AN EXPERIMENTAL DETERMINATION OF THE SIDEBAND DISTRIBUTION IN THE RCA COLOR TELEVISION SYSTEM

RADIO CORPORATION OF AMERICA
RCA LABORATORIES DIVISION

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E. W. ENGSTROM
VICE PRESIDENT IN CHARGE OF
RESEARCH

January 17, 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:

As a part of our progress report, dated December 30, 1949, on the subject dockets, we submitted a report covering energy distribution in the radiated signal of the RCA color television system as measured in the field (Part C - Item 1 of attachments to Progress Report of 12/30/49). This report has been put in bulletin form for wider distribution and is entitled, "An Experimental Determination of the Sideband Distribution in the RCA Color Television System." One hundred copies of this sixth bulletin* are filed herewith.

Copies of this bulletin will be mailed to the list of persons and organizations attached to Mr. Robert Zeller's letter of October 26.

Very truly yours,

E. W. Engstrom

E. W. Engstrom

*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 Dot 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 November 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

Radio Corporation of America

January 1950

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Introduction

In a radiated television signal utilizing the transmission standards of monochrome television, the distribution of frequency components consists of a high-intensity carrier and an almost continuous spectrum of sidebands extending approximately 4 megacycles above the carrier frequency and roughly 1 megacycle below the carrier frequency. The limitation in the lower frequency region is imposed by the use of vestigial-sideband transmission. The strength of the sideband components, relative to the carrier, is in inverse relationship to the departure from the carrier frequency.

Early in the Hearings before the Federal Communications Commission on Dockets No. 8736, 8975, 8976 and 9175, the RCA color television system was described.* In order to compress a high-definition color signal into a total channel assignment of 6 megacycles originally intended for monochrome transmission, a color-picture sampling technique was used where each of three primary colors was sampled by short pulses which had a basic frequency of 3.8 megacycles. The transmitted signal then consisted not only of the carrier surrounded by the sidebands generated by the horizontal and vertical synchronizing pulses and the normal sidebands generated by the video signal modulation but also another component displaced from the carrier 3.8 megacycles. This additional component is in turn surrounded by other components somewhat in the manner of a subcarrier and associated sidebands. A knowledge of the relative strength of this subcarrier is desirable in considering co-channel and adjacent channel interference effects to be expected when the RCA color television system is used.

General Discussion

This report relates the results of a number of measurements aimed at determining the relative intensities of the sideband components for a number of picture conditions. The transmitter of Television Station WNBW, Washington, D. C., was modulated with color television signals generated by a flying-spot slide scanner, the output of which was sampled in the manner prescribed for the RCA color television system.

*Exhibit 209, *A Six Megacycle Compatible High-Definition Color Television System*, Radio Corporation of America, September 26, 1949.

The transmissions were on Channel 4, with a picture carrier frequency of 67.25 megacycles.

The first measurements were made with a picture-sampling frequency of 3.8 megacycles. Later, when an investigation was progressing to determine the effect of variation of the sampling frequency, a second set of measurements was made with a picture-sampling frequency of 3.6 megacycles.

The measuring equipment was an RCA-WX1A Field Intensity Meter. A typical frequency-response characteristic of this instrument is shown in Fig. 1. It may be observed that the bandwidth is in excess of 200 kilocycles. Since

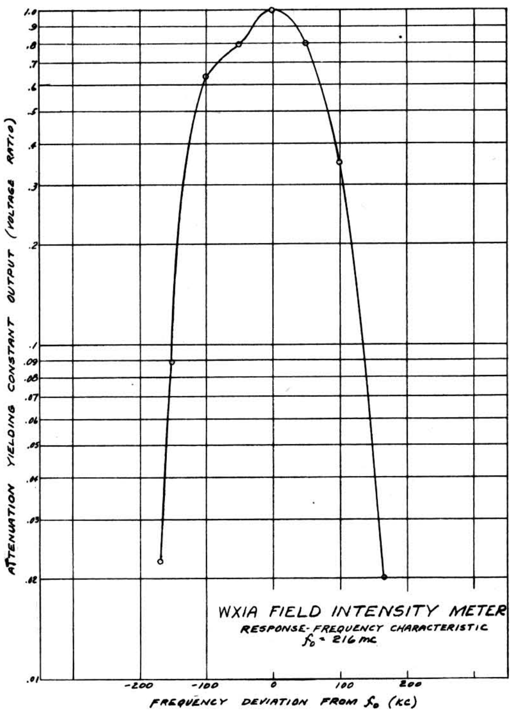

Fig. 1 - Frequency-response characteristic of the RCA-WXIA Field Intensity Meter.

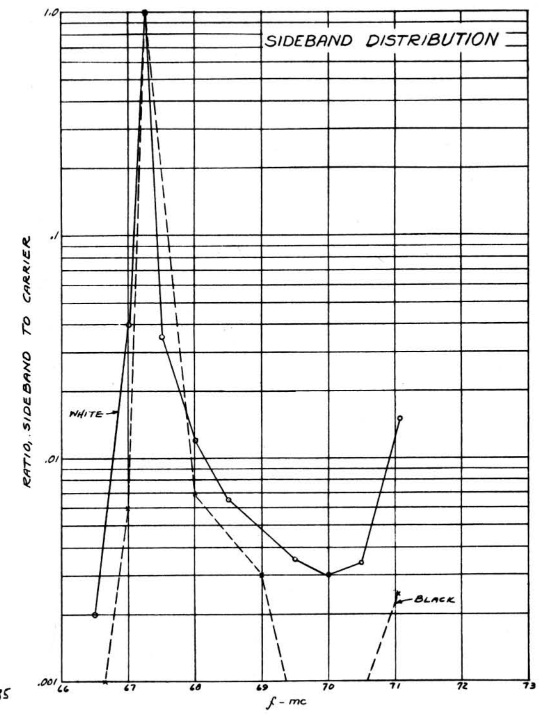

Fig. 3 - Sideband distribution for a white field and a black field. The sampling frequency is 3.8 megacycles.

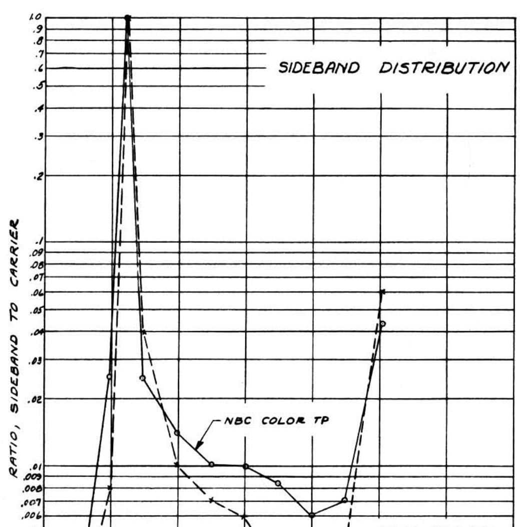

Fig. 2 - Sideband distribution of the RCA color television signal. The sampling frequency is 3.8 megacycles. The solid curve is the NBC color test pattern, while the dash curve is a slide made up of red, yellow, green and blue vertical bars, with each bar occupying approximately one-quarter of the total area.

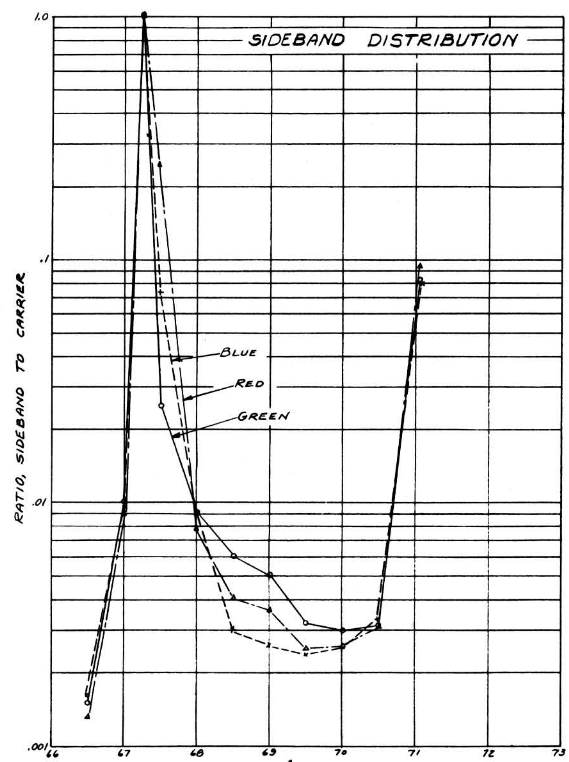

Fig. 4 - Distribution of sidebands for three slides, green, blue and red. The sampling frequency is 3.8 megacycles.

the sidebands occur at intervals not greater than the horizontal scanning frequency, 15,750 cycles, it is apparent that tuning to the carrier frequency will not give an exact value of the carrier strength alone. Instead, the reading at this point will be more nearly proportional to the strength of the radio-frequency signal during the horizontal synchronizing pulses. In turn, when the field intensity meter is tuned into the sideband region, the instrument will sum up the effects of all the sidebands occurring in a region of approximately 200 kilocycles. While it is realized that this method of measurement does not give exactly true values of the quantities desired, the lack of more precise measuring equipment fully justifies the use of devices now at hand.

Standard Monochrome Test Pattern

As a guide in evaluating measurements on the RCA color television signal, the transmitter was modulated by a standard NBC test pattern generated in a conventional flying-spot scanner. In this test, the signal applied to the transmitter was not sampled, but was entirely a monochrome transmission. The measured results are shown by the dotted curve of Fig. 5. It may be observed that sidebands which depart from the carrier frequency by more than 1 megacycle are less than 1 per cent of the intensity obtained by tuning the instrument to the carrier frequency.

The effect of the sideband filter becomes noticeable in the region of 66 megacycles.

Color Test Pattern

For the first tests with the RCA color television transmission, an NBC color test pattern was used. This pattern is very similar to the standard monochrome pattern, except that the four quadrants are colored red, green, yellow and blue. The sideband distribution is shown by the solid line of Fig. 2 with a sampling frequency of 3.8 megacycles. The result of sampling is now apparent by a response at 71.05 megacycles, 3.8 megacycles above carrier frequency.

The results obtained when the sampling frequency was 3.6 megacycles are shown by the solid curve of Fig. 5, with the peak of sideband response due to the sampling process now occurring at 70.85 megacycles.

The two curves of Fig. 5 make an excellent comparison of the sampled color signal and the standard monochrome signal, since the two test patterns were so very similar in detail.

Slide with Vertical Color Bars

The next slide was made up of four vertical color bars, red, yellow, green and blue, with each color occupying approximately one-quarter of the area of the slide. The distribution with a sampling frequency of 3.8 megacycles is displayed by means of the dashed curve of Fig. 2. A similar result with a sampling frequency of 3.6 megacycles is given in Fig. 8. In one case, the response due to sampling is 6 per cent of the carrier response, while in the other case the similar response is 10 per cent of the carrier response. The difference may be slightly due to transmitter adjustment and largely due to the fact that the two measurements were made at different locations. The first measurements were made in a relatively open space but some evidence of reflections was found by noting the changes in readings as the receiving antenna was moved. The second measurements were in a large open field at least 1000 feet from buildings or terrain irregularities. It was also learned at the completion of the measurements that two separate similar, but not identical, slides were used for the two sets of observations.

Solid Primary Colors

Three separate slides were used in order, each consisting of one of three primary colors, red, green or blue. The distributions corresponding to a sampling frequency of 3.8 megacycles are shown in Fig. 4.

Similar distributions are given in Fig. 7,

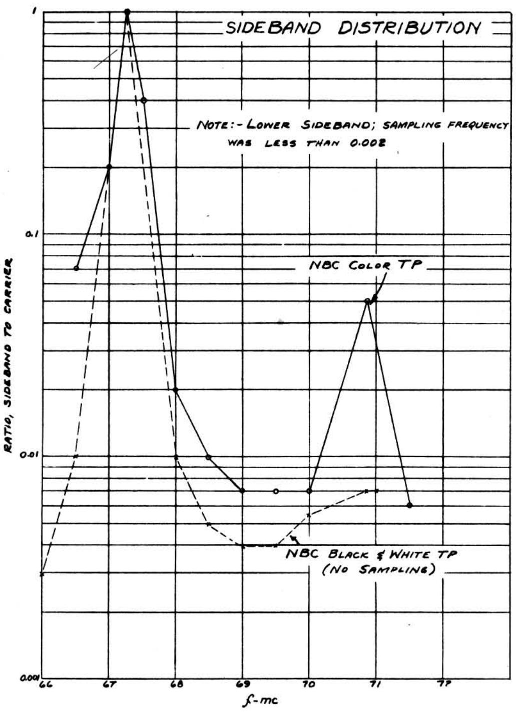

Fig. 5 - The dash curve shows the sideband distribution for a black-and-white NBC test pattern transmitted according to monochrome standards. The solid curve is for an NBC color test pattern, transmitted by the RCA color television system, with a sampling frequency of 3.6 megacycles.

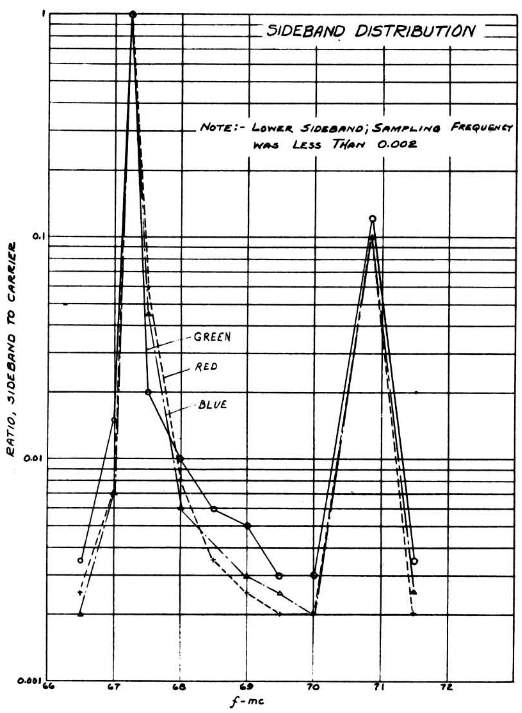

Fig. 7 - Distribution of sidebands for three slides, green, blue and red. The sampling frequency is 3.6 megacycles.

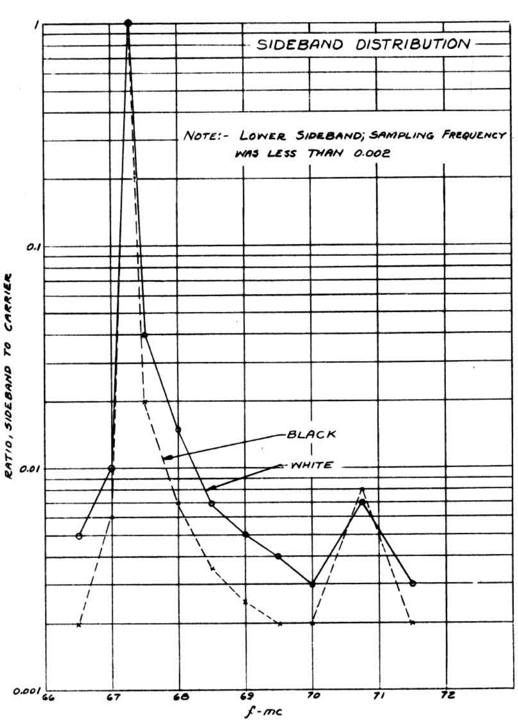

Fig. 6 - Sideband distribution for a white field and a black field. The sampling frequency is 3.6 megacycles.

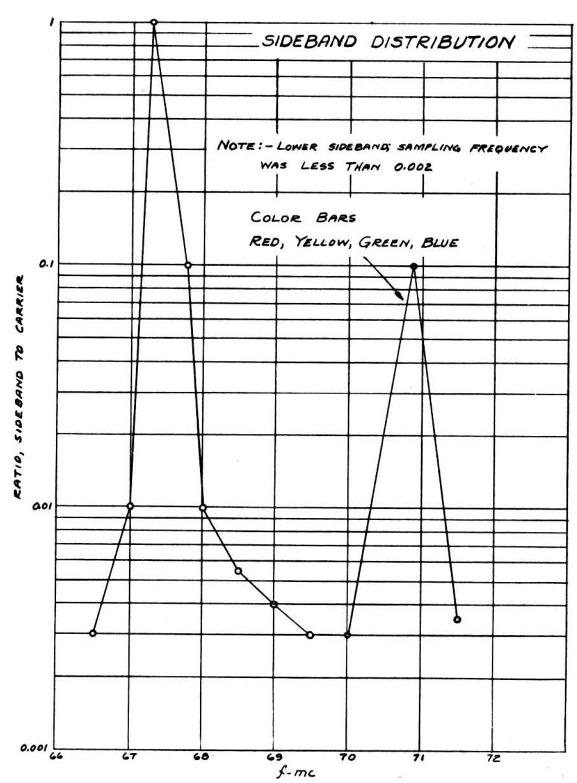

Fig. 8 - Sideband distribution for a slide made up of red, yellow, green and blue color bars.

for a sampling frequency of 3.6 megacycles. A theoretical analysis of the RCA color signal using a single primary color, together with a consideration of the properties of the WX1A Field Intensity Meter, indicates that the response at 70.85 megacycles should be slightly in excess of 10 per cent of the response obtained with the instrument tuned to carrier. The agreement with the results of Fig. 7 are excellent.

In exploring the response in the lower sideband region, it was found that the signals were hidden in the reading of the instrument due to inherent internal noise. However, it was determined that the response at 63.65 megacycles, 3.6 megacycles below carrier frequency, was less than 0.2 per cent of the response at picture carrier. Station WNBW is equipped with an RCA Vestigial Sideband Filter MI-19104-A, which has a response at 63.65 megacycles of 1.6 per cent of the response at carrier. This factor, coupled with the 10 per cent reading obtained at 70.85 megacycles as shown in Fig. 7, indicates that the measured value at 63.65 megacycles should be 0.16 per cent of the value obtained at picture carrier.

A Black Field and A White Field

A black slide and a white slide were next used to explore the sideband distribution, with the results shown in Fig. 3 and Fig. 6. The slight responses obtained at 71.05 megacycles in Fig. 3 and at 70.85 megacycles in Fig. 6 are very likely because the black slide was not entirely opaque and the white light was not a pure light.

Conclusion

The measurements displayed in this report show that the RCA color television system utilizes the spectrum space within a 6-megacycle channel more fully than does a monochrome system, and in so doing adds important color information to the intensity information of a monochrome system. The curves of Fig. 5 illustrate this point.

It has been shown that the RCA Vestigial Sideband Filter MI-19104-A provides adequate suppression of the lower sideband response which results from the sampling process.

Theoretically, the r-m-s value of the sideband generated by the sampling of a solid primary color should be 14.14 per cent of the r-m-s value of the total radio-frequency signal at the peak of synchronizing, when the transmitter is fully modulated with black level at 75 per cent of the peak of synchronizing and with white level established at 15 per cent of the peak of synchronizing. Examination of Figs. 4 and 7 reveals that the RCA-WX1A Field Intensity Meter yields results sufficiently close to theoretical value to be extremely useful in this field of investigation.