TESTING AND USING SYNCHRONOUS DEMODULATORS

By Charlie Rhodes

PART I

Introductory Discussion of Synchronous vs. Envelope Detectors

Synchronous detection of the vestigial sideband television picture signal is employed in modern demodulators to eliminate the quadrature distortion inherent with envelope detection.

Quadrature distortion produces differential gain (dG) and chrominance-luminance intermodulation (CLIM). It also introduces nonlinear transient distortion of the 2T pulse and bar test signals. This makes it impossible to measure the actual performance of the transmitter, and can lead to erroneous adjustments of the transmitter system, especially of linearity correctors and time domain response equalizers.

Figure 1 shows the 2T pulse normal and inverted*, *envelope* detected. In the photo we see that half-amplitude duration and overshoots differ due to quadrature distortion. Neither pulse is correct.

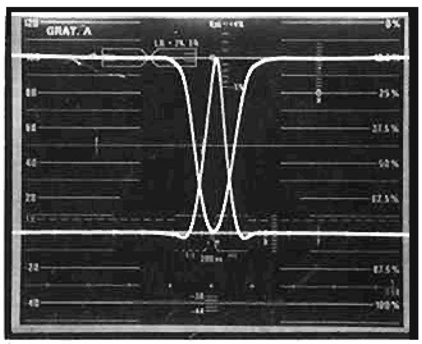

Figure 1.

Figure 2 is of the T bar, leading and trailing edges shown superimposed.* Each edge is affected in opposite ways by quadrature distortion. Note the preshoot on one transition is an overshoot on the other. Neither is indicative of transmitter performance. Any baseband correction of one edge only worsens the other transition.

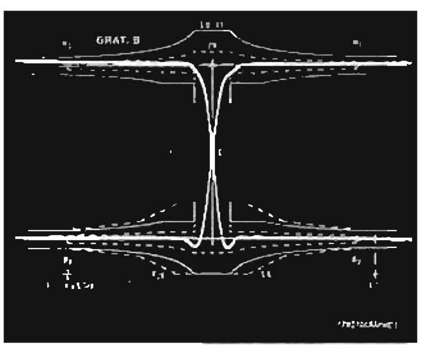

Figure 2.

Figure 3 shows the split-field color bars, normal bars and luminance component only.[1] Note that the ac axis of the chrominance is not correct because CLIM has shifted the ac axis toward black — especially on yellow and cyan bars. This is caused by quadrature distortion.

Figure 4 shows the chrominance component (only) of the color bar signal. Quadrature distortion had decreased the chrominance amplitude of the yellow and cyan bars relative to blue and red, respectively.

Differential gain caused by quadrature distortion always causes a loss in chrominance close to or at white level; i.e., on the last steps of a modulated stairstep signal. It is more severe with higher subcarrier amplitude (40 IRE vs. 20 IRE).

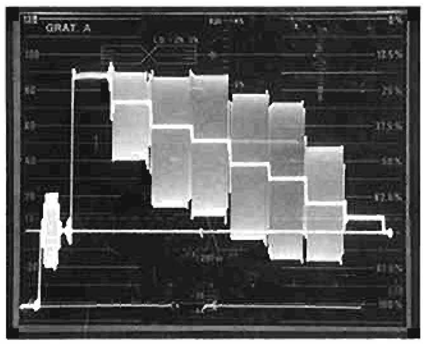

Figure 3.

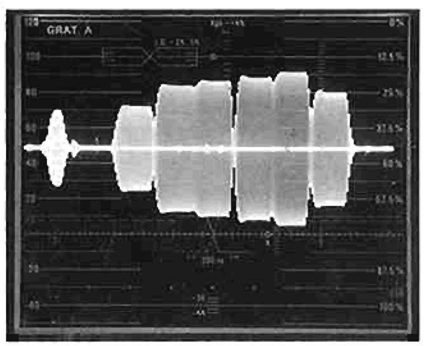

Figure 4.

Synchronous detection is used in modern demodulators to avoid quadrature distortion so that the transmitter's performance can be determined. Figures 5, 6, 7, and 8 show these test signals when synchronously detected. While the advantages of synchronous detection have been known for decades, it has only recently been practical to design and manufacture the needed circuitry. The troubles lie with the circuitry which must generate a picture carrier from the vestigial sideband I.F. signal. A phase-locked oscillator is used to generate the picture I.F. carrier required by the synchronous detector. If it does not lock to the incoming signal, the video output is unusable.[2] If it is frequency-locked, it may be out-of-phase with the picture I.F. carrier. Means to check carrier phase accuracy are required to establish validity of synchronously detected video. This is discussed in Part III.

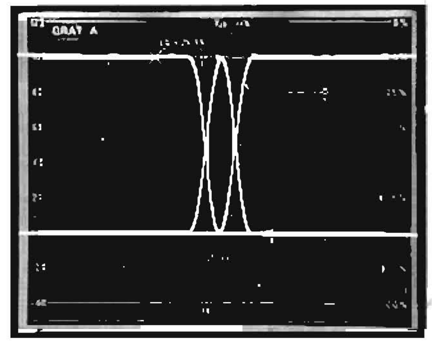

Figure 5.

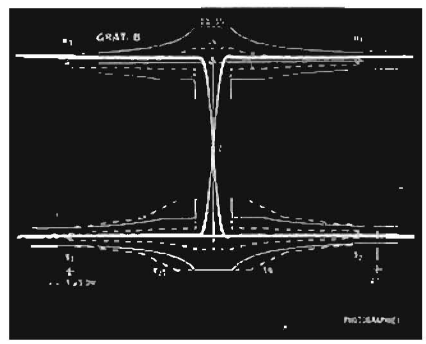

Figure 6.

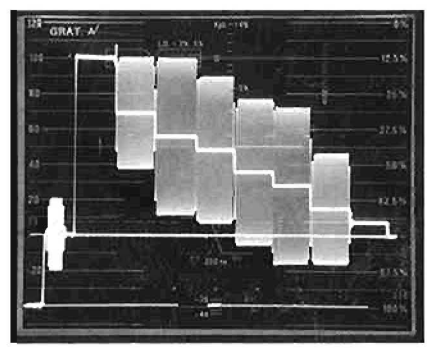

Figure 7.

*See Tektronix Application Note #13 on the use of Time Base Foldback to obtain these displays with a TEKTRONIX 1480 waveform monitor.

(1) 75% amplitude, 100% saturation; with setup, split-field color bars generated by TEKTRONIX 1410R (TSG 5) or 1910

(2) Failure to lock in frequency causes the TEKTRONIX 1450 to automatically switch to ENVELOPE DETECTION. When lock-up occurs, 1450 will go to synchronous mode, unless ENVELOPE MODE is selected by operator. Lock-up is normally nearly instantaneous.

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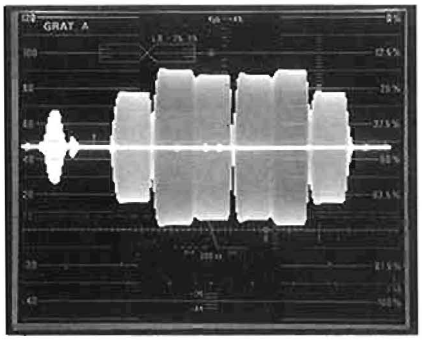

Figure 8.

Then, too, the regenerated carrier must not be phase modulated by noise. Phase noise would cause colored portions of the picture to have excess noise.

PART II

Applications of Synchronous and Envelope Detection Modes

In Part I, it was shown that quadrature distortion seriously affects the waveforms of standard test signals. This distortion occurs in the envelope demodulation process because the television VISUAL signal is vestigial sideband in nature. Quadrature distortion inevitably results when envelope detectors meet V.S.B. signals. Such distortion can be calculated. (Ref. 1)

One might, therefore, conclude that synchronous detection should be used for all measurements, and one might then question why envelope detection should be provided in addition.

Compliance with the F.C.C. Rules in their present form requires certain parameters to be measured in terms of the envelope of the radiated visual signal. Unfortunately, there is some incidental phase modulation (ICPM) of the visual transmitter's output so that these parameters will be different when measured synchronously. This is discussed in detail further on, but deserves clarification and emphasis here. Where it is known that ICPM is negligible and that the demodulator has negligible static phase error, synchronous demodulation can be used for *all* measurements, but these two restrictions must be rigorously observed.

Present F.C.C. Rules[3] address modulation depth, frequency response (gain + delay), and response to the 75% amplitude color bar signal.

Modulation depth must be monitored with envelope detection because even small amounts of ICPM can introduce errors which may be substantial in terms of the ±2½% tolerance permitted by the Rules. Fortunately, modulation depth is one measurement where quadrature distortion has no effect. Unfortunately, envelope detectors are usually quite non-linear at low-carrier levels, so just as one must know that static phase error is negligible, to use synchronous detection, one also needs to know the linearity of the envelope detection mode. This is discussed in Part VI.

The multiburst signal commonly used for remote control monitoring of unattended transmitters (See Figure 30) was especially designed to minimize effects of quadrature distortion. Results will be virtually the same with synchronous detection. A strict interpretation of the Rules dictates using envelope detection to measure frequency response. With a full-amplitude multiburst or swept frequency signal, envelope detection can only lead to very serious errors, or even worse, gross mis-tuning of the transmitter. While some demodulators attempt to reduce effect of quadrature distortion at color sub-carrier frequency, they cannot reduce it in the critical 1.25-3 MHz region. Full amplitude frequency response test signals should not be used to test transmitters in any case.

As we have shown, transient response test signals are seriously affected by quadrature distortion so they should never be measured using envelope detection.

The color bar signal is sensitive to quadrature distortion, and to ICPM, therefore, results will always vary between envelope and synchronous detection.

Differential gain must be measured using synchronous detection. Differential phase should be measured using envelope detection. Luminance non-linearity should be measured using synchronous detection. Chrominance-Luminance gain and delay inequalities (relative chrominance level, RCL, and relative chrominance time, RCT) must be measured with synchronous detection.

Chrominance-Luminance Intermodulation must be measured with synchronous detection ONLY.

The Broadcast Television Systems Committee of EIA recommends monitoring the VIR Signal with envelope detection, unless it is known that ICPM is negligible. As the VIR Signal was especially designed to minimize effects of quadrature distortion, its waveform differs little between envelope and synchronous detection, however chroma-burst phase may be seriously in error when synchronously detected due to ICPM in the transmitter.

Home receivers presently all use envelope detection so they would suffer a hue shift

PART III

The Static Phase Error Problem With Synchronous Detectors

Small static phase errors in the locally generated picture carrier introduce serious measurement errors. For example, chrominance-luminance delay inequality, RCT observed with the 12.5T pulse can result from static carrier phase error. Phase distortion of the 2T pulse and bar (asymmetrical pre-shoot and overshoots or ringing) may result from static phase errors. This is shown in Figures 9, 10, 11, and 12. These show that with synchronous detectors, it is very important to know that the carrier static phase error is negligible

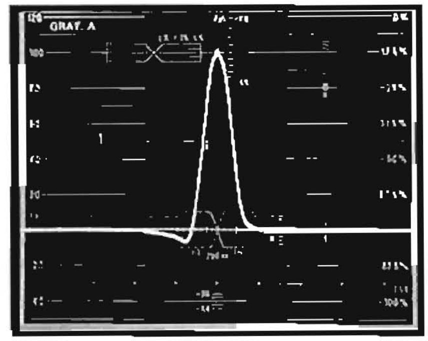

Figure 9.

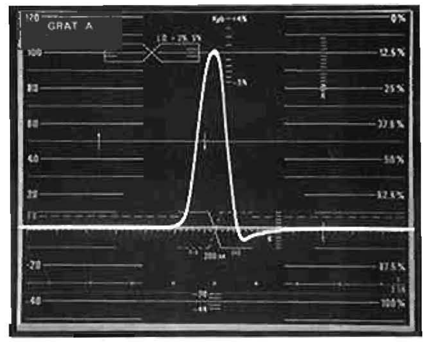

Figure 10.

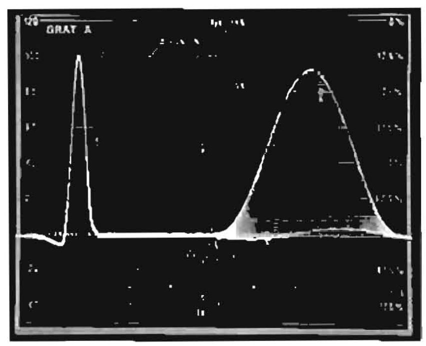

Figure 11.

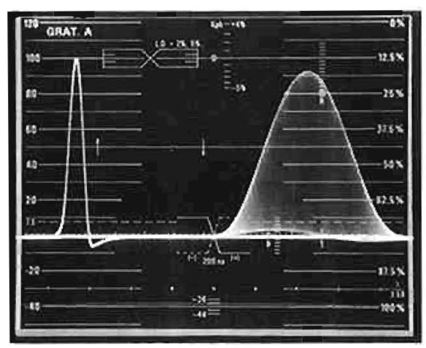

Figure 12.

(3)See F.C.C. Rules and Regulations § 73.682(a), § 73.687(a) and § 73.1590(c)

Transient distortion caused by carrier phase errors can be completely corrected with suitable baseband time domain equalizer. However, such corrections are entirely incorrect.

The TEKTRONIX 1450 Demodulator has two synchronous detectors operating in phase quadrature, i.e., 90° apart. The video signal is normally obtained from the in-phase detector. The output of the quadrature detector will be zero when the static carrier phase is correct. A small static phase error will decrease the video output of the in-phase synchronous demodulator slightly, but, more importantly, it will also cause a video signal to appear at the quadrature output where it is not normally present. The quadrature output provides a **very sensitive** means to check for carrier static phase error.

The null condition at the output of the quadrature detector is exploited in the design of the TEKTRONIX 1450 as the means to calibrate its carrier static phase. For accuracy, it depends only upon the electrical length of the delay line between the two synchronous detectors. This delay must be 90° at the picture I.F. carrier frequency (about 24 MHz). To check the static carrier phase error, the in-phase video output is connected (as usual) to the vertical input of the test oscilloscope and the quadrature output to the EXT HORIZ input. TEKTRONIX'S 1480-Series Television Waveform Monitors have a convenient provision for X-Y inputs to be used for such purposes. (The test setup is shown in Figure 13.)

The demodulator's zero carrier reference pulse is required for this test. It is used to position the oscilloscope trace. With zero static carrier phase error and using sync tip carrier reference, sync tips will appear **directly** below the zero carrier reference pulse (see Figure 14). The photographs in Figure 14 were taken using the special graticule, P/N 331-0393-12, (which is provided with each 1450) for the TEKTRONIX 1480. With normal vertical sensitivity, and the horizontal magnifier at X25, each radial corresponds to 2° in phase

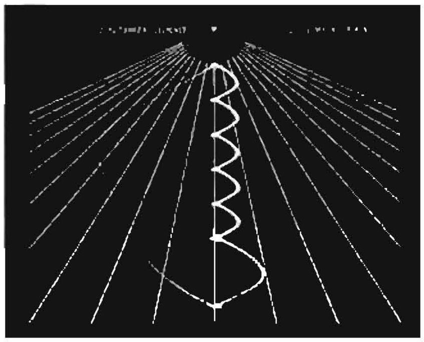

Figure 14.

The test described above is valid when the carrier is being regenerated by sampling sync tips. The TEKTRONIX 1450 provides selection of sync tip or backporch or continuous sampling of video for the carrier phase reference. (If backporch carrier reference is used, the blanking pulses should then lie directly beneath the zero carrier reference on the display.) Do not use 'continuous' to check the static carrier phase error because incidental carrier phase modulation in the transmitter or test modulator may introduce errors.

In summary, even a small static phase error in the locally generated carrier will lead to serious errors in the waveforms obtained by synchronous detection. In the TEKTRONIX 1450 a sensitive means to quickly verify any such error in the field is provided. This test is valid even if the transmitter has incidental phase modulation.

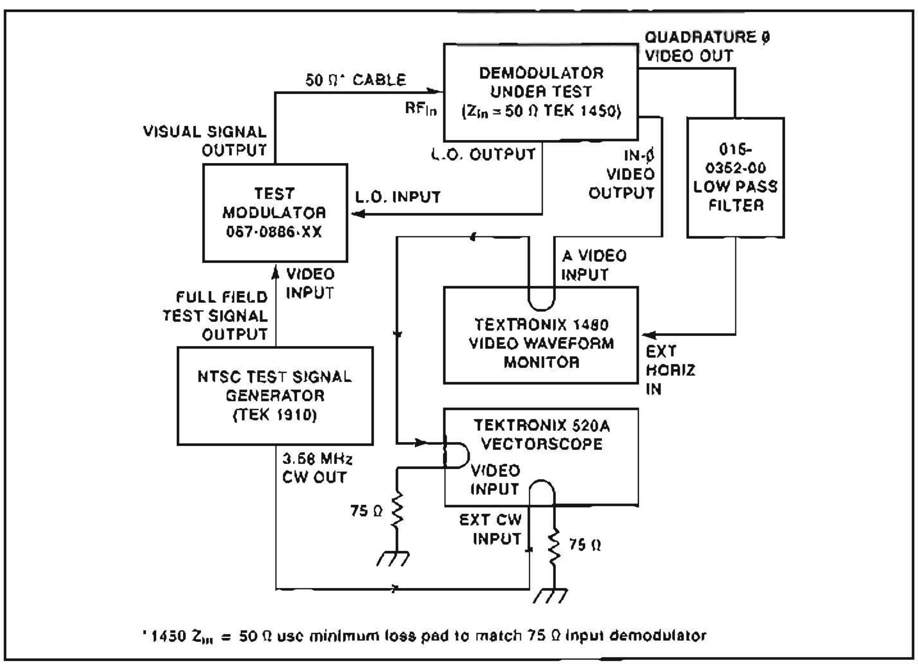

Figure 13.

PART IV

Incidental Carrier Phase Modulation (ICPM)

Ideally, the picture transmitter amplitude modulates the picture carrier and does not incidentally introduce any phase modulation.

Phase modulation of the visual carrier may cause "intercarrier buzz" in home receivers, and it may cause differential phase.

Phase modulation of the visual carrier may occur in the modulated amplifier stage either due to improper neutralization or, with diode modulators, due to modulator imbalance. It also may occur in the linear RF amplifier stages, especially in klystron amplifiers. Regardless of what causes ICPM, intercarrier buzz may be the result. When arising from modulator imbalance or improper neutralization of the modulated amplifier, ICPM will cause differential phase with envelope detection, but not with synchronous detection. As virtually all home receivers today use intercarrier sound and envelope detection, both sound and picture impairments may result due to this source of ICPM.

Occurence of ICPM in the linear RF amplifier stages of the visual transmitter may cause differential phase, the amount being potentially greater with true synchronous detection.

Of course, it is possible to have some differential phase occuring in the baseband modulation signal, and it is also possible for ICPM to occur in the signal due to all causes listed above.

In the exceptional case where the aural carrier is amplified in a common stage with the visual signal, intercarrier buzz (due to ICPM in the linear stage) will not occur.

When caused by modulator imbalance or improper neutralization of modulated amplifiers, ICPM will generally introduce maximum distortion at white (low carrier level). With klystron linear amplifiers, distortion is generally worst at sync tips (full power).

The relationship of "sync buzz" and ICPM between blanking and sync tips is presented in Table 1. As this audio noise is not random, it should be expressed in terms of peak-to-peak noise, with respect to ±25 kHz deviation of aural carrier. The table does not take into account the ICPM-caused audio noise produced by picture signal. That can be calculated only for specific, simple picture signals. A baseband full-field test signal consisting of sequences of all white and all black lines, as shown in Figure 15, can be used to objectively measure intercarrier noise which is picture-content related. Referring to Figure 15, the test signal produces audio noise whose fundamental frequency, 2 kHz, is low enough that it is not attenuated by the 75 μsec de-emphasis filter, and yet is close to the audio frequency to which, at low sound levels, the ear is very sensitive. Thus, it is a worst case situation which can be used to determine acceptable S/N (P-P). Such a test signal can be generated by feeding 660 mv *square* wave at 2 kHz rep rate to the auxiliary video input of the

TEKTRONIX 147A test signal generator. Place in AUX MODE, derive output from PREVIEW MONITOR OUTPUT. Adjust PEDESTAL CONTROL for 7½% set up. Positive peaks of this test signal should be at 100 IRE.

Table 1. Sync Buzz Due to ICPM

ICPM	Intercarrier Sound S/N ratio (dB) w/o de-emphasis	With 75μ de-emphasis
1°	−57.9	−75.0
2°	−52.4	−69.5
3°	−48.8	−65.9
4°	−46.3	−63.4
5°	−44.4	−61.5
6°	−42.8	−59.9
7°	−41.5	−58.6
8°	−40.3	−57.4
9°	−39.3	−56.4
10°	−38.3	−55.4

NOTE: Calculated on the basis of an all-black picture. This is the picture signal that establishes best possible audio S/N. Typical pictures will generally reduce S/N even further.

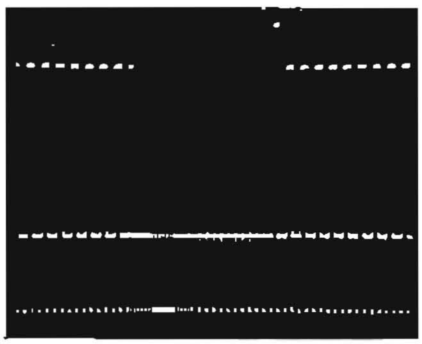

Figure 15.

Figure 16 shows audio noise due to picture signal ICPM with the test signal described above. As sync buzz and picture-related noise are not random, they should be measured on a peak-to-peak basis, not r.m.s. as is the practice for random noise. The high peak to r.m.s. ratio of such noise suggests that while the r.m.s. value might be low, it would still be discernible to the ear.

Although not required by F.C.C. rules for monophonic operation, it is good engineering practice to know how much ICPM is occurring in the transmitter. It may very well be reduced.

Using the setup illustrated in Figure 13, we can measure ICPM directly. For this measurement SYNCHRONOUS TIME CONSTANT SWITCH should be set to SLOW.

The test signal is one of the familiar linearity test signals. Either a ramp or staircase is suitable. The ramp is preferred; however, we have used a 5-step staircase in Figures 14, 17 and 18 as it is more graphic. It must extend from blanking to peak white. Subcarrier modulation is not required.

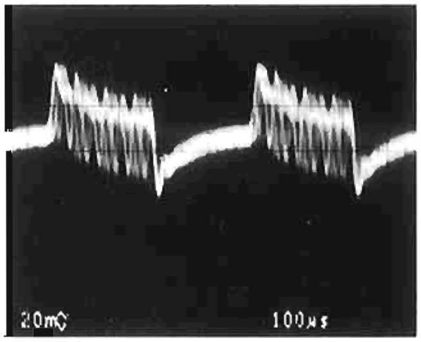

Figure 16.

ICPM is not present in Figure 14 as all of the dots (staircase treads) lie in a vertical line below the zero carrier reference dot. Sync tips show a 0.5° phase error in Figure 17 where the backporch reference is used for the carrier.

The p-p ICPM is 5° in Figure 18. These displays show the in-phase vs. the quadrature-phase components of the output of the transmitter between 100% and 12½% modulation. This distortion can be easily measured with a TEKTRONIX 1450 Demodulator using synchronous detection. It cannot be measured with envelope detection, nor can it be measured using a demodulator that is not equipped with two quadrature-phased synchronous detectors. A lowpass filter should be used to filter the quadrature phase signal and fed to the external H input. A suitable low pass (~250 kHz) filter is Tektronix's part number 015-0352-00. The 1480 vertical response must be "LOW PASS." Where an X-Y scope is used, both inputs should be band limited by this or similar low pass filters.

USE OF THE TEK 1480 AS X-Y SCOPE

It may be impossible to obtain a display when a TEKTRONIX 1480 being used for this purpose is first connected because the beam current is cut off. This may be remedied by moving a connector as described in the Instruction Manuals. See Schematic 9 note, 1480 Series manual (B 060000 up). Instruments are shipped with the jumper installed in a position to inhibit the beam current when using the EXT HORIZ input mode. Lead #1 in connector P4940 is to be moved to connector slot #2 same connector. This is located at rear of the SWEEP BOARD, underside of instrument.

ICPM occurs in the transmitter and results in a quadrature video output which is a non-linear function of modulation depth. Static carrier phase error may occur in the demodulator. It results in a quadrature output which is not zero at the sync tips if they are used as the reference for carrier regeneration, (or at blanking level if this is selected for carrier regeneration). The synchronous detection mode should be checked to determine that static phase error is negligible before any adjustments to a transmitter are attempted, and before conducting a "proof of performance."

Means to measure both ICPM and static phase error have been described.

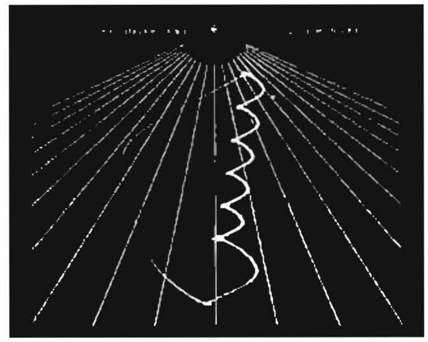

Figure 17.

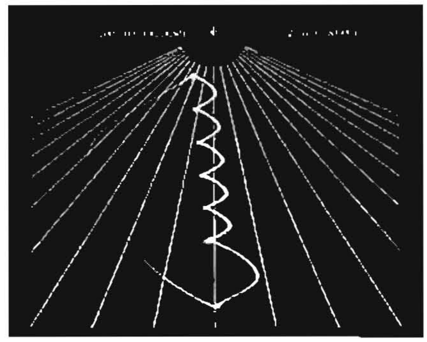

Figure 18.

PART V

Carrier Phase Noise — A New Color Selective Source of Noise

We have discussed static carrier phase error in synchronous demodulators and shown how to measure it in the TEKTRONIX 1450. Any instantaneous carrier phase error will introduce noise in those parts of the picture which contain color; the more vivid the color, the more noise will be observed.

A powerful test signal to measure carrier phase noise occurring in a synchronous demodulator is the modulated pedestal, or "pink panther pulse" shown in Figure 19. This is generated by the TEKTRONIX 1410R and 1910 NTSC Signal Generators. Unlike other sources of noise, carrier phase noise appears only where chrominance levels are high and, in fact, it vanishes when chrominance vanishes. Thus, the part of the screen where chrominance is equal to 80 IRE would appear noisy with respect to the remainder of the test line. No noise is observed to the right where chrominance is equal to zero IRE.

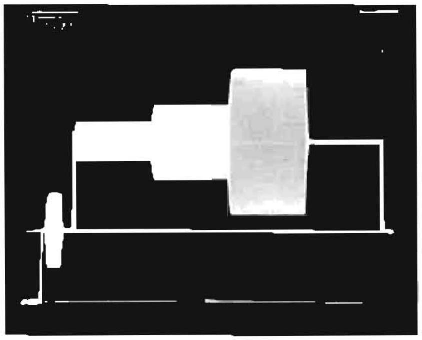

Figure 19.

As the input signal to the demodulator is reduced, the signal-to-noise ratio (S/N) at the video output decreases, therefore, it is reasonable to expect carrier phase noise to increase. Unless the carrier regenerator is exceptionally well designed, this may very well limit the minimum usable signal level for synchronous demodulation. This noise should, therefore, be measured in order to fully evaluate any demodulator which employs synchronous detection. A practical test signal to measure carrier phase noise is shown in Figure 19. To measure carrier phase noise, we shall measure the phase noise on the 80 IRE chrominance component of this test signal. There is a one-for-one correspondence between carrier phase noise and chroma phase noise.

Chroma phase noise is measured using the double trace differential phase display of the TEKTRONIX 520A Series Vectorscopes.

The test signal's chrominance component is synchronously demodulated by the vectorscope, using the C.W. color subcarrier, directly from the signal generator as shown in Figure 13. For this test, the vectorscope's subcarrier phase reference must be switched to external, not the burst controlled oscillator in the vectorscope.

The measurement technique to be used is called Tangential Noise Measurement (Ref. 2 and 3). The r.m.s. value of the noise is one half the offset signal amplitude (p-p). The offset signal, in the case of phase noise, is simply a phase offset and can be generated in the 520A by the circuitry responsible for the double trace display used to measure dØ (Ref 4). This circuitry reverses the phase at H rate. If the phase is +2° on one TV line, it is 180°-2° on the next line. At the output of the chroma demodulator, this results in square wave of 4° p-p amplitude.

Figure 20 shows the test signal having phase noise, demodulated with phase offset greater than the phase noise. There is a clear separation between the two distinct traces. Figure 21 shows the same signal with phase offset smaller by 1°, but still greater than phase noise. In Figure 22 the phase offset is exactly equal to two times r.m.s. value of the phase noise. Here the traces are tangential. When tangential, there is uniform brightness at center of the display. This condition is remarkably reproducible. It occurs because the two Gaussian distributions of trace intensity add in between the traces to form a region of constant intensity (Ref. 2). This condition exists when the traces are separated by a distance (phase) equal to two times the r.m.s. (phase) noise.

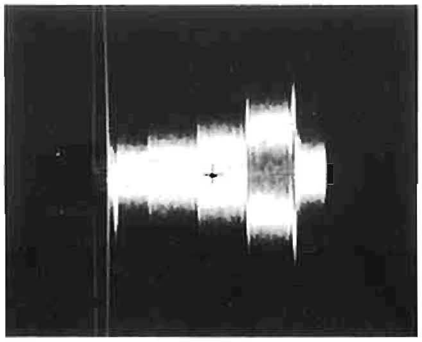

Figure 20.

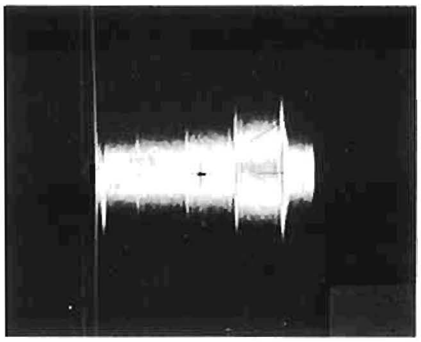

Figure 21.

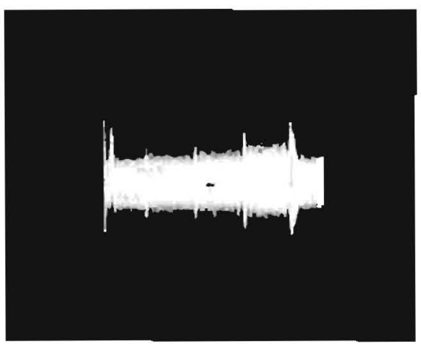

Figure 22.

With phase offset less than phase noise, the traces overlap, and the resultant trace is brighter at its center, due to this overlapping. This overlapping is not obvious to the observer.

Now the test procedure can be detailed:

1. Set calibrated phase shifter to −15.0°.
2. Adjust Goniometer to obtain complete trace separation as in Figure 20.
3. Adjust Calib Phase Shifter to make the traces tangential, i.e. constant brightness across central region. (as in Figure 22.) Note dial reading. For example −8°.
4. Continue rotation Calib Phase Shifter past where traces overlay to where they are again, well separated.
5. Now turn Calib Phase Shifter back (in opposite direction) to once again make the traces just tangential. Say +7.6° Always approach tangency from complete separation, never from an overlapping situation.

   NOTE THIS SECOND READING.
6. Sum of the two readings is twice the r.m.s. phase noise measured, so phase noise measured = 7.6° − (−8°) = 15.6° ÷ 2 = 7.8° r.m.s.

The chrominance channel bandpass of the 520A Series vectorscopes is about 0.6 MHz, therefore, phase noise is being measured over a 0.6 MHz band, which should be entirely adequate.

In Figure 23, (top) envelope detection is used with the same RF signal level as before Observed noise level is independent of the subcarrier level.

Figure 23, (bottom) shows the test signal synchronously detected, at the same RF signal level. Where sub-carrier is present, a much higher noise level is observed. This particular demodulator had chroma phase noise at this RF signal level, but, of course, only in its synchronous detection mode.

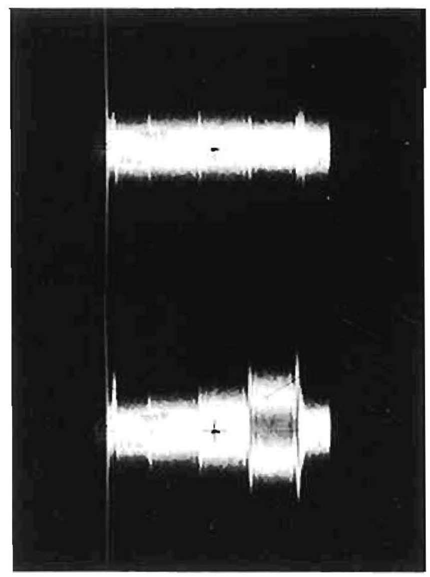

Figure 23.

Measurements made at several RF signal level inputs will establish the carrier phase noise versus the RF level. This may be the effective sensitivity limiting factor of some demodulators in their synchronous mode.

At minimum usable signal level with the TEKTRONIX 1450 it is found that there is no discernible increase in noise where subcarrier is present. Hence, its usable sensitivity is the same for both synchronous and envelope detection modes.

This application note should help in measuring phase noise characteristics of TV receivers and demodulators, and may be especially interesting in testing demodulators used in CATV systems as phase noise is passed on to all subscribers, or where OFF-AIR pickup of network programming is used to feed the station.

PART VI

Monitoring the Depth of the Visual Modulation

F.C.C. rules refer to the envelope of the radiated visual signal. Synchronously detected and envelope-detected video may show a difference in modulation depth for either blanking or white. These differences may be due to ICPM or envelope detector non-linearity. For example, if ICPM (in the transmitter) from blanking to sync tips is, say 15°, sync will appear compressed about 22% when synchronously detected relative to when envelope detected. Likewise, if ICPM from zero IRE to 70 IRE (as referred to the video input signal) is 10°, the phase of the VIR signal will differ from that of color burst phase by 10° when synchronous demodulation is used as compared to envelope detection, and the VIR signal amplitudes would also be in error.

Because envelope detectors are used in home receivers, any correction of phase based upon the VIR (or upon a VIT) signal should be made using envelope-detected video, unless the ICPM of the XMTR is known to be negligible. For this reason, the TEKTRONIX 1450 demodulator is designed so that synchronous or envelope detection can be selected either from the front panel or by remote control. The 1450 instruction manual explains how this function can be remotely controlled.

By definition, the video voltage during sync tips represents peak power or 100% modulation. Blanking level is nominally 75% of the sync tip voltage, corresponding to 75% modulation. Peak white level is nominally 12½% of the sync tip voltage, corresponding to 12½% modulation. The tolerance on both is ±2½%.

It is essential to establish the zero carrier level at the output of the demodulator in order to measure modulation depth. This used to be accomplished using an electro-mechanical 'chopper,' but a zero carrier reference pulse is now electronically generated in demodulators during the vertical blanking interval. This reference pulse is used to cut off the picture IF amplifier so that the output of the video detector corresponds exactly to zero carrier during this interval. That is, by cutting off the picture IF amplifier, the picture IF signal is modulated down to zero percent by this pulse. In this way, the video output during the zero carrier reference pulse represents precisely zero carrier voltage. Special means are employed in 1450 to be sure of the validity of this level with both synchronous and envelope detection, but the explanation of that process is beyond the scope of this application note.

One of the serious shortcomings of envelope detectors is their poor linearity at low carrier level, around white (12½%). Television demodulators use various means to correct the non-linearity of the envelope detector. Small non-linearities in envelope detectors affect accuracy when measuring the modulation depth at peak white. This is shown in Figures 24, 25 and 26. It is desirable to be able to measure the amplitude linearity of the envelope detector in the field. A very simple method used to accomplish this is to modulate a picture carrier with a test signal which includes a line-rate ramp or staircase (no subcarrier). The TEKTRONIX R147A provides this test signal. The full-field test signal is fed to the AUX VIDEO input on the front panel of the generator. The R147A is switched to AUX INPUT, and the output is then taken from one of its PREVIEW MONITOR outputs. This signal is applied to the test modulator. Figure 24 shows poor linearity of an envelope detector, using the ramp test signal. By adjusting the AUX PEDESTAL control, located on the front panel of the R147A, the ramp can explore modulation levels extending from below blanking to zero percent carrier pulse, as shown in Figures 27 and 28.

By observing the ramp recovered by the demodulator under test and by using the zero carrier pulse and sync tip as reference levels (0% and 100% respectively), it is possible to detect even small changes in the slope of the ramp as a function of modulation depth. In Figure 28, the AUX PEDESTAL control has been adjusted to a point where the ramp modulates carrier to 2%. Even when the ramp in Figure 28 reaches 2% carrier, no evidence of non-linearity is observed on the TEKTRONIX 1450's envelope-detected video output.

The video detector is specified linear to <3% carrier when the TEKTRONIX 1450 Demodulator is in the envelope-detection mode. It is entirely linear to zero percent in the synchronous detection mode. This can be verified by using the procedure described above.

While this application note is by no means all-inclusive, it does provide useful information about how to measure the performance of demodulators which employ envelope and synchronous detection. It also explains how to measure the ICPM of the transmitter and discusses the effect of ICPM upon both envelope and synchronously detected video signals and on monitoring modulation depth.

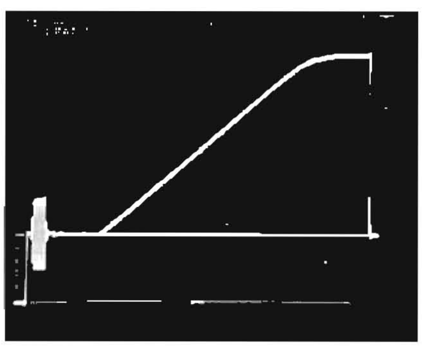

Figure 24.

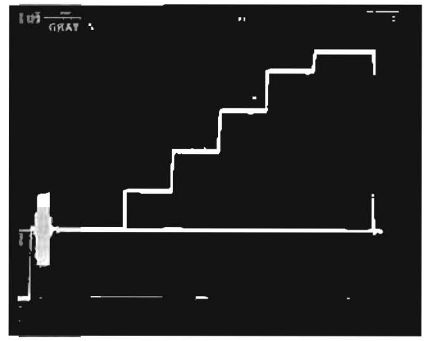

Figure 25.

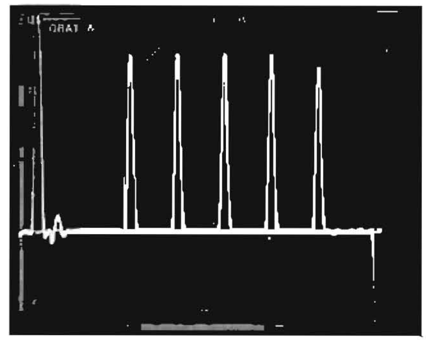

Figure 26

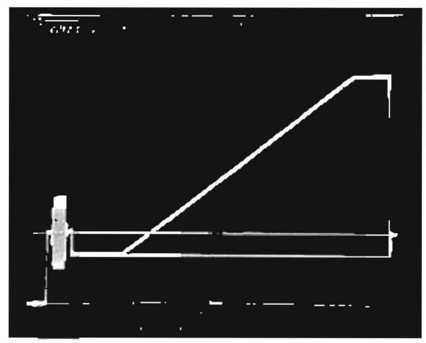

Figure 27.

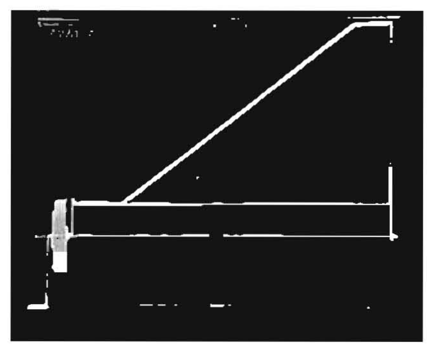

Figure 28.

PART VII

Monitoring Off-air Signals

As more stations go to unmanned transmitters, remote monitoring of OFF-AIR signals is becoming more commonplace.

While every engineer is well aware of ghosts and their cause, multipath reception, it isn't so obvious when there is only a small delay in the multipath so that the "ghost" is not distinct, i.e., delay difference less than 1 µsec. With close-in echos, frequency response over the video frequency spectrum can vary drastically. While an echo can add +6 dB, it can, with equal probability, completely cancel the signal at a specific frequency.

Not all echos are picked up by the antenna. Reflections from the demodulator's input impedance not being well matched to the coaxial cable used give rise to close-in echos and consequent frequency response distortion.

It is never easy to obtain low input voltage standing wave ratio in design of a demodulator. Regardless of excellence of design, best results are always obtained with some RF attenuation in the feed line to improve V.S.W.R. Any change in frequency response with RF attenuation indicates poor input V.S.W.R. characteristics or "Miller Effect" detuning with RF/IF gain variations.

With the TEKTRONIX 1450, no "Miller Effect" RF/IF selectivity changes can occur as its RF/IF amplifiers operate at constant gain. A.G.C. action is obtained using voltage controlled RF/IF attenuators (PIN diodes).

We strongly recommend operation of 1450 with at least 10 dB RF attenuation to get best possible input V.S.W.R. Twenty dB is even better, if signal level is adequate, (not too frequently the case).

Input impedance of 1450 is 50 ohms.

As input V.S.W.R. is so extremely important for measurement accuracy, we recommend use of high quality 50 ohm coaxial cable in a single piece from antenna to demodulator.

Use of 75 ohm coax requires a matching device, either a minimum loss pad 75 Ω to 50 Ω or matching transformer. If such are to be used, their V.S.W.R. must be taken into account. Great care is urged if 75 Ω BNC connectors are used. Such connectors are less robust than their 50 Ω look-alikes, and may be damaged if accidentally coupled to 50 Ω BNC

PART VIII

Measuring vs. Monitoring

Usually the terms measuring and monitoring are used interchangeably.

There is a very important distinction between these terms when applied to use of a demodulator.

E.I.A.'s Demodulator Standard (Ref. 5) associates "measurements" with the wideband frequency response a demodulator provides with its sound trap OFF. The EIA Demodulator Standard associates "Monitoring" with uses of the demodulator where the frequency response is limited by the sound trap.

Measurement of frequency domain and time domain test signals requires the demodulator's own bandpass to be greater than that of the transmitter. To operate WIDEBAND, the aural transmitter is shut down, hence (some) measurements can be made only on an out-of-service basis. In its measurement mode, there is no group envelope delay in the demodulator. To measure time domain test signals, the transmitter's precorrector (F.C.C. § 73.687 a.3) must be switched off. Its effect is to introduce a chrominance-luminance delay (RCT) of − 170 ns, a sinusoidal baseline distortion to the 12.5T modulated sin² pulse of 17% p-p, as shown in Figure 29.

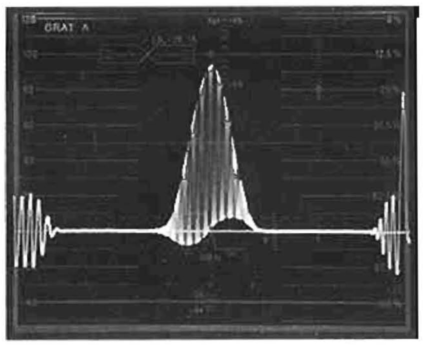

Figure 29.

Monitoring the transmitter's performance on an in-service basis requires the sound trap, and this affects the waveforms of VITS.

Those VIT signals normally used for remote monitoring of unattended transmitters are shown in Figures 30, 31 and 32 with the Tektronix demodulator operating in its wideband, synchronous "Measurement" Mode #1 per Ref. 5 (Delay pre-correction switched out.)

Waveform Figures 33, 34, 35, and 36 show these test signals synchronously demodulated with sound trap in, i.e., "Monitoring Mode". (Delay pre-correction IN).

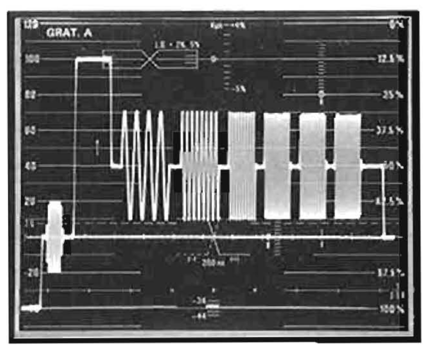

Figure 30.

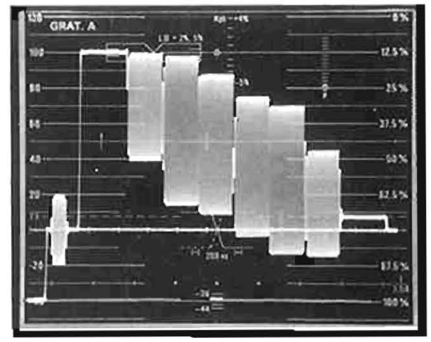

Figure 31.

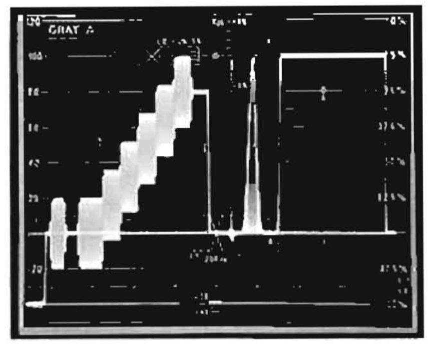

Figure 32.

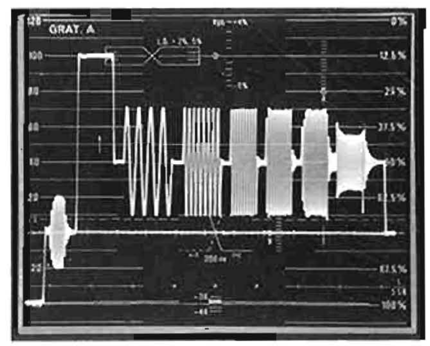

Figure 33.

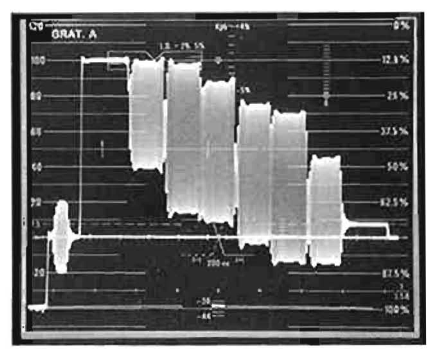

Figure 34.

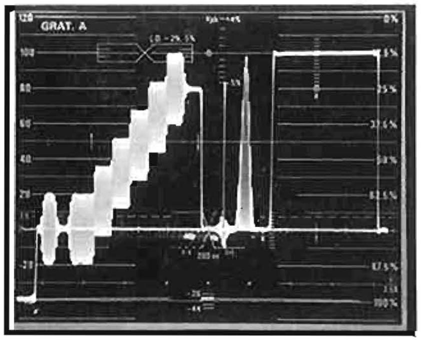

Figure 35.

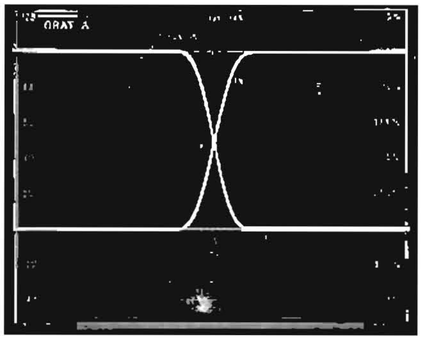

Figure 36.

Some stations may wish to use the same V.I.T. signals to monitor their transmitter that are being used by the major TV network in the U.S. (Ref. 6,7)

Waveform photos of these signals as recovered by the demodulator in the monitoring mode are shown in Figures 37, 38, and 39.

Quite noticeable differences in the edges of the bar signals are noticed when the two composite test signals, Figures 36 and 39 are observed in the "Monitor Mode." The F.C.C. composite signal's bar rise time is 250 ns (2T bar transitions). Its frequency spectrum is limited to 4 MHZ. The NTC/CCIR composite signal has 125 ns (1T) rise time so its spectrum extends to 8 MHZ. The ringing observed in this signal (Figure 39) is due to the bandwidth restriction in the demodulator; i.e., its sound trap. Ringing could be produced in the transmitter. If so, it would be more pronounced in the "Measurements Mode." If occuring in the demodulator, it should vanish in the measurement mode.

The IEEE Standard on measuring short time linear waveform distortion requires the bar transitions to have 1T (125 ns rise time). This measurement simply cannot be made using the F.C.C. VIT signal. However, Tektronix test signal generators can be easily set up to provide 125 ns r.t. (1T) bar transitions when it is desired to measure short time linear waveform distortion. The demodulator's "measurement" mode only must be used, of course.

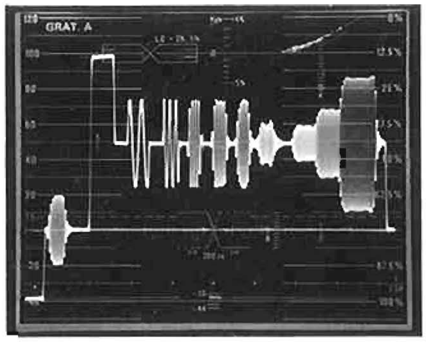

Figure 37.

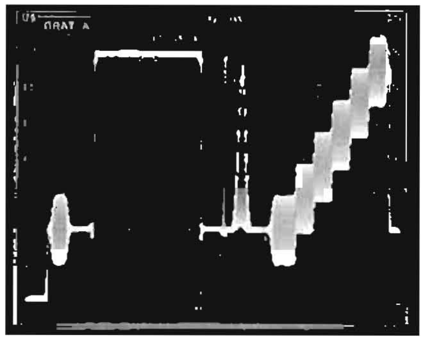

Figure 38.

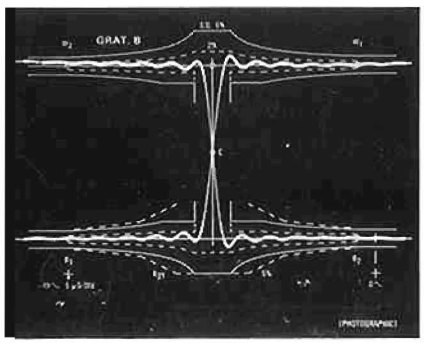

Figure 39.

The spectrum of the multiburst signal of the NTC/CCIR combination test signal (Figure 37) is somewhat broader than that of the F.C.C. multiburst (Figure 30) as the bursts are of shorter duration. This accounts for the differences observed between these signals in the monitoring mode. There are also differences in frequencies, especially 4.- vs. 4.2 MHz for last burst.

A word may be in order concerning monitoring of modulation depth of color burst using a spectrum analyzer. Due to the resolution bandwidth (@ −6 dB), usually 300 kHz, color burst modulation depth measured on a spectrum analyzer will be less than that measured using a demodulator. This is also true of measurements of frequency response using any multiburst test signal. To make such measurements, a correction factor must be applied, taking into account spectrum analyzer's resolution bandwidth (@ −6 dB) and the duration of the individual bursts.

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6. Network Transmission Committee Report No. 7.
7. C.C.I.R. Rec. 473 Annex II.

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