TIME SELECTIVE SPECTRUM ANALYSIS
EXTENDING SPECTRUM ANALYZER'S USEFULLNESS

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TIMES MIRROR CABLE TELEVISION

Spectrum Analysis of Radio Frequency Carriers modulated with video, can be made more comprehensive when the time of observation is assisted by a Video Waveform Monitor's timing circuits.

Anyone who has used a spectrum analyzer to observe a television modulated carrier, knows the difficulty in seeing through all the video signals clutter when looking for spurious signals. Spurious signals, V.I.T.S. and other video RF responses can be observed and recorded easily without interference from other ambiguous video signals.

The technique described in this paper will extend the utility of the Spectrum Analyzer and help provide information that was difficult or impossible to record using the previous techniques.

This paper will assume that you have a working knowledge of the Spectrum Analyzer and the Video Waveform Monitor.

THE APPROACH TO THE THEORY OF TIME SELECTIVE SPECTRUM ANALYSIS

The concept is over 10 years old with over five years of useful experience with an occasional new application using this technique.

I will confine this paper to useful application of Analysis of Cable Television signal carriers using Time Selective Spectrum Analysis.

The minimum additional basic equipment to perform the needed functions are:

1. A Radio Frequency Spectrum Analyzer with a Z Axis input.

2. A Video Waveform Monitor with field and line select capabilities and the output of horizontal strobe or the CRT brightening pulse.

3. Time Selective Spectrum Analysis (T.S.S.A.) is accomplished with Z Axis Control Module to condition and control the timing pulses from the Video Waveform Monitor to the Z Axis input of the Spectrum Analyzer.

4. A television demodulator with a base band video output.

5. A means of storing the observed presentation of the Spectrum Analyzer, such as a storage scope and polaroid camera.

EQUIPMENT CONFIGURATION

1. The equipment is connected as shown in the functional diagram, using proper techniques in handling radio frequency and video signals with coaxial cables.

2. The input level of radio frequency carrier of television signals should be of sufficient level to display at least 60 dB of dynamic range of signals above the noise floor of the spectrum analyzer.

3. The Spectrum Analyzer is to be set to scan radio frequency spectrum of interest with the demodulator tuned to the TV Channel which occupies the same frequency.

4. The Video Waveform Monitor line select will display an appropriate line, with the sync select on external, the input select on A-B. (With the input select on B, the Z axis timing pulse is presented)

5. The Z Axis Control Module controls the time delay and duration that the Spectrum Analyzer's Z Axis is turned on. The Z Axis module is triggered by the strobe output of the Video Waveform Monitor.

6. The Spectrum Analyzer is set to scan the frequency range at a rate of from 5 to 25 second per horizontal centimeter, the single scan mode is manually started, the vertical gain is set in the usual manner. The IF bandwidth would use 300,

100 or 30 Kilohertz depending on the desired information.

When all equipment is connected and operating properly, the Spectrum Analyzer CRT is turned off except for the very short duration in time selected by the Video Waveform Monitor and the Z Axis Control Module. The configuration allows repetition of samples of the same duration and time during a television frame, the duration can be from 4 to 65 microseconds at a rate of 30 times a second. The Spectrum Analyzer scans the spectrum that contains the video modulated RF carrier and associated side-band information that the demodulator is tuned to, such as 52 to 62 megahertz for the Spectrum Analyzer and Channel 2 for the demodulator. The short duration that the CRT is turned on is then stored in progression of the scan of the Spectrum Analyzer displaying the amplitude of the R.F. energy that is detected during these short duration that the Z Axis is turned on. The number of samples is dictated by the speed of the horizontal scan of the Spectrum Analyzer and the desired resolution of the recorded data.

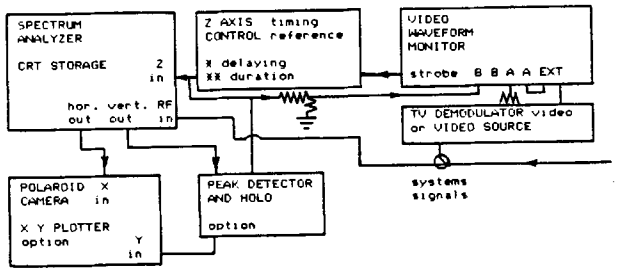
The Video Waveform Monitor is multifunctional. Initially selecting the line in the video frame that is to be analyzed, the horizontal strobe is sent to the Z Axis Control Module. Also displayed with that line is the desired delaying time with the Spectrum Analyzer Z Axis duration time by displacing the normal presentation on the Video Waveform Monitor. The presentation allows critical adjustments to be made on the delaying and duration controls. A small time differential occurs due to the delay in propagation of the R.F. signal through the Spectrum Analyzer of 1 to 3 microseconds depending on the I.F. bandwidth.

The time is rare that you could observe a Cable System when there is no video information being transmitted so that spurious signals can be easily observed with the normal Spectrum Analyzer Techniques. The video signal is made up in such a way that there are times when there is no change in transmitted carrier power and, therefore, no transmitted sideband energy. It is during these short intervals of time that observation of the television channel can be made without the presence of sideband R.F. energy. A blank line during the vertical interval is such a time. 50 millionths of a second is a long enough time when using the technique described here.

The I.F. bandwidth setting of the Spectrum Analyzer will determine the resolution desired, 30 Kilohertz for observing spurious C.W. signals whereas noise level measurements can best be made using a 300 Kilohertz I.F. bandwidth.

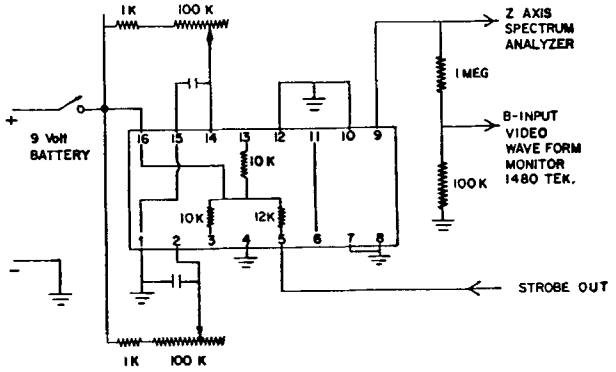
Most observations will be made with the Spectrum Analyzer in the 10 dB log vertical display. The resolution is better than 1 dB. Where comparison of amplitude is a narrow range, such as with the vertical Interval Test Signals Multiburst, then 1 or 2 dB per vertical division provides greater amplitude resolution.

The polaroid photographs are of Spectrum Analyzer stored CRT and the Video Waveform Monitor CRT displays. The plots are from the vertical output of a Spectrum Analyzer and time domain vertical interval test signals are from a Video Test Signal Generator with associated timing delay and duration pulse from the Z Axis Control Module.



FUNCTIONAL DIAGRAM

TIME SLECTIVE SPECTRUM ANALYSIS



Z Axis Control

C-MOS ics
C405IP HEP
CD4098BE RCA
ECG 4098B SYL

ILLUSTRATIONS

Graphic plots are used here as they best illustrate the magnitude of the information that can be observed and recorded.

The plots showing Channels 2 through 5 are as performed on an operating system.

The entire vertical interval is dis-

played with markers defining the start and stop of the selected portion to be analyzed. The next time domain display is of a single horizontal line which is included in the portion of the vertical interval display. The third time domain display indicates the time and duration of the Z Axis Pulse that is sent to the Spectrum Analyzer and to the B input of the Video Waveform Monitor.

The graphic plot is a reduced copy of a standard size graphed plot of a Time Selective Spectrum Analysis with a greater than 70 decibel display of video carriers showing Channels 2 through 5 with the associated audio carriers.

The polaroid photos are of stored displays on a Spectrum Analyzer, the R.F. energy of a single picture carrier and sideband energy from one equalizing pulse and of a VITS multiburst.

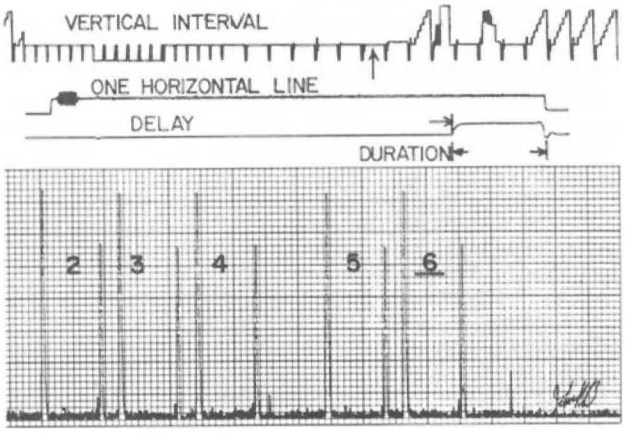
SPURIOUS SIGNALS

The plot is of a single television channel with amplitude modulated visual carrier and audio carrier.

The I.F. Bandwidth of the Spectrum Analyzer is 30 Kilohertz. The vertical calibration is 10 dB per major division and scan is 2.5 megahertz per major division.

The single spurious response is residual color subcarrier from a Tektronix 147 Video Signal Generator, and greater than -70 dB from picture carrier level.

The duration of the Z Axis is approximately 5 microseconds. The delay allows the narrow band I.F. to respond properly.



SPURIOUS SIGNALS - 30 Kilohertz I.F. Bandwidth 10 dB log the same time is selected for noise.

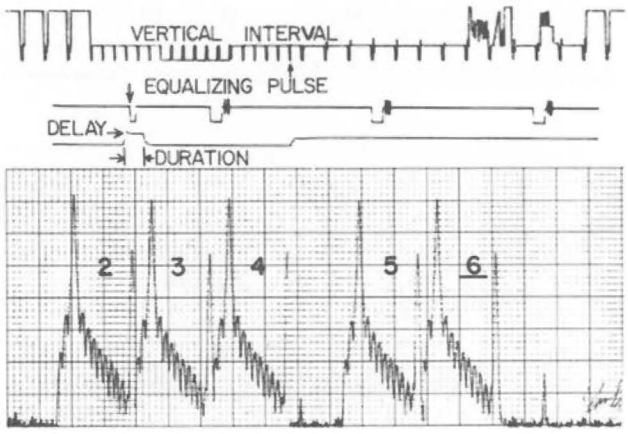
The carrier level with the blank line is 2.5 dB below peak carrier level at the sync tip.

PICTURE QUALITY

The most significant observation that can be made of a television channel is to examine the energy distribution in the side band frequencies of a square wave pulse. The best equalizing pulse for observation is at the start of line 9 of field 2.

The Spectrum Analyzer I.F. band is set to 100 Kilohertz. Although 30 Kilohertz will also perform, it is too detailed for general use.

The number of responses on the upper sideband on a scale of one to ten rating of picture quality is easy. The noise and frequency response contribute directly to the quality of the picture and the rating. A normal horizontal sync pulse will also respond but will normally contain the color burst and have more responses.



PICTURE QUALITY - 100 Kilohertz I.F. Bandwidth 10 dB log.

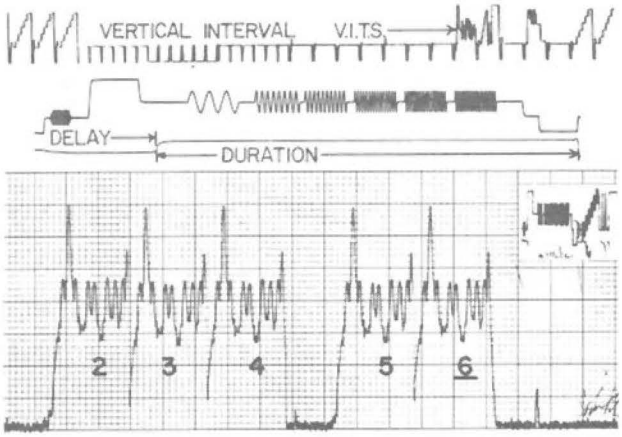
AMPLITUDE FREQUENCY RESPONSE

To prove that the processors at the headend are up to FCC standards or want to determine the effect that multipath propagation has had on the off-air television signals, T.S.S.A. will provide amplitude response by analyzing the Multiburst of the Vertical Interval Test Signals.

The Z Axis duration in excess of 63 microseconds will include a horizontal sync pulse which will give you peak carrier level. Confining the duration to include only the multibursts, will lower the carrier level so that 300 Kilohertz I.F. will show the response of the upper and

lower side band energy of the .5 megahertz burst. Dual displays with 300 and 100 Kilohertz of I.F. bandwith will indicate relative duration of each burst of the multiburst.

The vertical display of 1 or 2 dB per one cm. division will make accurate amplitude measurements to the degree of compliance to channel R.F. amplitude response standards. 10 dB per vertical division would show peak picture carrier and adjacent out of band response.



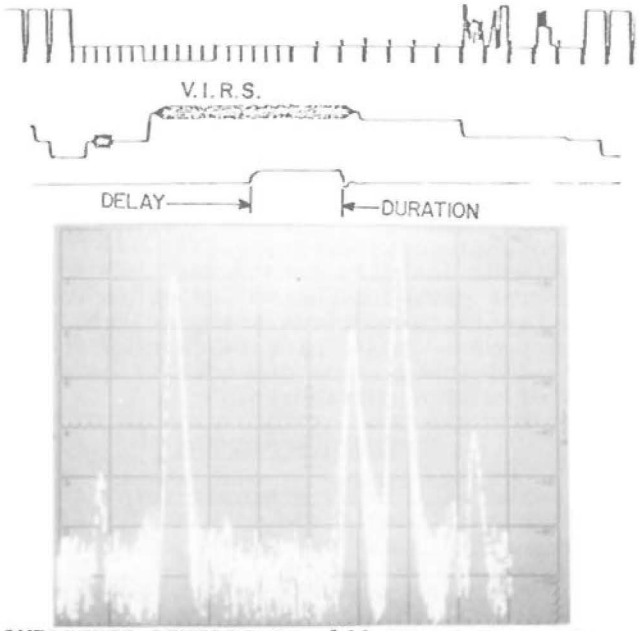
R.F. AMPLITUDE RESPONSE - 300 Kilohertz IF Bandwidth 10 dB log.

AMPLIFIER LINEARITY

The relationship of carriers within a television channel that can interact from nonlinear amplification can be shown graphically with T.S.S.A.

Most television stations transmit a Vertical Interval Reference Signal so that the color of the video signal can be referenced. A short duration of the transmitted color frequency can be selected and the linearity of an amplifier or processor can be determined from the component of the audio carrier and color signal that are mixed with video carrier and be detected 920 Kilohertz from the picture carrier. Using 100 Kilohertz I.F. and a selected time during the V.I.R.S., the mixing of the audio carrier and the color signal will show as a 920 Kilohertz signal near the picture carrier. The 920 Kilohertz beat will prove the linearity of the amplifier or processor under test.

The Spectrum Analyzer is set at 100 Kilohertz I.F. and the Z Axis duration of 5 microseconds near the termination of the color reference. The step up in the video carrier level immediately after the V.I.R.S. should be avoided as the energy level change will produce sidebands that will obscure the desired observation with ploting techniques.



AMPLIFIER LINEARITY - 100 KHz I.F. Bandwidth, 10 dB log vertical.

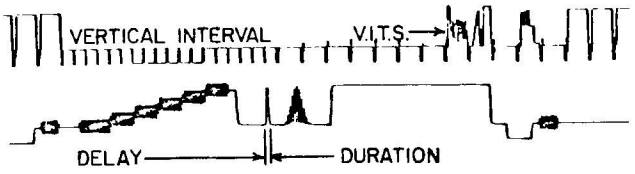
EXERCISING 2T RESPONSE

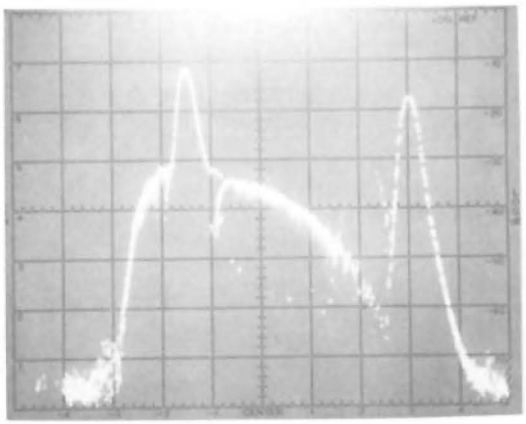
The 2T pulse of the V.I.T.S. has the shortest duration, is close to other video test signals and is the hardest to capture.

There are some uses for this display when used to determine distortion of envelope detectors of demodulators and are similar to analysis of leading or trailing edge of the bar signal which has a shorter H.A.D. The accomplishment of this measurement will be the ultimate of accuracy that the two control of the Z Axis Module can accomplish.

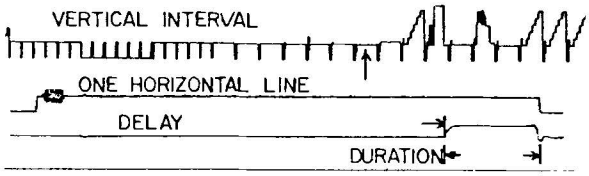
The Spectrum Analyzer will only perform with 300 Kilohertz or wider I.F. band width. The duration of the Z Axis pulse will have to be observed closely on the A-B presentation of the Video Waveform Monitor because of the difference in propagation of the R.F. signal through the Spectrum Analyzer. The duration will appear to occur during the 12.5 T pulse due to the difference of propagation. There are color frequency test signals before and after the 2T pulse which could interfere if the delay and the duration are not properly set.

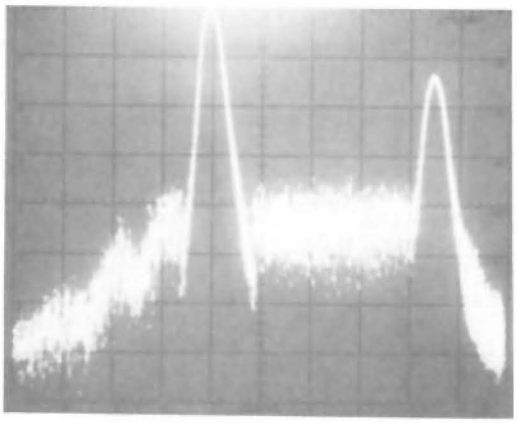
Phase canceling of the picture carrier to blanking level will allow presentation of only the sideband energy. The carrier canceling technique can be applied to any of the T.S.S.A. procedures.





2T RESPONSE - 300 KHz I.F. Bandwidth, 10 dB log vertical.





CARRIER TO NOISE - 300 KHz I.F. Bandwidth, 10 dB log.

NOISE MEASUREMENT

Although the noise of a television channel can be measured with a 30 Kilohertz bandwidth I.F., 300 Kilohertz will measure the noise with greater resolution. Calibration can be achieved directly with this noise plot where the noise was introduced at different levels with -20, -40 and -50 dB below peak video output from the Tektronix 147 Video Signal Generator.

Normal propagation and processing will present very little difference in noise energy distribution. Poor signal processor alignment can be seen as well as the signature of a dual channel video recoder or a satellite earth station receiver.

When the Video Waveform Monitor is on manual line select and placed on line 4 in the vertical sync pulse time, true peak video carrier can be recorded. Care must be exercised on these lines as incorrect timing will allow energy from nearby sync pulse to be recorded.

NOTES

The C-MOS integrated circuit may require different approaches in the disposition of the unused pins. The configuration in this circuit has worked for most C-MOS ICs. Some ICs will work if the unused pins are left to float but can cause unexpected results.

OTHER APPLICATIONS

Using the pulse from the Z Axis control unit and applying this pulse to control the output of a tracking signal generator, high level sweep of all the headend equipment can be made without interference to normal operation of a cable system. The applying of sweep signal during a blank line in the vertical interval makes this type of sweeping possible. Offset frequency can produce video sweep at base band to test modulator at their output frequency.

T.S.S.A. of TV signals on FM carriers can be as revealing as T.S.S.A. at base band frequencies. Microwave AM and FM signals can also be measured for many of their characteristics.

SUMMARY

The Time Selective Spectrum Analysis, by using the Z Axis control module in conjunction with the Video Waveform Monitor and Spectrum Analyzer, will allow considerable additional utility to the Spectrum Analyzer. Additional understanding will occur concerning the theory and operation of the modulation characteristics of Radio Frequency Carriers.

There are many uses suggested in this paper which describes the minimum equipment that may be found in a Cable System. With other equipment, such as a plotter, tracking generator, offset frequency generation, the utility will be even more greatly expanded.

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