A TECHNIQUE USING SEVERAL DELAY LINES TO CORRECT FOR MULTIPLE GHOSTING AND POOR FREQUENCY RESPONSE DUE TO MULTIPATH

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Ghosting on received television pictures can be minimized by directive antenna arrays if the reflected signal arrives at a significantly different angle than the desired signal. When the angle between the desired and undesired signal is small, this method is not feasible and other methods are used.

This paper describes a method of minimizing the effects of ghosting by branching the received signal into a multiplicity of parallel paths of different delay times and recombing the result into a single feed for the active processing equipment. Methods of estimating the required delay times from the detected waveform are discussed. The equipment and technique for evaluating the results are discussed with the aid of photographs and plots of an actual case.

Broadcast signals which would optimize the adjustment of this equipment at the receiving site are discussed.

This technique provides an answer to a common problem that usually goes uncorrected, or has rather expensive alternates.

Television and television ghosting came into being at the same time. With the vast increases in technology, it would appear that little knowledge could be added as to the effect, causes and remedies of ghosting on television pictures.

Ghosting that occurs during the transmission of television signals is due to more than one propagation path, and the time delay differences due to differences in the length of paths the transmitted signals travel.

Short differences in delay times affect frequency response causing problems with color and definition of picture.

Elimination of reflected signals occurring in the small cone in the direction of the wanted signal, a 5° arc in any direction from the direct line with antenna phasing or arrays are not practical.

The effect of reflected signals from within the small cone may be minimized by branching the received signal into multiple paths through parallel and series coaxial cable delay lines, and then combining so that the resulting signal through the delay lines will then minimize the effect from the received multipath signals.

The technique will first be described and later its application to a specific case.

The method for estimation of delay time of the individual component delay lines consists of a careful examination of the demodulated waveform.

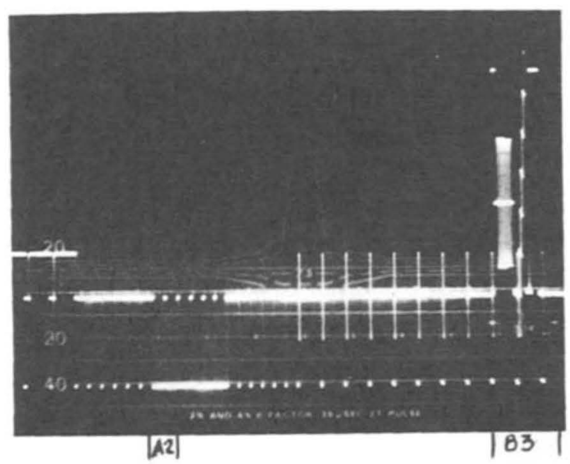


FIGURE 1. Laboratory generated television video signal vertical interval. A2 portion expanded in Figure 2. B3 portion expanded in Figure 3.

The first blanking level-to-peak sync step of the vertical sync pulse provides a single step in which to identify polarity as well as amplitude and time delay of multipath signals. The presence of echos on the following peak sync level allows timing measurements out to approximately 30 microseconds.

A horizontal sync pulse and blank line in the vertical interval provides echo time measurement to near 60 microseconds. The vertical interval test signals (V.I.T.S.) extends the time and frequency domain measurement to less than 10 nanoseconds. Figure 3 shows that the multiburst provides a measurement of frequency response to short multipath delays. The 2T and bar are areas to analyze for time and polarity of multipath delayed signals.

The modulated FM audio carrier of the television signal with its associated frequency domain, FM AM information can be observed on an X-Y scope to identify phase, amplitudes and time delays as shown in Figure 5.

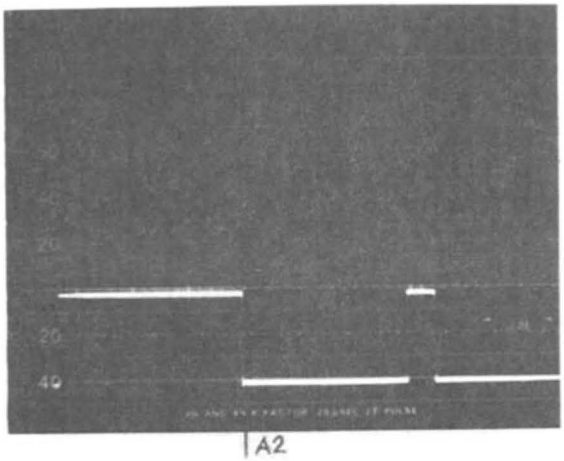


FIGURE 2. First vertical sync pulse.

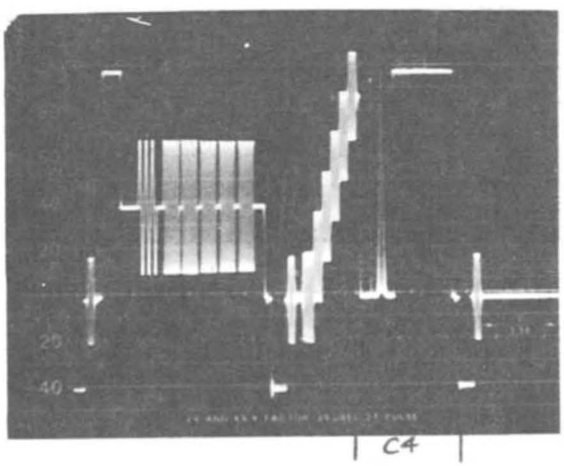


FIGURE 3. One frame of vertical interval test signals, white flag, multiburst, stair step with color, 2T, 12.5T with color and bar.

The direction of the multipath signals can be determined to within a fraction of a degree by phasing antenna arrays.

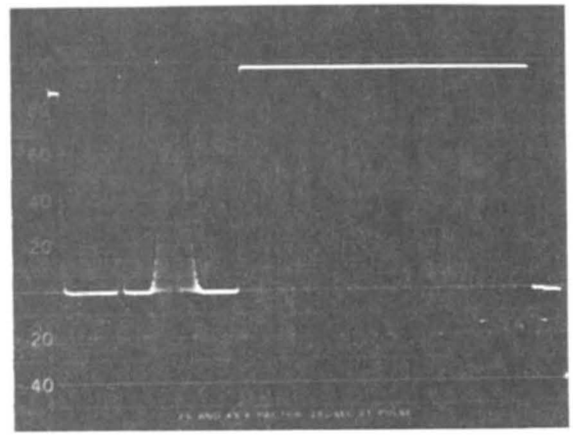


FIGURE 4. Expanded portion of C4, Figure 3. 2T, 12.5T with color and bar.

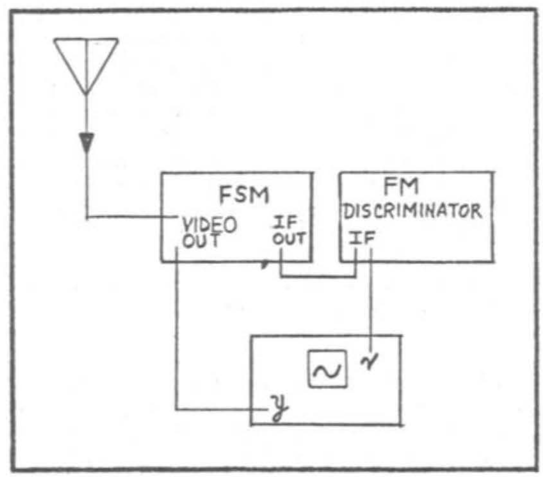
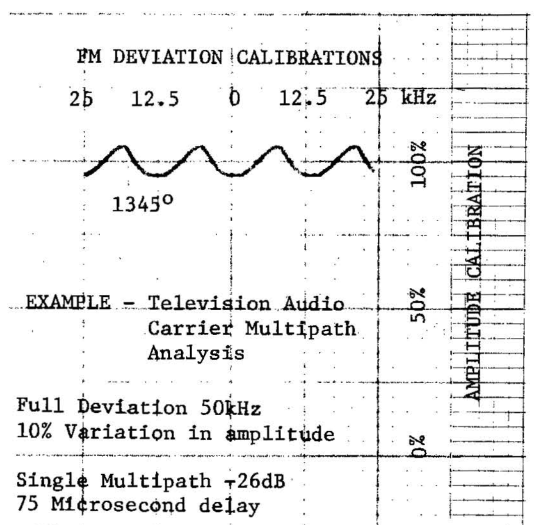


FIGURE 5



A case history showing use of technique.

July 4, 1973, heralded the first telecast in San Francisco from the new Sutro Tower with its candelabra arrangement of television transmitting antenna.

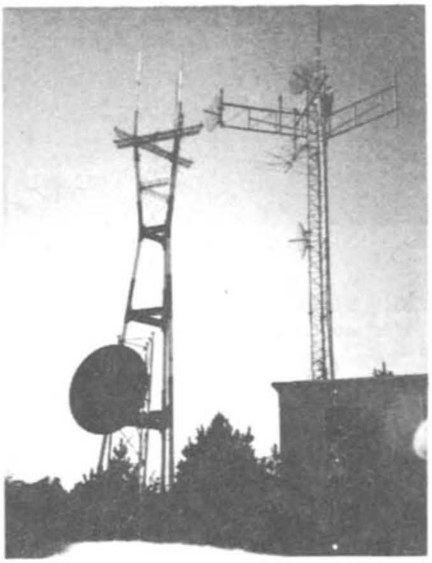


FIGURE 6. Head end site with Sutro Tower in background.

Surprisingly, multipath free signals were not received at the cable system's head end 1,500 feet east of Sutro Tower. Attempts to eliminate multipath by directional antennas and phased arrays indicated nearly all the multipath was originating from the direction of Sutro Tower.

This then confirmed the longer than 2 microsecond multipath delay with an associated very short delay as originating from the transmitting antenna. Other multipaths that affected frequency response were due to the antenna supporting structure. Longer multipath delays to over 60 microseconds originated from large buildings toward the east caused streaking of the picture appearing similar to low frequency response.

Test coaxial delay lines were constructed using RG6 cable and A.B. type switching with incremental control of delays to 2 microseconds in 5 nanosecond steps. (Figure 11.)

Two adjustable delay lines in series were used to cancel the longer than 2 microseconds and its shorter second reflection, as shown in Figure 12.

Delay times were duplicated with fixed coaxial delays and adjustable path loss.

Three adjustable delay lines in parallel were placed in series with the previous fixed longer delay, 2.435 microseconds and .160 nanosecond delay correction. (Figure 13.)

Observing 2T and multiburst frequency presentation, adjustment on all the delays and their attenuation were made for best overall response and pulse shape correcting to near normal.

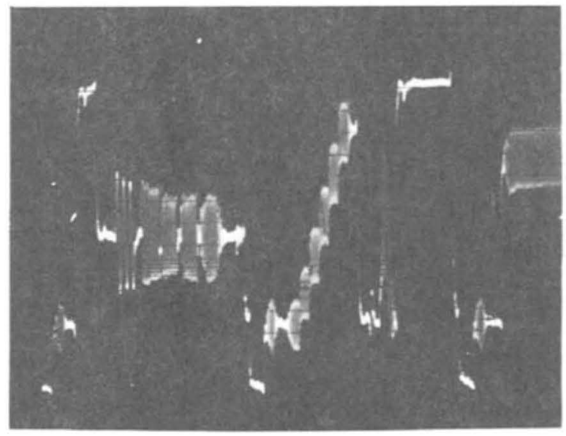


FIGURE 7. V.I.T.S. observed 13,600 feet east of Sutro Tower. The bar portion is expanded in Figure 9(a), the time is taken from the calibration of the waveform monitor. 25 x .25H per CM, 4CM delay

$$\frac{4 \times 63.56 \times .25}{25}$$

equal 2,540 nanosecond, plus a second reflection.

$$\frac{.25\text{CM} - \text{x} \ .25 \times 63.56}{25}$$

equal 158 nanoseconds. Several shorter delays affect the leading edge of the bar, the vector sum of the multiburst also showing short delays.

The delays of each adjustable line were measured and duplicated for permanent use.

The best test of the multiple delayed lines as a means of cancelling multipath was performed with the cooperation of the television station KPIX, Channel 5, engineers.

The television station uses a video sweep of the video transmitter during non-broadcast hours. This allowed testing of the delay lines, as well as giving definite proof of the effects of multipath and its correction. (Figures 16 and 17.)

Incorporation of a video sweep during vertical interval would be a method of thorough investigation or propagation effects on television signals.

Cable television uses "No ghost interference free signal" as a selling point.

Note: The long delay signal of a 2.4 microsecond and 160 nanosecond, has been since corrected in the transmission system, leaving only three parallel delay lines in present use.

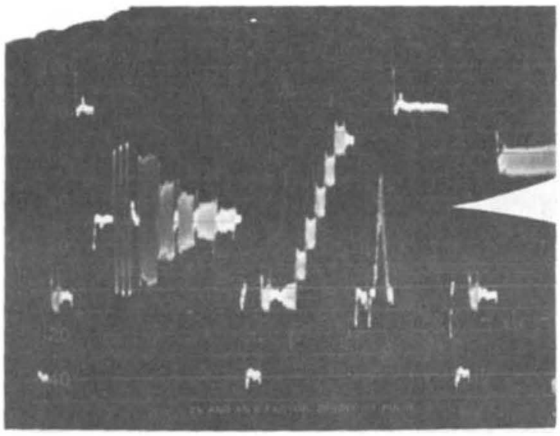


FIGURE 8. V.I.T.S. observed 1,500 feet east of Sutro Tower at head end with approximately some delay, but with opposite vector sum.

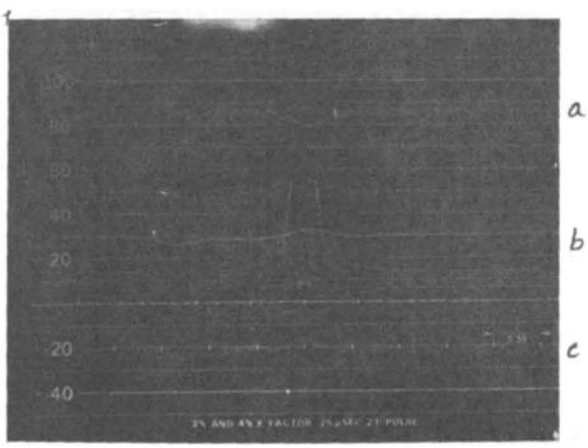


FIGURE 9. V.I.T.S. bar expanded 25 times. "c" portion is expanded bar of Figure 8.

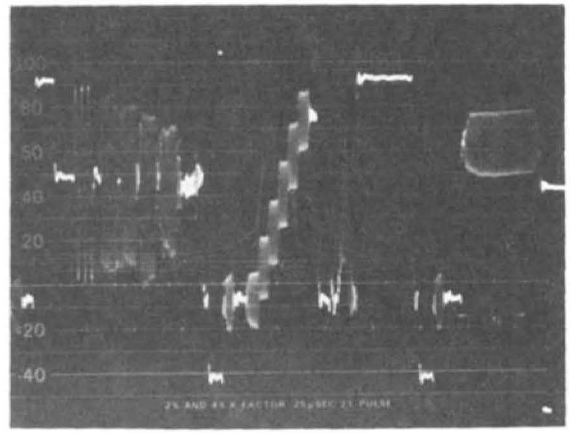


FIGURE 10. Signal, as shown on Figure 8, with corrective delay lines.

This section of delay line constructed in triplicate

Only one section with these delays

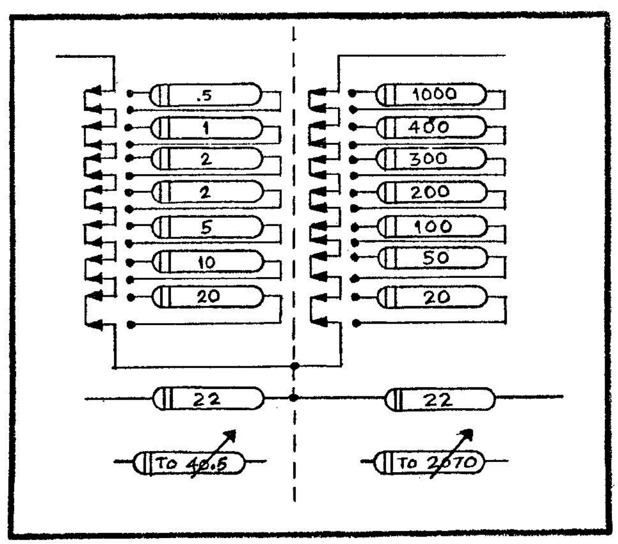


FIGURE 11

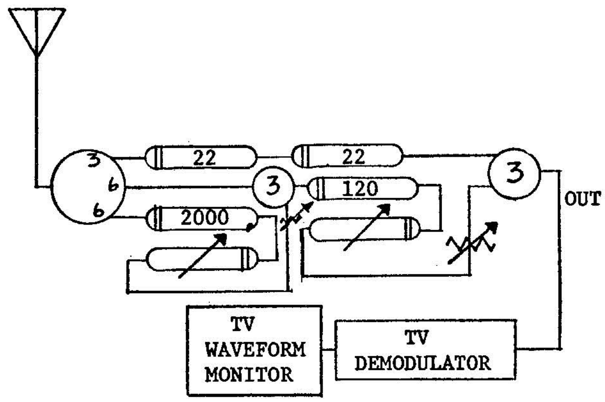
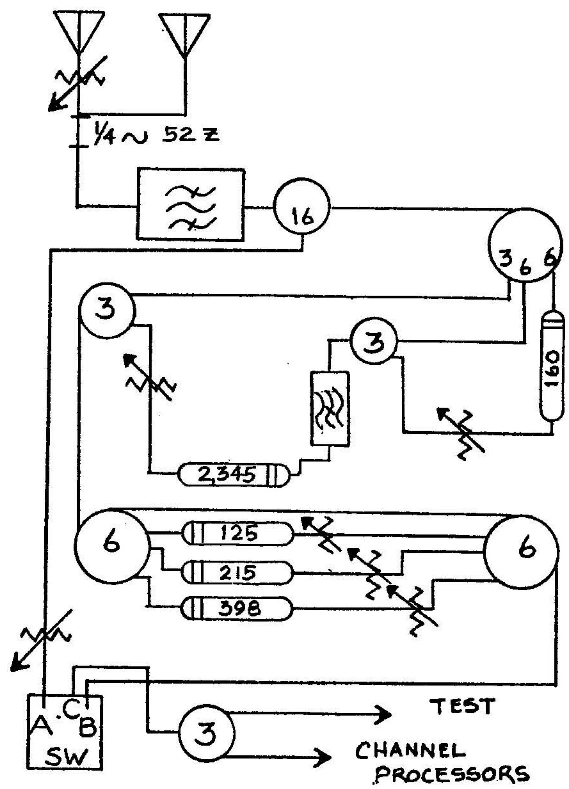


FIGURE 12



MULTIPATH DELAY PROCESSING

Delay time nanoseconds
All attenuators 0-20dB

FIGURE 13

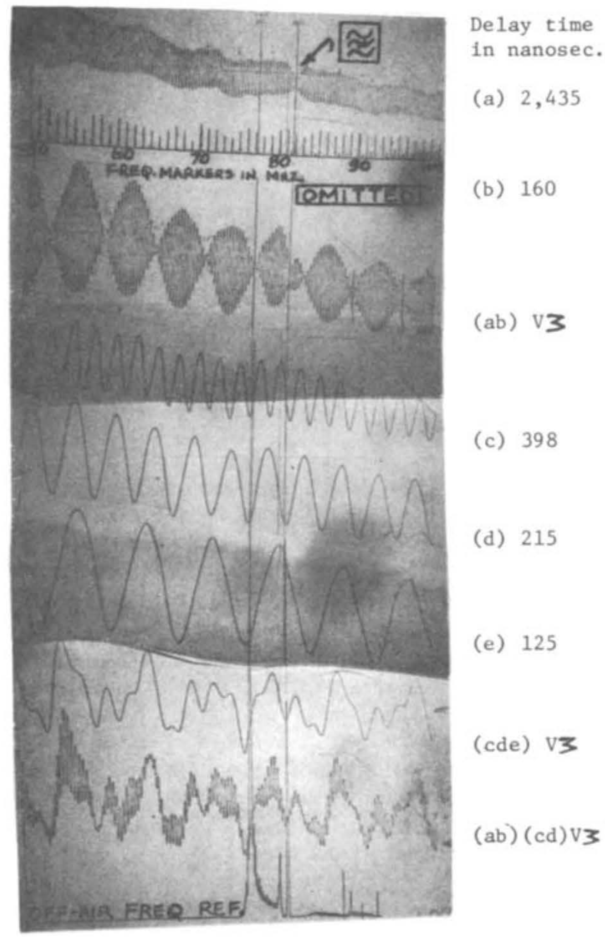


FIGURE 14. X-Y Plots of individual coaxial delay line in reference of RF signal, the combination of each section and ultimate combination. Individual amplitude response to sweep is not calibrated.

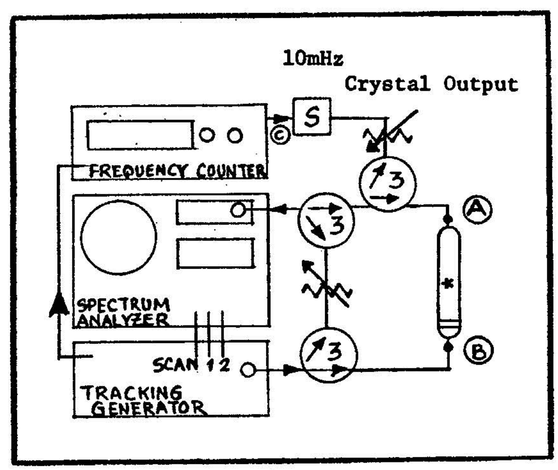


FIGURE 15. Delay Line Calibration with S-Scaler on 10mHz crystal source divided by 10, divided by 100, provides 1mHz and .1mHz calibration of any delay inserted between A and B .

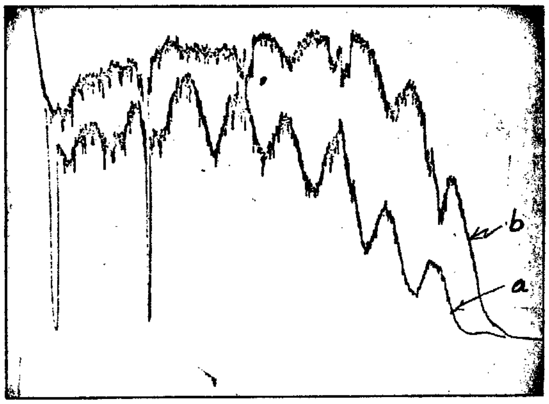


FIGURE 16. Spectrum response to video sweep of station transmitter.
Plot "a" - trace uncorrected.
Plot "b" - corrected response.

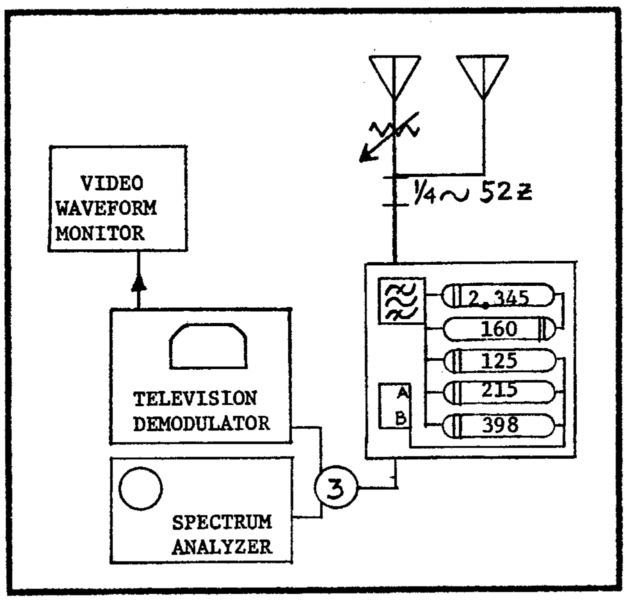


FIGURE 17. Final test of television V.I.T.S. and video sweep.

Research References

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3. Radio Shack Electronics Data Book.

4. A.B.C. Report #26
"Methods of Waveform Testing Pulse and Bar 'K' Factor", by C. R. Wilhelm.

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Thanks to Jim Vaughn, Chief Technician, Viacom Cablevision of San Francisco; and KPIX Channel 5, Engineering personnel: Ray Holtz, Chief Engineer; Don Lincoln, Assistant Engineer; Walt Nichols, Technician Supervisor; Fred Neidert, Transmitter Crew Chief.