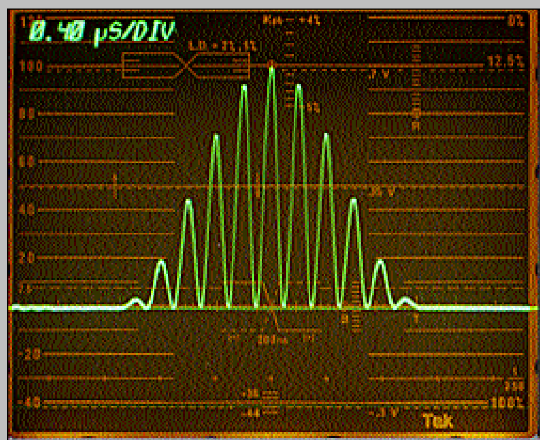
NTSC Systems

Television Measurements



Contents

To characterize television system performance, an understanding of signal distortions and measurement methods as well as proper instrumentation is needed. This booklet provides information on television test and measurement practices and serves as a comprehensive reference on methods of quantifying signal distortions. This publication deals with NTSC composite analog signals. Analog component, digital composite and component, and HDTV measurements are outside its scope.

New instruments, test signals, and measurement procedures are introduced as television test and measurement technology evolves. This booklet encompasses both traditional measurement techniques and newer methods. After a discussion of good measurement practices, five general categories of television measurements are addressed:

I. Video Amplitude and Time Measurements

II. Linear Distortions

III. Nonlinear Distortions

IV. Noise

V. Transmitter Measurements

A basic knowledge of video is assumed and a glossary of commonly used terms is included as a refresher and to introduce new concepts. This booklet does not provide detailed instructions on how to use particular instruments. The basics of waveform monitor and vectorscope operation are assumed. Consult the instrument manuals for specific operating instructions.

EQUIPMENT REQUIREMENTS

Television system performance is evaluated by sending test signals with known characteristics through the signal path. The signals are then observed at the output (or at intermediate points) to determine whether or not they are being accurately transferred through the system. Two basic types of television test and measurement equipment are required to perform these tasks. Test signal generators provide the stimulus and specialized oscilloscopes, known as waveform monitors and vectorscopes, provide the tools for evaluating the response.

Test Signal Generators. Television signal generators provide a wide variety of test and synchronization signals. Two key criteria in selection of a test signal generator for precision measurements are signal complement and accuracy. The generator should provide all of the test signals to support the required measurements and the signal accuracy must be better than the tolerances of the measurements to be made. If possible, the generator accuracy should be twice as good as the measurement tolerance. For example, differential gain measurement to 1% accuracy should be made with a generator having 0.5% or less differential gain distortion.

Television equipment and system performance is generally assessed on either an out-of-service or in-service basis. In broadcast television applications, measurements must often be made during regular broadcast hours or on an in-service basis. This requires a generator capable of placing test signals within the vertical blanking interval (VBI) of the television program signal. Out-of-service measurements, those performed on other than an in-service basis, may be made with any suitable full field test signal generator.

For out-of-service measurements, the Tektronix TG2000 Signal Generation Platform with the AVG1 and AGL1 modules is the recommended product. The AVG1 Analog Video Generator provides comprehensive signal sets and sufficient accuracy for virtually all measurement requirements. The AVG1 is also a multiformat unit capable of supporting measurements in other composite and analog component formats. This eliminates the need for additional signal generation equipment where there is the requirement for measurements in multiple formats. For synchronization of the equipment under test, a black burst reference signal is provided by the TG2000 mainframe. For applications requiring the test signal source be synchronous with existing equipment, the AGL1 Analog Genlock module provides the interface needed to lock the TG2000 to an external black burst reference signal.

For in-service measurements, the Tektronix VITS200 Generator and Inserter is the recommended product. The VITS200 provides a full complement of NTSC test signals and high degree of flexibility in placement of these signals within the VBI. Signal accuracy is adequate for most transmission and transmitter measurement requirements.

Both the TG2000 and VITS200 fully support the measurement capabilities of the 1780R and VM700 Series Video Measurement Sets.

Waveform Monitors and Vectorscopes. The instruments used to evaluate a system's response to test signals make up the second major category of television test and measurement equipment. Although some measurements can be performed with a general purpose oscilloscope, a waveform monitor is generally preferred in television facilities. Waveform monitors provide TV triggering capabilities and video filters that allow evaluation the chrominance and luminance portions of the signal independently. Most models also have a line selector for looking at signals on individual lines.

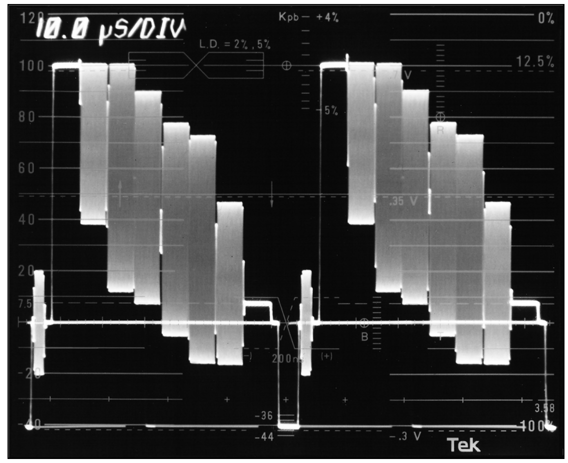
A vectorscope, which demodulates the signal and displays R-Y versus B-Y, is another important test and measurement tool. With a vectorscope, the chrominance portion of the signal can be accurately evaluated.

When selecting a waveform monitor and vectorscope, carefully evaluate the feature sets and specifications to make sure they will meet present and future needs. This is particularly true if making accurate measurements of all signal parameters and distortions described in this booklet. Many varieties of waveform monitors and vectorscopes are available today but the majority of them are not intended for precision measurement applications. Most vectorscopes, for example, do not have precision differential phase and gain measurement capabilities.

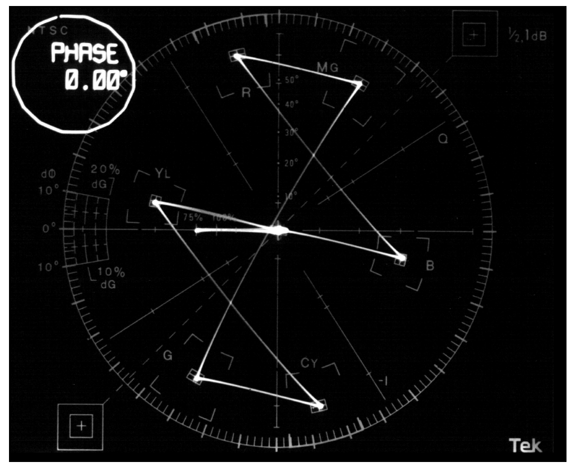
The recommended products for precision measurement applications are the Tektronix 1780R and the VM700T. Most of the measurement procedures in this booklet are based on these instruments.

The 1780R provides waveform monitor and vectorscope functions as well as many specialized measurement features and modes that simplify complex measurements.

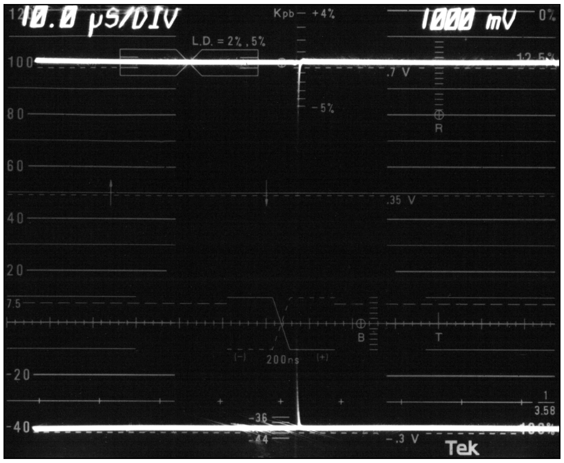
The VM700T is an automated measurement set with results available in numeric and graphic form. Waveform and vector displays, similar to those of traditional waveform monitors and vectorscopes operating in line select mode, are also provided. The VM700T Measure mode provides unique displays of measurement results, many of which are presented in this book.



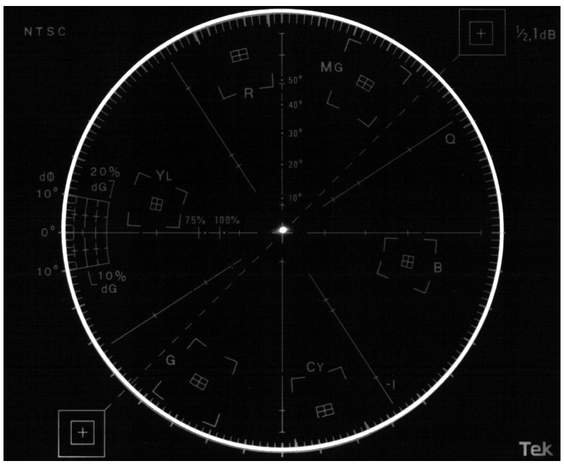
A waveform monitor display of color bars.



A vectorscope display of color bars.



The 1780R waveform calibrator.



The 1780R vectorscope calibration oscillator.

CALIBRATION

Most instruments are quite stable over time, however, it is good practice to verify equipment calibration prior to every measurement session. Many instruments have internally generated calibration signals that facilitate this process. In the absence of a calibrator, or as an additional check, a test signal directly out of a high quality generator makes a good substitute. Calibration procedures vary from instrument to instrument and the manuals contain detailed instructions.

Analog CRT-based instruments such as the 1780R have a specified warm up time, typically 20 or 30 minutes. Turn the instrument on and allow it to operate for at least that long before checking the calibration and performing measurements. This ensures that the measurement instrumentation will have little or no effect on the measurement results.

Computer-based instruments such as the VM700T also specify a warm up time but the operator does not need to verify or adjust the calibration settings. The VM700T will automatically calibrate itself when it is turned on and will continue to do so periodically during operation. For best results, wait 20 or 30 minutes after initial turn-on before making any measurements.

INSTRUMENT CONFIGURATION

Most of the functions on analog waveform monitor and vectorscope front panels are fairly straightforward and have obvious applications in measurement procedures. A few controls, however, might need a bit more explanation.

DC Restorer. The basic function of the DC restorer in a waveform monitor is to clamp one point of the video waveform to a fixed DC level. This ensures that the display will not move vertically with changes in signal amplitude or APL (Average Picture Level).

Some instruments offer a choice of slow and fast DC restorer speeds. The slow setting is used to measure hum or other low frequency distortions. The fast setting removes hum from the display so it will not interfere with other measurements. Back porch is the most commonly used clamp point, but sync tip clamping has some applications at the transmitter.

AFC/Direct. This control provides selection of the method of triggering the waveform monitor horizontal sweep. The ramp that produces the horizontal sweep is always synchronous with the H or V pulses of the reference video and is started either by the pulses themselves (Direct) or by their average (AFC).

In the direct mode, the video sync pulses directly trigger the waveform monitor's horizontal sweep. The direct setting should be used to remove the effects of time base jitter from the display in order to evaluate other parameters. Since a new trigger point is established for each sweep, line-to-line jitter is not visible in this mode.

In the AFC (Automatic Frequency Control) mode, a phase-locked loop generates pulses that represent the average timing of the sync pulses. These averaged pulses are used to trigger the sweep. The AFC mode is useful for making measurements in the presence of noise as the effects of noise-induced horizontal jitter are removed from the display.

The AFC mode is also useful for evaluating the amount of time base jitter in a signal. The leading edge of sync will appear wide (blurred) if much time base jitter is present. This method is very useful for comparing signals or for indicating the presence of jitter but be cautious about actually trying to measure it. The bandwidth of the AFC phase-locked loop also affects the display.

75%/100% Bars. Some vectorscopes have a 75%/100% selection on the front panel. This setting changes the calibration of the vectorscope chrominance gain to accommodate two different types of color bars. The 75%/100% distinction refers to amplitude, not to saturation or white bar level. These issues are discussed in detail in Appendix A.

75% bars are most frequently used in NTSC systems as the large chrominance peaks in 100% bars may overload the transmitter. However, some test signal generators produce both. It is important to know what amplitude color bar is being used and to select the corresponding gain setting on the vectorscope. Otherwise chrominance gain can easily be misadjusted.

DEMODULATED RF SIGNALS

All of the baseband measurements discussed in this booklet may also be made on demodulated RF signals. It is important, however, to eliminate the demodulator itself as a possible source of distortion. Measurement-quality instruments such as the Tektronix TV1350 and 1450 Television Demodulators will eliminate the likelihood that the demodulator is introducing distortion.

TERMINATION

Improper termination is a very common source of operator error and frustration. Always make sure the signal under measurement is terminated with a 75 Ohm terminator in one location. It is generally best to terminate at the final piece of equipment in the signal path.

The quality of the terminator is also important, particularly when measuring very small distortions. Select a terminator with the tightest practical tolerance as incorrect termination impedance can cause amplitude errors, frequency response problems, and pulse distortions. Terminators in the 1/2% to 1/4% tolerance range are widely available and are generally adequate for routine testing.

STANDARDS AND PERFORMANCE GOALS

No one standard defines all amplitude and timing relationships for the NTSC signal. There are a number of reference documents produced by different organizations, several of which are in common use today. RS-170A and FCC 73.699 Figure 6, two of the most frequently used, are reproduced in Appendices C and D of this booklet. Both documents define blanking and synchronizing signal parameters. RS-170A includes references to SCH phase and is generally used in studio environments. The FCC diagram is used to verify the quality of transmitted signals. Use them as a reference but exercise caution in assuming that compliance with these standards is mandatory or that compliance is sufficient to ensure signal quality.

Acceptable levels of distortion are usually determined subjectively but a number of organizations publish documents that provide recommended limits. These standards, which include EIA-250-C, are frequently edited and revised. Each facility ultimately needs to determine its own performance goals, however, these documents can provide some good guidelines.

While there is usually agreement about the nature of each distortion, definitions for expressing the magnitude of the distortion vary considerably from standard to standard. A number of questions should be kept in mind. Is the measurement absolute or relative? If it is relative, what is the reference? Under what conditions is the reference established? Is the peak-to-peak variation or the largest single deviation to be quoted as the distortion?

A misunderstanding of any one of these issues can seriously affect measurement results so it is important to become familiar with the definitions in whatever standards are used. Make sure those involved in measuring system performance agree on how to express the amount of distortion. It is good practice to record this information along with the measurement results.