification of Types of Adjacent Channel Interference

Ad acent channel interference with co-existent color television and monochrome services may be classified in eight types according to position of the interfering picture and sound signals lower or upper adjacent channel) and the nature of picture signals on the desired and interfering channels color or monochrome as follows

Type 1 Desired signal – standard monochrome nterfering signal – standard monochrome or color, including sound, on lower ad acent channel

Type 2 Desired signal – standard monochrome

Interfering signal – standard monochrome or color, including sound on upper adjacent channel

Type 3. Desired signal – compatible color signal viewed on a standard monochrome receiver
Interfering signal – standard monochrome, including sound, on upper adjacent channel

Type 4 Desired signal – compatible color signal viewed on a standard monochrome receiver
Interfering signal – standard monochrome including sound on lower adjacent channel

Type 5. Desired signal – color signal viewed on color receiver
nterfering signal – standard monochrome, including sound on upper adjacent channel

Type 6. Desired signal – color signal viewed on color receiver
Interfering signal – standard monochrome, including sound, on lower adjacent channel

Type 7 Desired signal – color signal viewed on color receiver
Interfering signal – color signal, including sound, on upper adjacent channel

Type 8 Desired signal – color signal viewed on color receiver
Interfering signal – color signal, including sound, on lower adjacent channel

In all of the observer tests which are analyzed below according to type, observers were instructed to stop the operator when the strength of the interfering signal corresponded 1 to interference on the threshold of visibility, and 2) to interference at the limit of tolerance The observer was requested not to imagine that the test slide was a favorite program, but to base judgment on the test subject as such Hence, the ratios of desired signal to interfering signal which were obtained may be regarded as conservative values

Discussion of Experiments

Type 1

Lower adjacent-channel interference is controlled by the lower wing response and the attenuation of the adjacent sound in the television receiver

Table V indicates that the average ratio of desired picture signal to interfering picture signal ranges over the relatively narrow interval of 2 to 10 decibels for threshold observable interference and 0 to –5 decibels for tolerable interference The spread between average threshold and tolerable ratios for particular types of interfering signal ranged from 7 to 10 decibels

Figs 23 and 24 indicate the spread of observer datum points for 15 observers

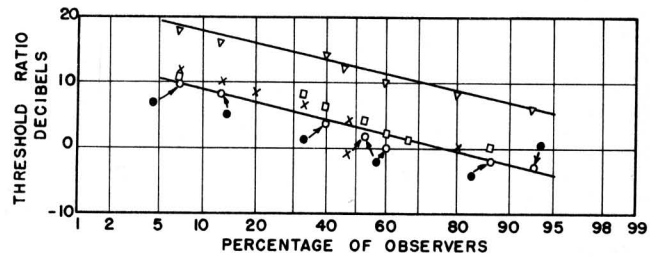


Fig 23 – Threshold values of lower adjacent channel interfering signals, as a function of the percentage of observers requiring ratios greater than the ordinate values Desired signal is standard monochrome viewed on standard monochrome receiver See Table V for undesired signals

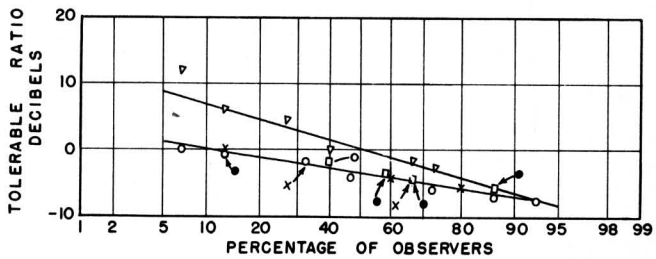


Fig 24 – Tolerable values of lower adjacent channel interfering signals, as a function of the percentage of observers requiring ratios greater than the ordinate values Desired signal is standard monochrome viewed on standard monochrome receiver See Table V for undesired signals

Type 2:

Upper adjacent channel interference is controlled by the attenuation provided in the receiver at the frequency of the adjacent picture carrier

TABLE V

Summary of Tolerable and Threshold Ratios of Desired to Undesired Adjacent Channel Television Signals

Channel 4 - desired signal
Channel 3 - undesired picture and sound signals ratio of sound to picture = 0 71

Figure	Symbol	Desired Signal	Undesired Signal	Average ratio required by the observers (decibels)	
				Threshold	Tolerable
23 and 24	□	Standard monochrome viewed on standard monochrome receiver	Standard monochrome	4	-4
23 and 24	●	Standard monochrome viewed on standard monochrome receiver	Field-sequential color	2	-5
23 and 24	X	Standard monochrome viewed on standard monochrome receiver	Line-sequential color Sequence C	3	-4
23 and 24	△	Standard monochrome viewed on standard monochrome receiver	Dot-sequential color	10	0
23 and 24	○	Standard monochrome viewed on standard monochrome receiver	Adjacent sound channel only ratio corresponds to interfering picture	2	-5

TABLE VI

Summary of Tolerable and Threshold Ratios of Desired to Undesired Adjacent Channel Television Signals

Channel 3 - desired signal
Channel 4 - undesired picture and sound signals ratio of sound to picture = 0 71

Figure	Symbol	Desired Signal	Undesired Signal	Average ratio required by the observers (decibels)	
				Threshold	Tolerable
25 and 26	□	Standard monochrome viewed on standard monochrome receiver	Standard monochrome	-9	-14
25 and 26	●	Standard monochrome viewed on standard monochrome receiver	Field-sequential color	-9	-12
25 and 26	X	Standard monochrome viewed on standard monochrome receiver	Line-sequential color Sequence C	-10	-14
25 and 26	△	Standard monochrome viewed on standard monochrome receiver	Dot-sequential color	-9	-13

Table VI shows that the average ratio required by the observers for threshold interference ranges from -9 to -10 decibels and for tolerable interference from -12 to -14 decibels Differences between threshold and tolerable interference ratios for the various types of signal ranged from 3 to 5 decibels

The spread in observer datum points is given in Figs 25 and 26

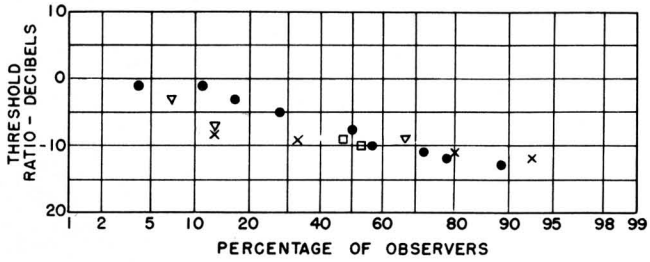


Fig 25 - Threshold values of upper adjacent channel interfering signals, as a function of the percentage of observers requiring ratios greater than the ordinate values Desired signal is standard monochrome viewed on standard monochrome receiver See Table VI for undesired signals

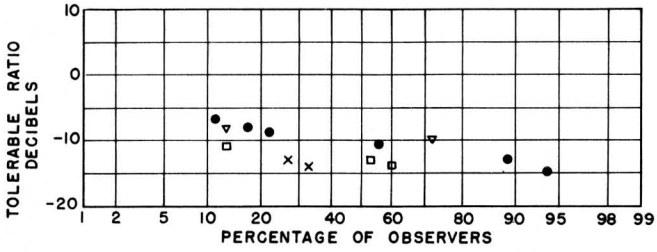


Fig 26 - Tolerable values of upper adjacent channel interfering signals, as a function of the percentage of observers requiring ratios greater than the ordinate values Desired signal is standard monochrome viewed on standard monochrome receiver See Table VI for undesired signals

All observers agreed that the sound signal associated with the upper ad acent channel did not give rise to observable interference for the ratios recorded in Table VI That is the threshold and tolerable ratios were dictated by interference commonly known as "windshield wiper" interference caused by the sub ect matter of the non-synchronous interfering pictures

Reference to the tabulation of average ratios and the curves in Figs 25 and 26 reveals that upper adjacent channel interference is dependent upon picture carrier ratios and independent of the type of modulation whether monochrome or any of the three color signals

Type 3

Measurements of interference ratios were confined to the dot-sequential system The field-sequential system is not compatible in the sense that such signals are usable with a standard unmodified monochrome receiver

Although the line-sequential color system Sequences B and C has been stated to be compatible the observed effect of a visually-coarse line structure renders uncertain the interpretation of observer data

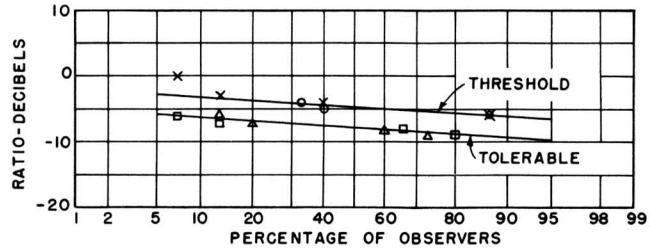


Fig 27 - Threshold and tolerable values of upper adjacent channel interfering signals, as a function of the percentage of observers requiring ratios greater than the ordinate values The desired signal is dot-sequential color and the interfering signal is standard monochrome See Table VII

Inspection of Fig 27 and the corresponding average ratios in Table VII shows that interference caused by a monochrome signal on the upper adjacent channel is observed to substantially the same extent on a dot-sequential color receiver and a monochrome receiver that utilizes the dot-sequential signal for the reproduction of a monochrome picture The threshold ratio is -5 to -6 decibels and the tolerable ratio is -8 decibels, representing a spread of about 2 to 3 decibels between threshold and tolerable

Type 4

Observers agreed that the sound signal in

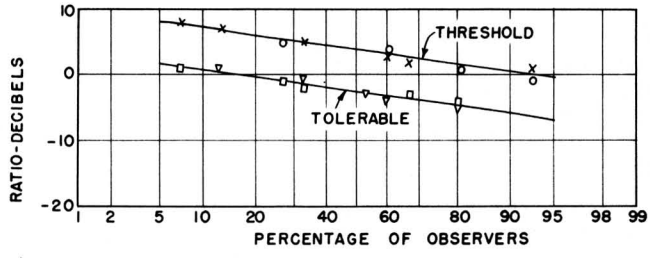


Fig 28 - Threshold and tolerable values of lower adjacent channel interfering signals, as a function of the percentage of observers requiring ratios greater than the ordinate values The desired signal is dot-sequential color and the interfering signal is standard monochrome See Table VIII

TABLE VII

Summary of Tolerable and Threshold Ratios of Desired to Undesired Adjacent Channel Television Signals

Channel 3 - desired signal
Channel 4 - undesired picture and sound signals ratio of sound to picture = 0 71

Figure	Symbol	Desired Signal	Undesired Signal	Average ratio required by the observers decibels)	
				Threshold	Tolerable
27	O Threshold □ Tolerable	Dot-sequential color viewed on color receiver	Standard monochrome	-5	-8
27	× Threshold △ Tolerable	Dot-sequential color viewed on standard monochrome receiver	Standard monochrome	-6	-8
29	O Threshold □ Tolerable	Field-sequential color viewed on color receiver	Field-sequential color	-10	-13
29	× Threshold △ Tolerable	Field-sequential color viewed on color receiver	Standard monochrome	-15	-19

TA BLE VIII

Summary of Tolerable and Threshold Ratios of Desired to Undesired Adjacent Channel Television Signals

Channel 4 - desired signal
Channel 3 - undesired picture and sound signals, ratio of sound to picture = 0 71

F gure	Symbol	Desired Signal	Undesired Signal	Average ratio required by the observers (decibels)	
				Threshold	Tolerable
28	O Threshold □ Tolerable	Dot-sequential color viewed on color receiver	Standard monochrome	3	-3
28	× Threshold △ Tolerable	Dot-sequential color viewed on standard monochrome receiver	Standard monochrome	3	-3
30	O Threshold □ Tolerable	Field-sequential color viewed on color receiver	Field-sequential color	0	-7
30	× Threshold △ Tolerable	Field-sequential color viewed on color receiver	Standard monochrome	-2	-9

the lower adjacent channel was decisive in producing threshold and tolerable interference ratios Substantial agreement of entries in Table VIII for Fig 28 and last entry in Table V for the sound carrier only may be noted

Type 5

The threshold and tolerable ratios for the dot-sequential signal as the desired signal are recorded in Table VII as -5 and -8 decibels, respectively The spread is 3 decibels Corresponding threshold and tolerable ratios for the field-sequential system are -15 and -19 decibels with a spread of 4 decibels

Satisfactory data could not be taken for the line-sequential color signal utilized for reproduction of color due to the observed effect of a visually-coarse line structure

Type 6:

Observers agreed that the perceptible and tolerable ratios for the field-sequential and dot-sequential systems were set by the interference caused by the lower ad acent sound carrier, rather than the lower adjacent picture carrier.

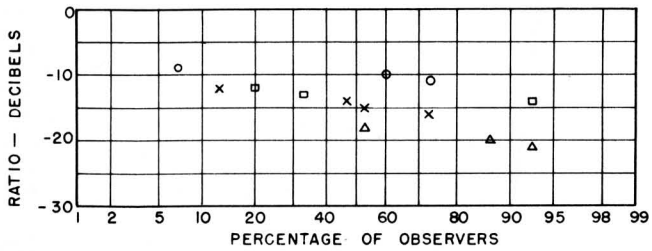


Fig 29 - Threshold and tolerable values of upper adjacent channel interfering signals, as a function of the percentage of observers requiring ratios greater than the ordinate values The desired signal is field-sequential color See Table VII for the undesired signals

Type 7

The requirement of two independent color signal sources restricted the scope of observations with *Type 7* interference to the field-sequential system for which the signal generating equipment was available Average threshold and tolerable ratios of -10 and -13 decibels are shown in Table VII

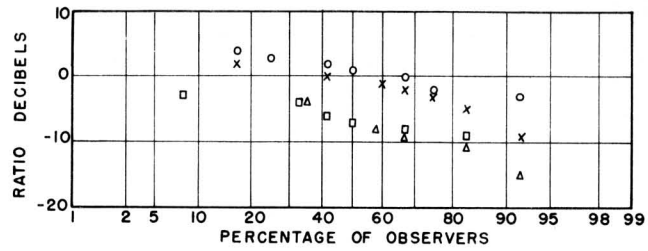


Fig 30 - Threshold and tolerable values of lower adjacent channel interfering signals, as a function of the percentage of observers requiring ratios greater than the ordinate values. The desired signal is field-sequential color See Table VIII for the undesired signals

Type 8

As mentioned above the lack of two sources of color picture restricted the scope of observations to the field-sequential system Table VIII indicates threshold and tolerable ratios of 0 and -7 decibels which are substantially the same as corresponding ratios of 2 and -5 decibels listed in Table V for the interference due to the adjacent sound signal Here as in other instances of lower adjacent channel interference, the sound signal was the dominant cause of interference

Conclusion

When the interfering signal is on the lower ad acent channel the tolerable ratio of desired to undesired signal is very dependent upon the adjustment of the adjacent channel sound trap

Upper adjacent channel interference comes mainly from the undesired picture carrier and sidebands closely associated with this carrier, and is determined by the attenuation achieved in the upper adjacent channel picture carrier trap

Lower adjacent channel interference is more severe than upper adjacent channel interference by almost 10 decibels

From the standpoint of allocation no substantial difference in the tolerable ratios was found for the various combinations of color and monochrome signals tested