User Manual

Tektronix

WFM 601i
Serial Digital Component Monitor

070-8966-01

Please check for change information at the rear of this manual.

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In order to obtain service under this warranty, Customer must notify Tektronix of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. Customer shall be responsible for packaging and shipping the defective product to the service center designated by Tektronix, with shipping charges prepaid. Tektronix shall pay for the return of the product to Customer if the shipment is to a location within the country in which the Tektronix service center is located. Customer shall be responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to any other locations.

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We

Tektronix Holland N.V.
Marktweg 73A
8444 AB Heerenveen
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declare under sole responsibility that the

WFM 601i Serial Digital Component Monitor

meets the intent of Directive 89/336/EEC for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:

EN 50081-1 Emissions:

EN 55022	Class B Radiated and Conducted Emissions

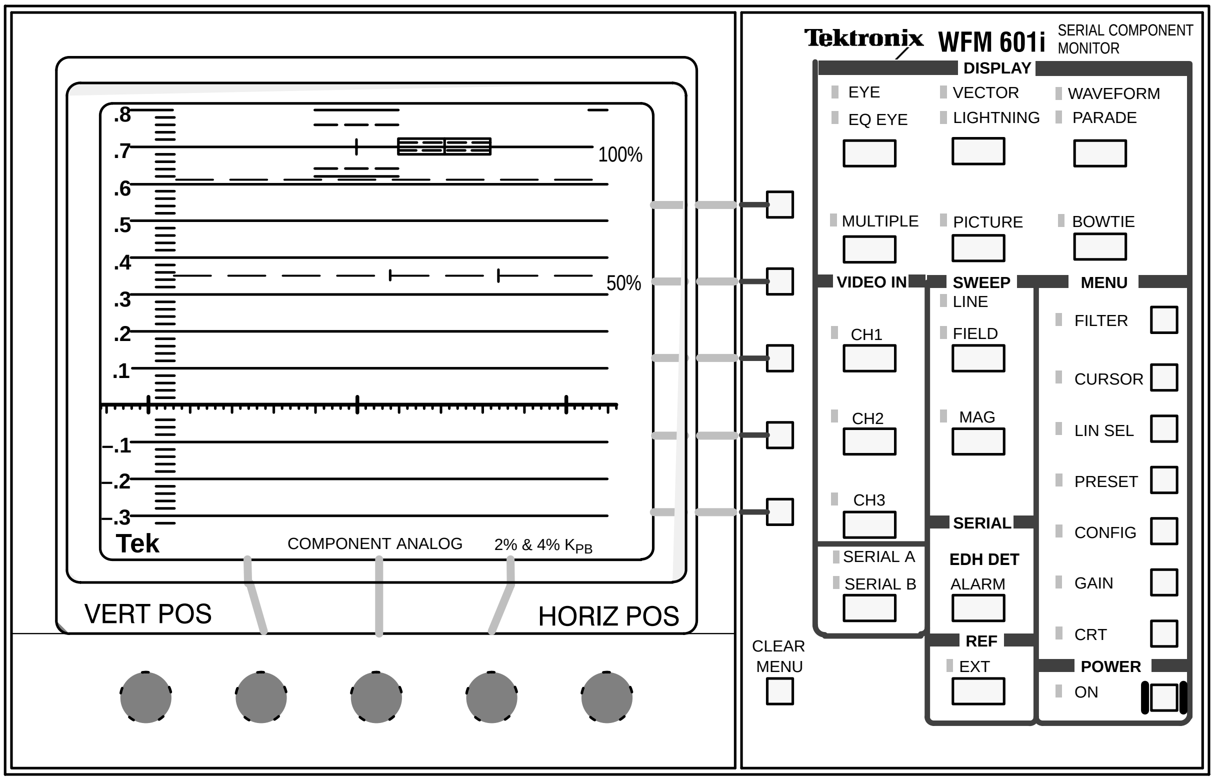
EN 50082-1 Immunity:

IEC 801-2	Electrostatic Discharge Immunity
IEC 801-3	RF Electromagnetic Field Immunity
IEC 801-4	Electrical Fast Transient/Burst Immunity

High-quality shielded cables must be used to ensure compliance to the above listed standards.

This product complies when installed into any of the following Tektronix instrument enclosures:

1700F00 Standard Cabinet
1700F02 Portable Cabinet
1700F05 Rack Adapter



WFM 601i Serial Digital Component Monitor

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Safety Summary

Symbols and Terms

These Terms Appear in Manuals:

CAUTION. statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING. statements identify conditions or practices that could result in personal injury or loss of life.

These Terms Appear on Equipment:

- *CAUTION* indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property, including the equipment itself. Refer to the manual for information.
- *DANGER* indicates a personal injury hazard immediately accessible as one reads the marking.

These Symbols Appear on Equipment:

DANGER High Voltage — Protective ground (earth) terminal — ATTENTION Refer to manual

Specific Precautions

Use the Proper Power Source

This product is intended to operate from a power source that will apply no more than 250 V rms between the supply conductors or between either supply conductor and ground. A protective-ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Ground the Product

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting to the product input or output terminals. A protective-ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Danger May Arise from Loss of Ground

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electric shock.

Use the Proper Fuse

To avoid fire hazard, use only the fuse of correct type, voltage rating, and current rating as specified in the parts list for your product. Refer fuse replacement to qualified service personnel.

Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate this product in an explosive atmosphere.

Do Not Operate Without a Cabinet

To avoid personal injury, do not remove the product covers or panels. Do not operate the product without the covers and panels properly installed.

Do Not Service Alone

Do not perform internal service or adjustment of this product unless another person capable of rendering first aid and resuscitation is present.

Preface

This manual is a guide for operators of the WFM 601i monitor.

Please complete and mail the "Business Reply Card" at the front of this manual to receive a service manual when it becomes available.

Manual Overview

Getting Started provides the material needed to place the instrument in service. It contains "Product Description", "Installation", and "Functional Check".

Operation Basics provides information needed for daily operation. It has "At a Glance", which describes the controls and connectors, and "Functional Overview" which discusses operation of the instrument.

Reference provides detailed descriptions of instrument operation and theory. "Graticules", "Measurement Applications", and "Measurement Theory" are in this section.

Appendix A provides instrument specifications, both electrical and mechanical.

Appendix B describes the rear panel remote control connectors.

Appendix C covers routine service procedures, such as replacing fuses and graticule light bulbs.

The appendices are followed by a glossary of specialized terms and an index.

Getting Started

Product Description

The WFM 601i is capable of measuring and monitoring 4:2:2 component serial digital. It displays the video signal in the familiar component analog representation, either paraded or overlaid. An equivalent time sampler is incorporated to show the eye pattern of the serial signal. Data integrity is verified by the EDH (Error Detection and Handling) system, and by a suite of serial digital format checks.

Features

The following list composes the feature set for the WFM 601i.

- Eye Pattern Display of the Selected Serial Input.
- Serial Jitter Measurement; three selectable bandwidths.
- Serial Format Checking.
- EDH: (Follows A/B switching) LED for presence and an alarm, rear panel TTL low through Remote Connector.
- RGB or Y P_B P_R display format.
- Any or all of channels 1, 2, or 3 displayed.
- Parade or Overlay display.
- Flat, Low Pass, or Diff'd Step filtering.
- X1, X5, X10, and Variable Vertical gain.
- Line and Field sweeps.
- 200 ns/div Line sweep.
- Bar Cursors; amplitude, time, amplitude + time, and marker.
- Line Select with readout; 1 line or 15 line, all fields or 1 of 2 fields. Bright up of selected lines on Picture Monitor Out (Y or G Channel).
- Vector Display; fixed or variable gain, 75% or 100% bars, SMPTE/EBU N10.
- Lightning or Diamond display; vertical gain, 75% or 100% bars, SMPTE/EBU N10.
- Electronic graticules for Lightning, Diamond, and Vector displays.

- Monitor Output; GBR or Y P_B P_R (follows A/B switching). Gamut error bright up.
- Reclocked Serial Component Digital output following A/B switching.
- Video Reference: Internal Serial Component signal (follows A/B switching), External Composite.

Menu

An expanded feature set is available through menus and multi-use buttons and knobs. When the operator selects a menu item, such as Voltage and Timing Cursors, an on-screen label shows the current function of the controls.

The operator can also recall up to 10 front-panel setups through the Preset menu; 9 presets are user-programmable and 1 is factory-programmed.

Calibrator

Vertical and horizontal instrument gain can be set using the calibrator signal. The calibrator signal is a 700 mV 100 kHz signal.

Accessories

Standard Accessories

The following accessory items are included with this product:

1 User Manual with Service Manual request card (070–8966–00)

1 Power Cord: United States and Japan only (161–0216–XX)

1 Replacement Fuse Cartridge: 3AG, 2A, 250V, fast-blow (159–0021–00)

4 Replacement Graticule Light Bulbs (150–0168–00)

4 Replacement Air Filters for Fan (378–0335–00)

2 75Ω End-line Terminations: 26 dB to 300 MHz (011–0163–00)

1 Smoke Grey CRT Filter (installed on instrument) (378–0258–00)

Optional Accessories

The following items can be ordered with the monitor, or purchased through a Tektronix field office or distributor. When ordering, include both the name and number of the option.

Viewing Hood (016-0475-00)

Front Panel Cover (200-3897-01)

Camera, C9 Option 20

1700F00 Plain Cabinet — This plain metal half-rack size cabinet is painted silver-gray. Ventilating holes in the top, bottom, and sides of the cabinet allow heat generated within the instrument to dissipate.

1700F02 Carrying Case —This portable cabinet is similar to the 1700F00, but has feet, a carrying handle, flipstand, and front cover.

1700F05 Side-by-Side Rack Adapter — The 1700F05 allows the user to mount two half-rack width instruments in a standard 19-inch rack.

1700F06 Blank Panel — If only one section of a 1700F05 is used, the 1700F06 Blank Panel can be inserted in the unused section to improve appearance and air flow.

1700F07 Utility Drawer — When only one side of a 1700F05 is used, this utility drawer can be installed in the unused section to provide storage. The drawer opens and closes freely, unless latched for transport.

Options

Power Cord Options

Power cord options are the only options currently available. Any of the following power cord options can be ordered for the WFM 601i Serial Component Monitor. If no power cord option is specified, instruments are shipped with a North American 125 V power cord and one replacement fuse.

Power cords for use in North America are UL listed and CSA certified. Cords for use in areas other than North America are approved by at least one test house acceptable in the country to which the product is shipped.

Option A1. Power, Universal Europe, 220 V/16 A (Locking Power Cord)

Option A2. Power, United Kingdom, 240 V/15 A (Power Cord)

Option A3. Power, Australia, 240 V/10 A (Power Cord)

Option A4. Power, North America, 250V/10 A (Power Cord)

Option A5. Power, Swiss, 240 V/6 A (Power Cord)

Installation

Packaging

At installation time, save the shipping carton and packing materials (including anti-static bag) in case it becomes necessary to ship the instrument to a Tektronix Service Center for service or repair.

Repackaging for Shipment

If it becomes necessary to ship the instrument to a Tektronix Service Center for service or repair, follow these instructions for repackaging:

1. Attach a tag to the instrument showing: the owner, complete address and phone number of someone at your firm who can be contacted, the instrument serial number and a description of the required service.
2. Repackage the instrument in the original packaging materials. If the original packaging materials are not available, follow these directions:
   - **a.** Obtain a carton of corrugated cardboard having inside dimensions six or more inches greater than the dimensions of the instrument. Use a shipping carton that has a test strength of at least 275 pounds.
   - **b.** Surround the instrument with a protective bag (anti-static preferred). For instruments which are not in a cabinet, wrap a cardboard piece around the bagged instrument to protect components.
   - **c.** Pack dunnage or urethane foam between the instrument and the carton. If using Styrofoam kernels, overfill the box and compress by closing the lid. There should be three inches of tightly packed cushioning on all sides of the instrument.
3. Seal the carton with shipping tape, industrial stapler, or both.

Packaged Accessories

The following accessory items are included with these monitors:

- User Manual with Service Manual request card.
- Power Cord
- Replacement Fuse Cartridge (Qty. 1)
- Replacement Graticule Light Bulbs (Qty. 4)
- Replacement Air Filters for Fan (Qty. 4)
- 75Ω End-line Terminations, 26 dB to 300 MHz (Qty. 2)

Internal Jumper

Jumper J6 changes the rear panel Serial Out signal amplitude. Normal Output amplitude is 800 mV, but some equipment may work best at 740 mV. Jumper J6, located on the Deserializer board, can be changed so that the Serial Output is 740 mV. Table 1–1 gives the jumper settings.

Looking at the front of the WFM 601i, the Deserializer board is located on the left hand side, near the rear instrument.

Table 1–1: Serial Output Jumper Settings (J6 Deserializer board)

Pins	Monitor Output
1 to 2	800 mV (default setting)
2 to 3	740 mV

Mechanical Installation

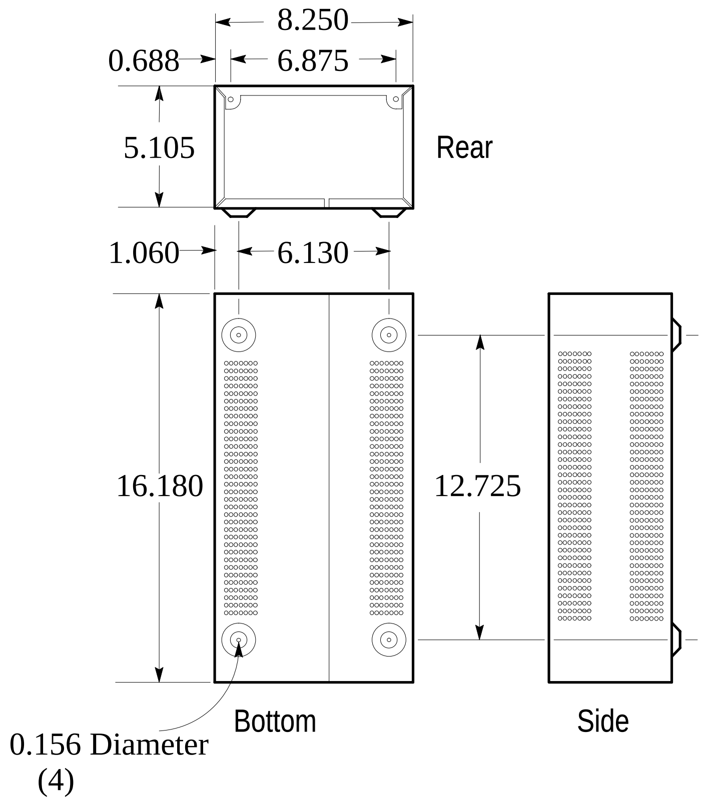


Figure 1-1: Dimensions of the 1700F00 plain cabinet.

Cabinets

The cabinets available for this instrument not only provide necessary shielding, and protection against accidental electrical shock, but also provide internal circuitry with protection against build up of dust. A supply of filtered, cooling air is provided from the rear panel and exits through the cabinet vent holes. Operation in air flow restricted environments may lead to excessive heat build up.

All qualification testing for the WFM 601i was performed in a 1700F00 cabinet. To guarantee compliance with specifications, the instrument should be operated in a cabinet. The plain cabinet, 1700F00, is shown in Figure 1-1.

***NOTE**. To meet EMI emission specifications, the WFM 601i must be installed in a Tektronix 1700F00, 1700F02, or 1700F05 enclosure. The enclosure front edges must securely contact the instrument's conductive front bezel on all four sides.*

The optional 1700F00 cabinet is the basic element for all of the cabinets that fit this instrument. The 1700F02 Portable carrying case is an enhanced version of this cabinet, as is the 1700F05 side-by-side rack mount assembly. All of these cabinets are available from Tektronix. If you need one of these cabinets, contact your nearest Tektronix field office or representative for assistance in ordering.

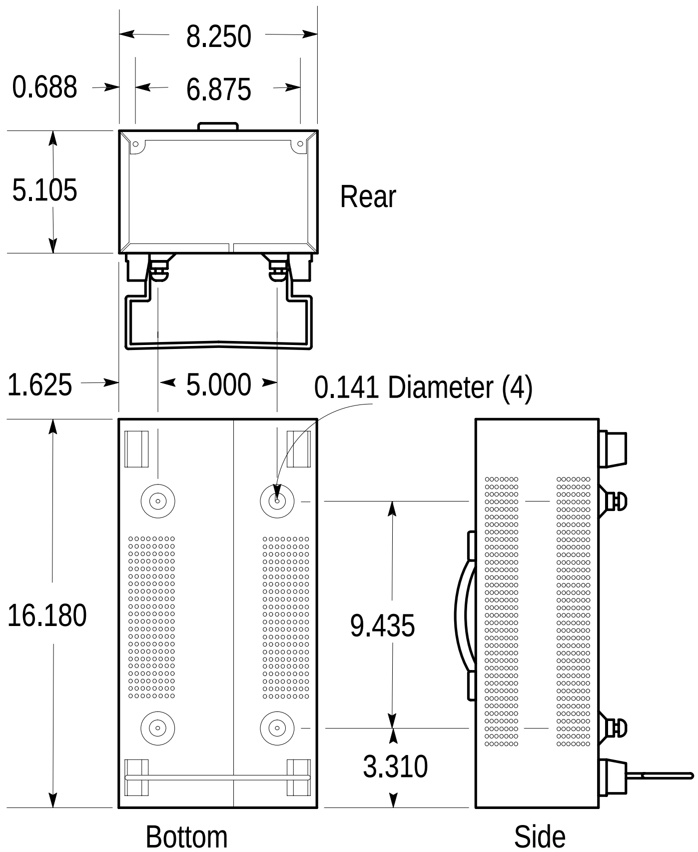


Figure 1-2: 1700F02 portable cabinet.

The portable cabinet, 1700F02, is shown in Figure 1-2. The 1700F02 has a handle, four feet, and a flip-up stand. The mounting hole sizes and spacing are different from those of the 1700F00.

Cabinetizing

Do not attempt to carry a cabinetized instrument without installing the mounting screws. Without the mounting screws there is nothing to hold the instrument in the cabinet if it is tipped forward.

The instrument is secured to the cabinet by two 6-32 Pozidrive® screws, located in the upper corners of the rear panel. See Figure 1-3.

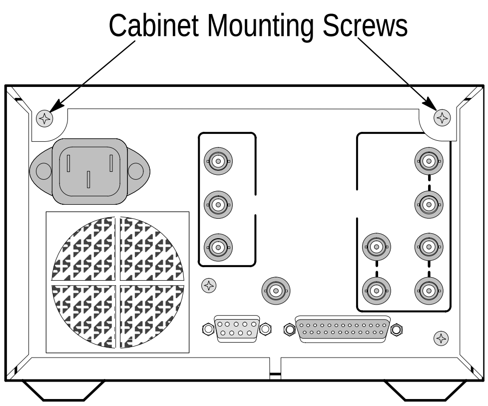


Figure 1-3: Rear view of the WFM 601i.

Rack Adapter

The optional 1700F05 side-by-side rack adapter, shown in Figure 1-4, consists of two attached cabinets. It can be used to mount the WFM 601i and another half-rack width instrument, such as an analog component monitor (Tektronix WFM 300A or 1760-Series), in a standard 19-inch rack.

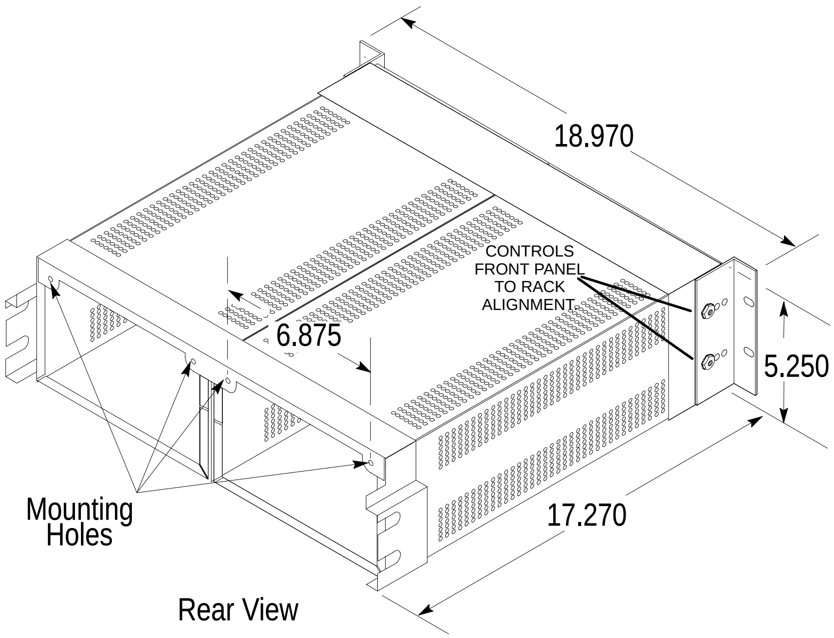


Figure 1-4: The 1700F05 side-by-side rack adapter.

The rack adapter is adjustable, so that the WFM 601i can be more closely aligned with other equipment in the rack. See Figure 1-4.

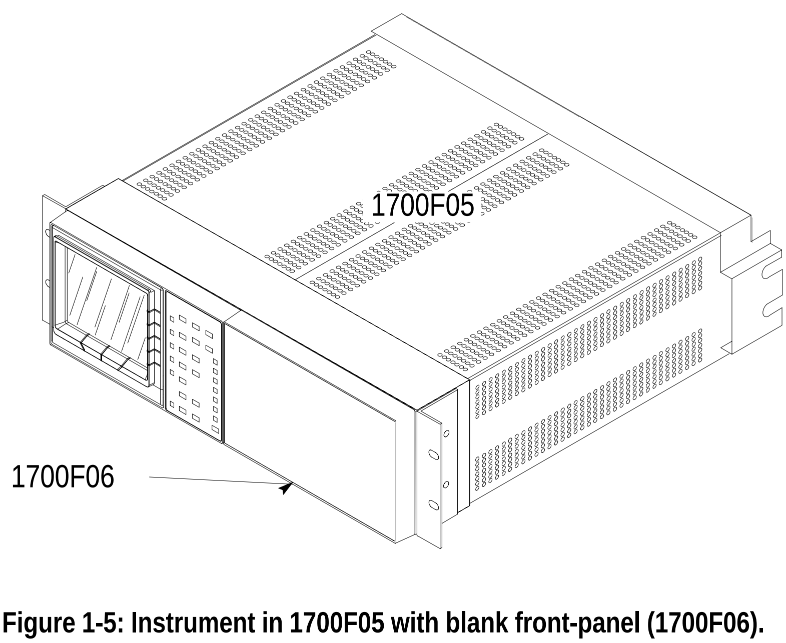


Figure 1-5: Instrument in 1700F05 with blank front-panel (1700F06).

If only one side of the rack adapter is used, a 1700F06 Blank Panel can be inserted in the unused section. See Figure 1-5. The rack adapter and panel are available through your local Tektronix field office or representative.

When only one instrument is mounted in the side-by-side adaptor an accessory drawer (1700F07) can be installed in the blank side of the cabinet. See Figure 1-6.

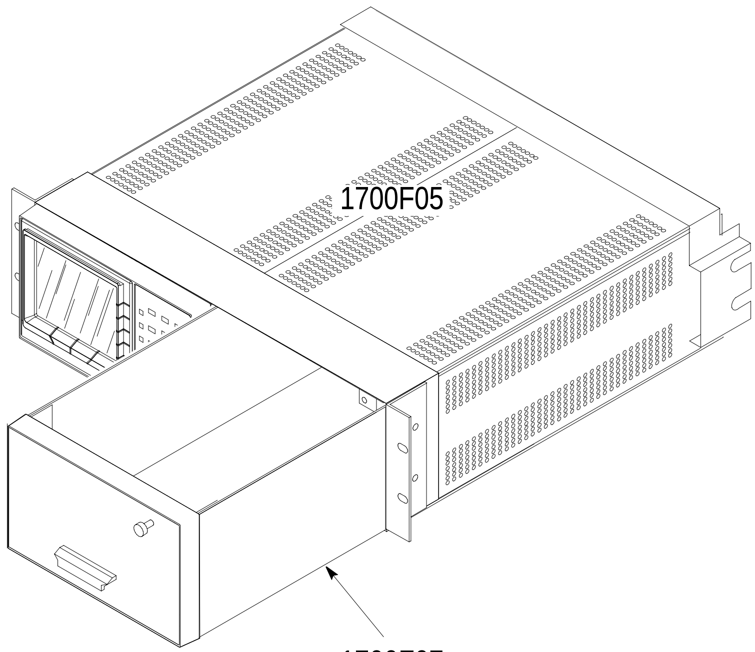


Figure 1-6: 1700F05 cabinet with 1700F07 utility drawer.

Custom Installation

For applications such as consoles the instrument can be mounted with the front molding flush or protruding from the console. In both cases, allow approximately 3 inches of rear clearance for BNC and power-cord connections.

To mount the WFM 601i safely, attach it to a shelf strong enough to hold its weight. Install the mounting screws through the four 0.156-inch diameter holes in the bottom of the 1700F00 cabinet. See Figure 1-7.

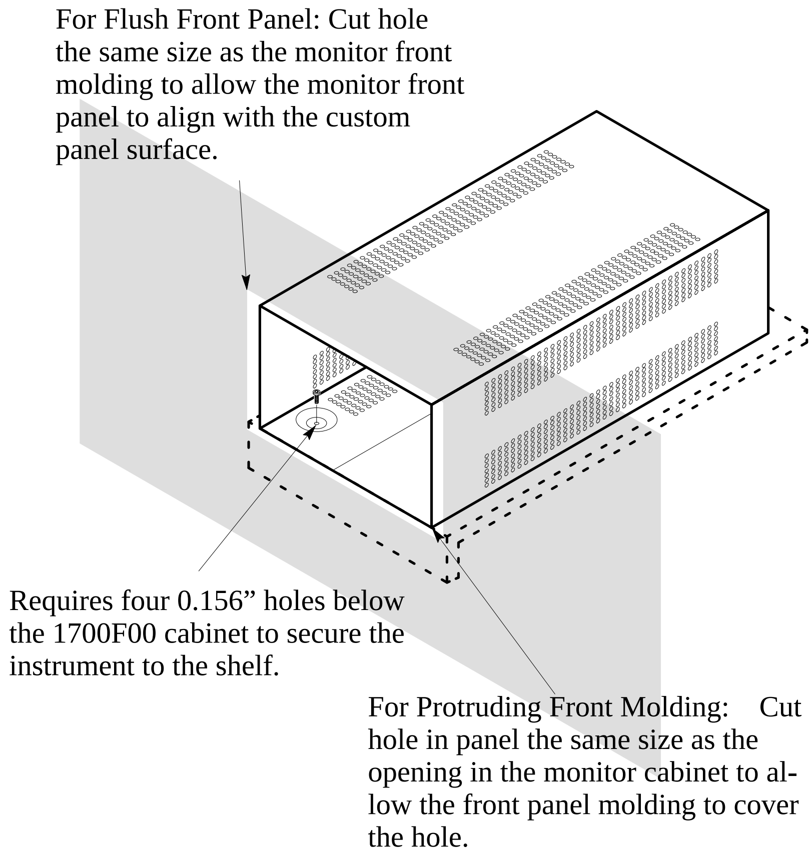


Figure 1-7: Custom installation considerations.

Connecting Power

These monitors are designed to operate from a single-phase power source having one of its current-carrying conductors at or near earth ground (the neutral conductor). Only the line conductor is fused for over-current protection. Systems that have both current-carrying conductors live with respect to ground (such as phase-to-phase on multiphase systems) are not recommended as power sources. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

⚠ ***WARNING.*** *When power is supplied, line voltage will be present in the instrument, even if the POWER switch is set to STANDBY.*

Mains Frequency and Voltage Range

The WFM 601i monitors operate at 50 and 60 Hz, over the range of 90–250 Volts, without operator adjustment.

Remote Control

Remote Connector

The rear-panel REMOTE connector is a 25-pin, D-type connector. It provides limited remote control functions via TTL signal or ground closures to designated pins. Eight front-panel setups can also be stored and recalled through the Remote connector. See Appendix B.

RS232 Connector

The rear-panel RS232 connector is a 9-pin subminiature D-type connector that provides a serial interface for calibration. The RS232 pin assignments are given in Appendix B.

Installing the WFM 601i in a Serial Video System

The serial digital monitor can operate almost anywhere in the distribution system due to its high impedance, bridging, loop-through design. The following describes two specific connections.

Most serial equipment employs a receiver and then later regenerates an output signal. Routing the incoming serial signal through one of the loop-though inputs, while connecting the output of the device to the other loop-through (for either further distribution or termination) allows a check of both the incoming signal and the equalized regenerated output signal. See Figure 1-8.

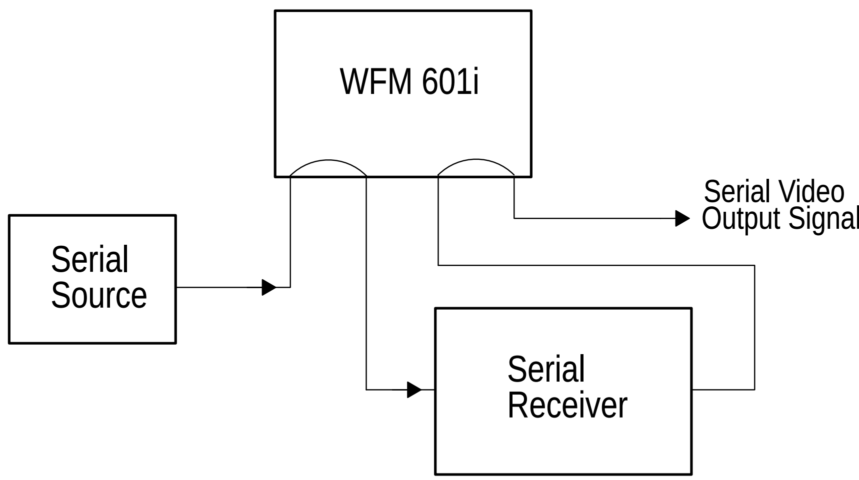


Figure 1-8: Monitoring the video bit stream of a serial receiver.

The WFM 601i can also be used to check serial digital signals around a routing switcher. It is possible to look at all the inputs to the switcher with the use of a patch panel and the serial monitor. See Figure 1-9.

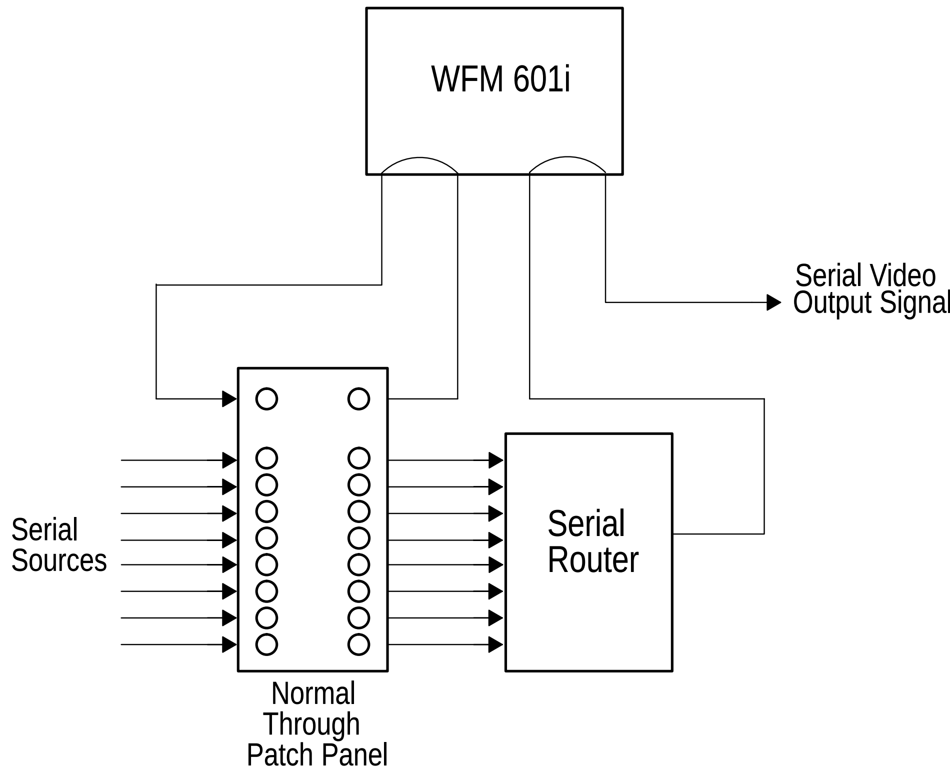


Figure 1-9: Monitoring serial digital signals around a routing switcher.

Line Termination

The WFM 601i uses passive loop-through serial inputs, similar in concept to those commonly found in baseband video equipment. Accordingly, the loop-through must be terminated externally. It is important that this external termination meet accuracy and return loss requirements.

If the instrument is installed to monitor an operating link, with the serial source on one side of the loop-through and the destination receiver on the other side, the destination receiver (and the cable between it and the loop-through) serves as the termination. This is the preferred monitoring connection because the performance of the entire serial path can be inspected. The return loss of the WFM 601i is sufficiently high that, in most cases, the system return loss will be set by that of the destination receiver.

In cases where the WFM 601i is placed at the end of a link, a bnc termination must be installed on the other side of the loop-through. This connection might be used to measure a source, for example. The termination must be 75 Ω, and its return loss should exceed 25 dB from 10 kHz to 270 MHz. It is preferable that it be dc coupled (good return loss extends to dc). The terminators supplied with the WFM 601i (P/N 011–0163–00) are recommended. Be aware that good return loss at baseband video frequencies (dc to 6 MHz) does not guarantee good high frequency return loss.

A terminator can be inspected for return loss problems using the WFM 601i and a serial source with low aberrations, such as the TEKTRONIX TSG 422, Option 1S Digital Component Generator. Connect the generator serial output to one side of the WFM 601i loop-through and place the terminator on the other side. Select the EYE mode and observe the eye pattern, paying particular attention to leading edge aberrations.

Figure 1-10 shows the eye pattern with a good return loss terminator and Figure 1-11 shows the eye pattern of a terminator having only 13 dB return loss at 100 MHz (capacitive). Terminations causing aberrations of under 10% should be acceptable.

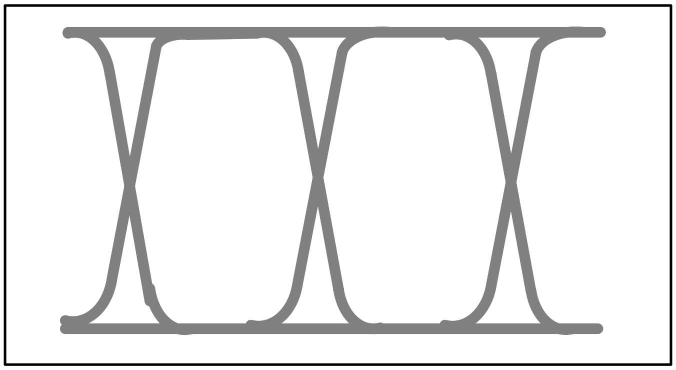


Figure 1-10: Eye pattern display of a termination with good return loss.

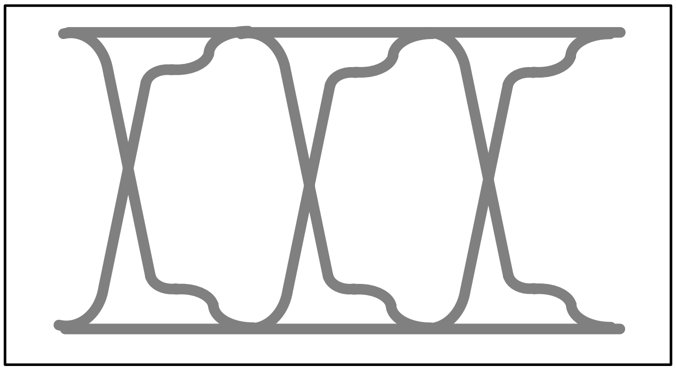


Figure 1-11: Eye pattern display of a termination with poor return loss.

One final note: Most video equipment bnc connectors, whether 50 or 75 Ω, use a 50 Ω standard center pin. Some laboratory 75 Ω bnc connectors use a smaller diameter center pin. The bnc connectors on the WFM 601i are designed to work with the 50 Ω standard (large diameter) center pins.

Do not use connectors or terminators with the smaller center pins. They could cause an intermittent connection.

Functional Check

The following procedure is provided to aid in obtaining a display on the WFM 601i Serial Component Monitor. It is designed for operator familiarization and as a check of basic instrument operation. Only instrument functions, not measurement quantities or specifications, are checked in this procedure. Therefore, a minimum amount of test equipment is required.

WARNING. *Be sure that the cabinet is installed on the instrument to avoid personal injury.*

All checks are made with the cabinet installed. The cabinet, an optional accessory, must be installed on the instrument to avoid personal injury, maintain proper environment for the instrument, keep dust out, and provide proper EMI shielding.

NOTE*. Unless otherwise noted, the waveforms shown in this procedure are representations of actual displays on the WFM601i.*

If performing the Functional Check reveals improper operation or instrument malfunction, first check the operation of the associated equipment. If it is operating normally but the WFM601i is not, then refer the instrument to qualified service personnel for repair or adjustment.

When a complete check of the instrument performance to specification is desired, refer qualified service personnel to the Performance Verification procedure in the Service manual.

Required Equipment

The following equipment is required to perform this procedure:

1. Digital Component Television Signal Generator to provide:
Color bar, Luminance Staircase, and Component Timing signal (Bowtie).

For example: Tektronix TSG-422 Digital Component Generator, Option 1S (Serial Digital output); the 422 generator was used to prepare this procedure.

2. Coaxial Cables
1 — 42-inch 75Ω RG6 type cable (Tektronix Part No. 012-0159-00)

3. 75Ω Terminators
1 — End-line (Tektronix Part No. 011-0163-00)

Initial Equipment Connections

- Connect the WFM 601i to an appropriate AC power source.
- Connect the component serial digital signal to SER A and terminate the other side of the loop-through with a 75Ω terminator.

  This procedure does not check at the Monitor Out, but if there is a GBR or Y–P_B–P_R analog component color monitor available, it can be hooked up to check these outputs.

Procedure

1. Initialize the Front-Panel Controls

The TektronixWFM 601i Serial Component Monitor is shipped with an internal preset which sets the front-panel controls to a factory-defined setting. To reset the front-panel controls to the factory presets, enter the MENU by pressing the PRESET button. Select the FACTORY setting by turning the front-panel bezel knob under the list of presets until FACTORY is highlighted. Press the bezel button adjacent to RECALL. The PRESET MENU is automatically exited, and the front-panel control settings are set to the factory preset. This preset automatically selects the line rate (625 or 525). Note that upper left hand corner of the CRT displays the scan rate with a readout preceded by an Ⓐ (scan rate automatically selected.) Check that the instrument is now in the Waveform display mode with the luminance portion of the Color Bar signal displayed at a line sweep of 10 μs/Div.

2. Display Control

Adjust the VERT and HORIZ POS knobs to center the signal display. The CRT menu allows the operator to adjust the instrument CRT display. Enter the menu by pressing the CRT button. The knobs under the CRT now control the focus, scale illumination, and display intensity of the signal. Adjust the controls to the desired viewing levels. See Figure 1-12.

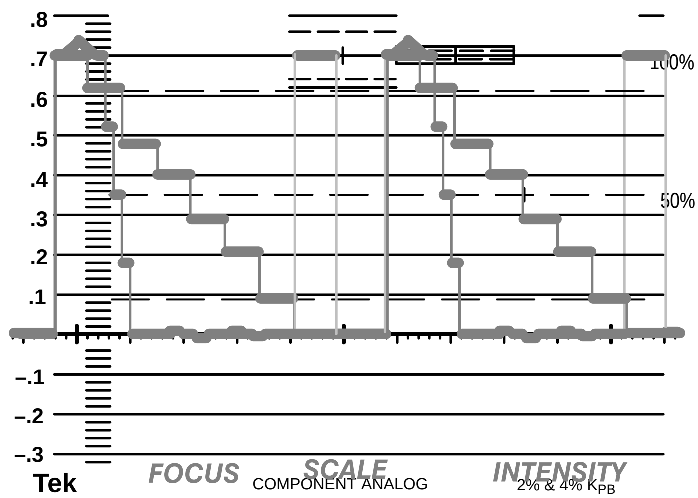


Figure 1-12: Channel 1 of color bar with level reference on the WFM 601i.

Press the top front-panel bezel button to select READOUT. One of the knobs now controls the readout intensity. Adjust the control to the desired level.

***NOTE**. READOUT INTENSITY controls the intensity of the menus that are used to select and setup instrument operation. Be sure to set this level at a comfortable, yet visible setting. If the readout intensity is accidently turned too low to see, consult the CRT Menu discussion on page 2–21 for the recovery procedure.*

Press the top bezel button again to select TRACE. One of the knobs now controls the trace rotation. Adjust the control for a level signal baseline parallel to the graticule 0 line.

Press the bottom bezel button to turn on RO TEST. Note that a cross mark is now displayed at the center of the 0.7 volt line, directly under the target mark.

Exit the CRT menu by pressing either the CLEAR MENU or the CRT button. The changes made while the menu was displayed remain in effect, but the readout test mark disappears.

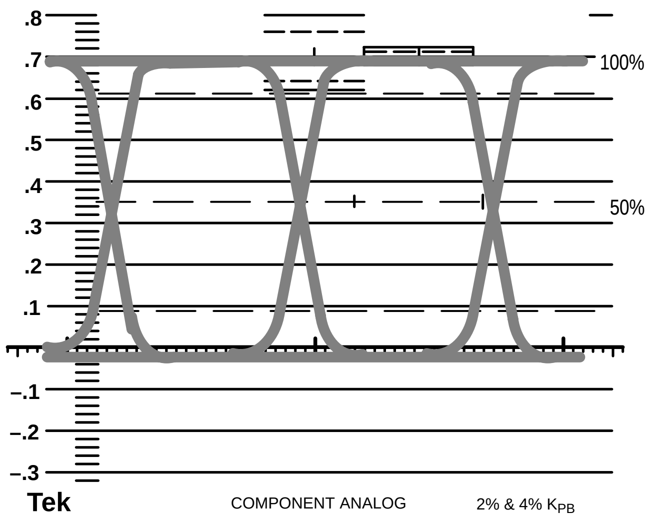


Figure 1-13: Eye pattern display.

3. Eye Display

To get the eye pattern display of the serial digital signal press the EYE/EQ EYE button. Check that the EYE indicator is illuminated.

To change the display from OVERLAY to 10 EYE:

> Press the CONFIG button. Use the second from the left bezel knob to change the submenu to the EYE PATTERN menu. Push the button adjacent to the menu selection for DISPLAY (second from the top bezel button). The cursor box should move from OVERLAY to 10 EYE and the display will change to 10 EYE mode. Press the CONFIG button to remove the menu from the display.

Press the EYE/EQ EYE button and check that the EQ EYE indicator is illuminated. EQ EYE displays the signal after serial receiver equalization.

4. Parade Display

The WFM 601i can display the YP_BP_R components in the Parade mode. To display the INPUT signals in a paraded display, press the PARADE button. Check that the PARADE indicator lights.

Press the CH 2 button and check that both the CH 1 (luminance) signal and the CH 2 (P_B) signal are displayed. See Figure 1-14.

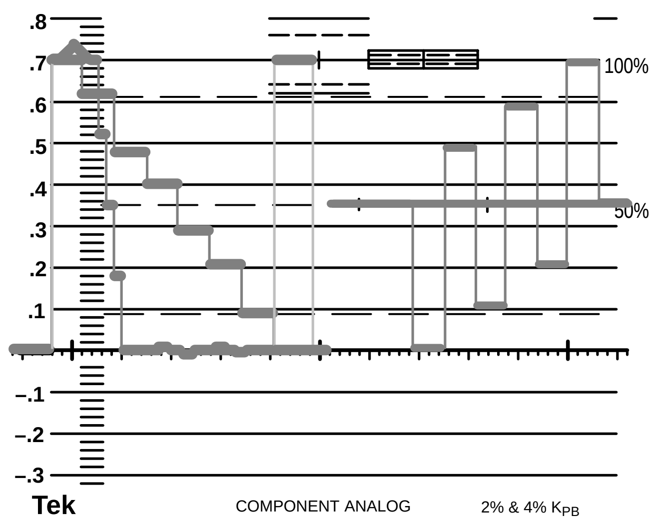


Figure 1-14: Parade display of Y and P_B.

Press the CH 3 button and check that the CH 1 (luminance) signal, the CH 2 (P_B), and the CH 3 (P_R) signals are displayed. See Figure 1-15.

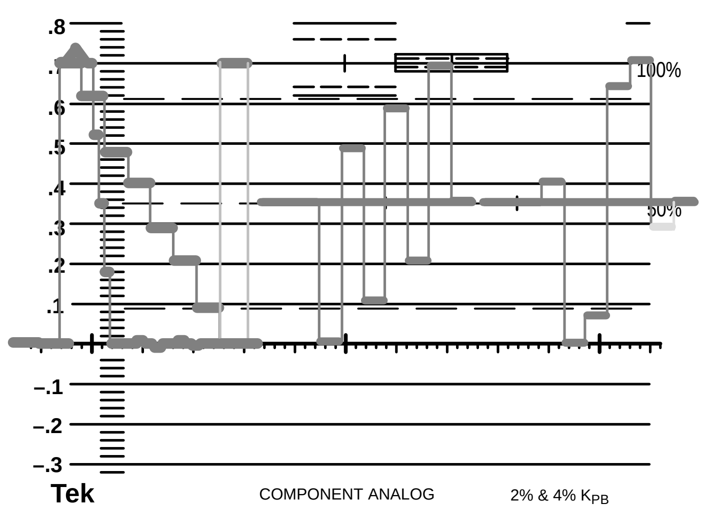


Figure 1-15: Parade display of Y, P_B, and P_R.

5. RGB Screen Display

There is a choice to display color difference signals or RGB. The choice is accessed through the instrument’s CONFIGURE menu.

Push the CONFIG button to enter the CONFIGURE menu. Select the WFM/VEC submenu. Push the button adjacent to the menu selection for WFM AS to select RGB. A three line parade of the R, G, and B color components will appear. See Figure 1-16

Return to the YP_BP_R setting for WFM AS. Push the CLEAR MENU button.

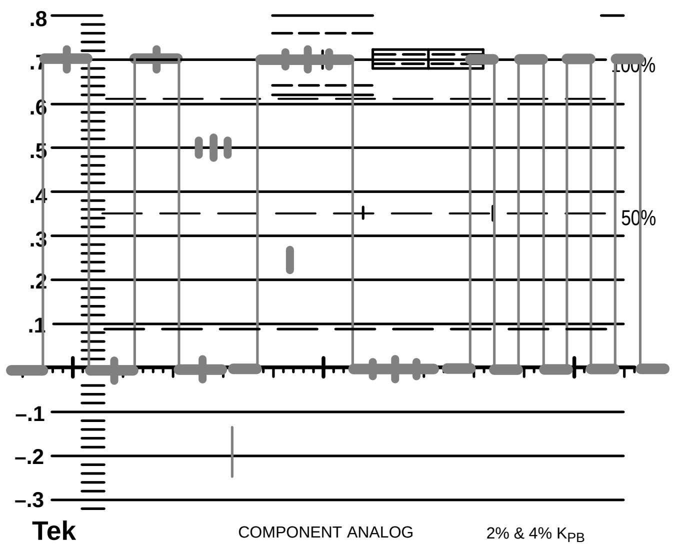


Figure 1-16: WFM 601i on screen RGB display.

6. Check Gain

The WFM 601i has an internal calibration signal which can be used to check the vertical and horizontal calibration. To display the calibration signal, press the CONFIG button to enter the configure menu. Select CALIBRATE by turning the knob under the list of configuration categories until CALIBRATE is highlighted. Press the top bezel button to select CAL SIG ON.

Select WAVEFORM VIDEO DISPLAY.

The calibrator signal should now be displayed. Position the signal as in Figure 1-17.

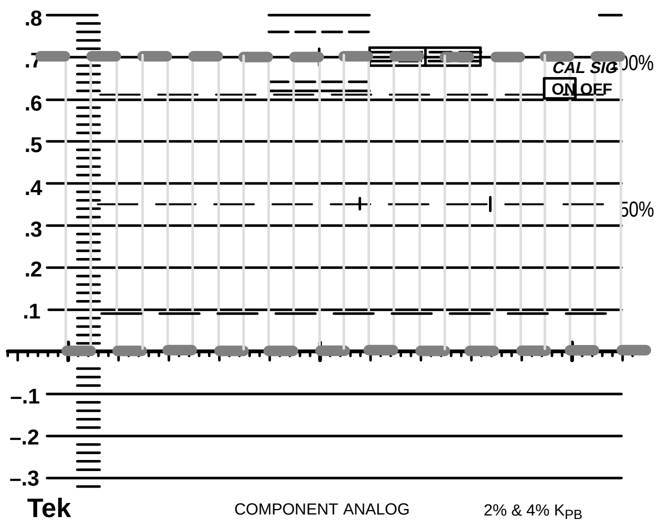


Figure 1-17: WFM 601i calibrator display.

7. Gain Calibration

The WFM 601i has both factory preset and user adjustable horizontal and vertical gain calibration. To access GAIN CAL (you must be in the CONFIGURE/CALIBRATE submenu) push the second from the bottom bezel button and observe that the cursor box now surrounds the ON readout.

The other two assignable bezel controls are now labeled V CAL and H CAL. Rotate both controls enough to see that the horizontal and vertical gains have changed noticeably and that two new labels have appeared next to the bezel buttons. They are RESET V CAL and RESET H CAL. See Figure 1-18.

Push the RESET V CAL button to return to the factory calibration setting. Note that the vertical amplitude returns to 700 mV and that the RESET V CAL label disappears.

Push the RESET H CAL and note that the horizontal gain returns to one cycle per division and the RESET H CAL label disappears. Exit the configure menu by pressing the CONFIG button. The calibrator signal is automatically turned off.

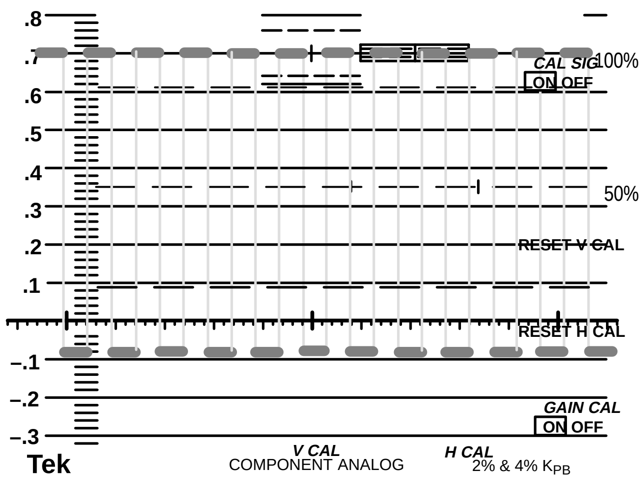


Figure 1-18: Calibrator signal, both gains misadjusted.

8. Gain Control

There are three calibrated gain settings available (X1, X5, and X10), as well as an independent VARIABLE GAIN control.

Turn off CH 2 and CH 3. Press the GAIN button to enter the gain menu. Press the bezel button corresponding to X5. Check that X5 is highlighted and that the display is immediately amplified. Press the bezel button corresponding to X10. Check that X10 is highlighted and that the display is immediately amplified again.

Press the bezel button adjacent to the VARIABLE ON/OFF menu selection. Check that ON is highlighted and that one of the knobs is identified as the VAR GAIN control. Adjust the control to the minimum gain setting. The entire signal should now be visible on the CRT. Set the WFM VAR GAIN control to the maximum setting and see that by adjusting the VERT POS control, any portion of the signal can be displayed on the CRT.

Return the gain to normal by pressing the GAIN button to exit the gain menu. The next time the gain menu is entered, the settings will be the same (variable X10 gain). Adjust the VERT POS control to place the signal on the baseline.

9. Sweep Timing

The LINE/FIELD button cycles the waveform sweep rate through 1 LINE (5 μs/div), 2 LINE (10 μs/div), 1 FIELD, and 2 FIELD. The MAG button provides additional line sweep rates of 200 ns/div and 1 μs/div. The FIELD sweeps are magnified by approximately 25X.

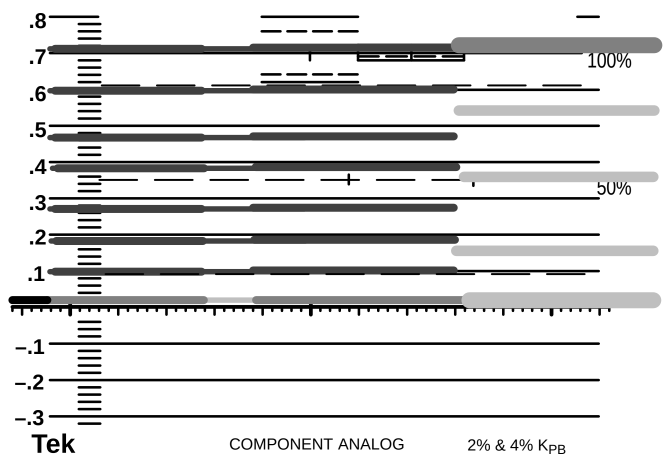


Figure 1-19: One field display of CH 1 (Y) signal.

Press the LINE/FIELD button. Check that the FIELD indicator lights and that the display changes to 1 FIELD. See Figure 1-19. Press the LINE/FIELD button again. Check that the display changes to 2 FIELD. See 1-20. Press the LINE/FIELD button twice to return to the 2 LINE (10 μs/Div) display.

Figure 1-20: Two field display of CH 1 (Y) signal.

Check that the readout shows 10 µs/DIV. Horizontally center the display and then press the MAG button. Check that the MAG indicator lights and that the display changes to 1 µs/Div. See Figure 1-21. Press the MAG button again to return to 10 µs/Div sweep.

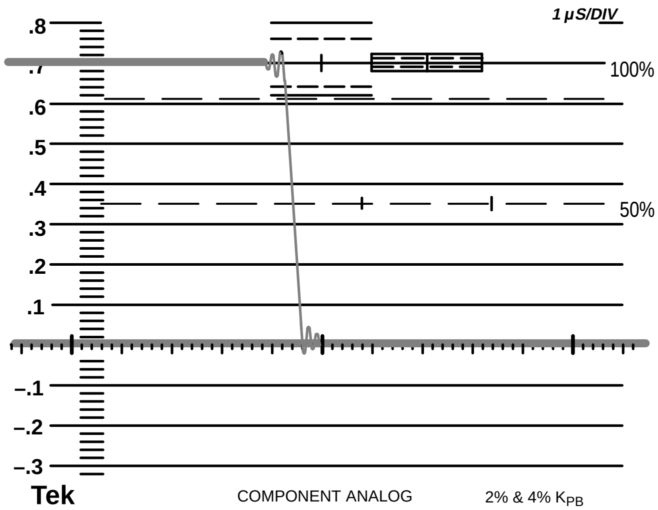


Figure 1-21: Two Line Magnified Display.

10. Flat or Differentiated Filter Selection

The WFM 601i offers the selection of an unfiltered display (FLAT), a 1 MHz low-pass filter (LPASS), or a differentiated step (DIFF) filter for the waveform display. The normal display is unfiltered. Press the FILTER button to enter the filter menu. Check that FLAT is highlighted.

Change the digital input signal to the five-step luminance staircase signal.

Press the bezel button adjacent to LPASS and see that the label is highlighted by the cursor box.

Press the bezel button adjacent to DIFF and see that the label is highlighted by the cursor box. Check that there is a display similar to Figure 1-22.

Push the bezel button adjacent to FLAT and see that it is highlighted and the five-step staircase luminance staircase is again displayed.

Push the FILTER button to turn off the FILTER menu and return to the unfiltered staircase display.

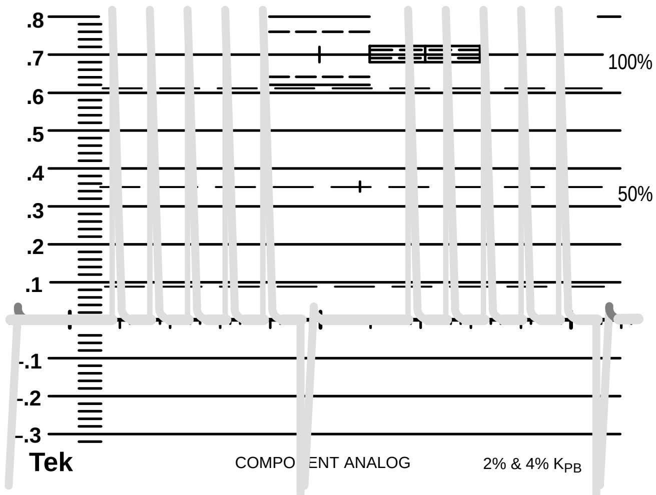


Figure 1-22: A two-line differentiated step display.

11. Line Select

The WFM 601i can display one line out of two fields, one line in both fields or up to 15 continuous lines in either or both fields. Display can be 1 line, 2 lines, 1 field, or 2 fields.

Change the digital generator signal to color bars.

Press the LIN SEL button to enter the LINE SELECT menu. Turn the LINE SEL knob until the readout, in the upper left corner of the CRT, displays ALL 150. Note that there is no NEXT FIELD label. In the 2 LINE display, the left display is line 150 and the right display is line 151. Press the bezel button adjacent to ALL/1 OF 2 to highlight 1 OF 2. Note that the NEXT FIELD label appears.

Press the LINE/FIELD button twice to select 2 FIELD sweep. If the readout is displaying “F2:”, push the button adjacent to NEXT FIELD and check that the readout now reads F1:150. Note the intensified portion of the display is in the first field. See Figure 1-23.

Press the bezel button next to the NEXT FIELD selection and note that the readout in the upper left corner of the CRT changes from F1 to F2 and that the location of the intensified line has moved to the second field. Press NEXT FIELD again to return to F1

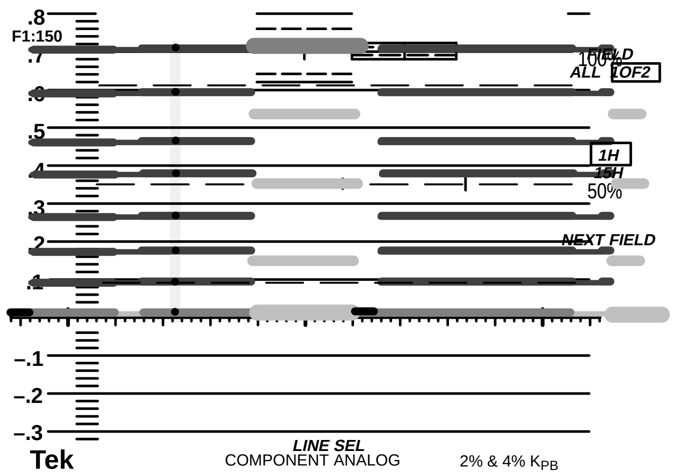


Figure 1-23: Two field line select display; line number 150 selected.

Press the bezel button adjacent to 1H/15H. Check that 15H is highlighted and that the intensified portion of each field increases in width. See Figure 1-24. Note that the line select readout now reads the selected line range (F1:150/164 if you are in the first field).

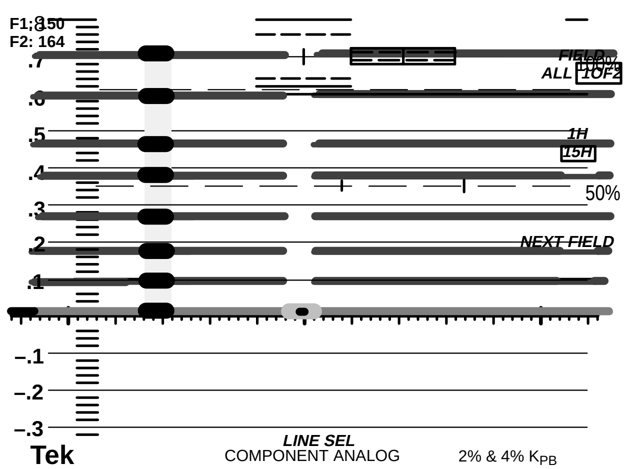


Figure 1-24: Line select, 15-line display; lines 150–164 displayed.

Line select is available for the WAVEFORM, VECTOR, PICTURE and LIGHTNING displays. When line select is used in the MULTIPLE display mode, the displays appear in the following order: WAVEFORM, VECTOR.

Return to the normal 2 FIELD display by pressing the LIN SEL button to exit the LINE SELECT menu. The next time the LINE SELECT menu is entered, the settings will be just as they were left this time. Press the LINE/FIELD button to select the 2 LINE (10 µs/Div) sweep.

12. Vector Display

The WFM 601i vector display uses an electronic graticule. Amplification of the vertical and horizontal axes for both the signal and the graticule are the same, which eliminates errors due to CRT geometry anomalies.

Press the VECTOR/LIGHTNING button to switch the monitor to the vectorscope display mode. The display should look similar to Figure 1-25.

Press the CONFIG button to enter the CONFIGURATION menu. Rotate the menu selection control until WFM/VEC is high lighted. Press the bezel button adjacent to the COLOR BARS label to change from 100% to 75%. Note that the color bar vector dots are no longer in the target boxes.

Press the bezel button again and note that the dots and the targets are again aligned. Press the CONFIG button again to exit the configure menu.

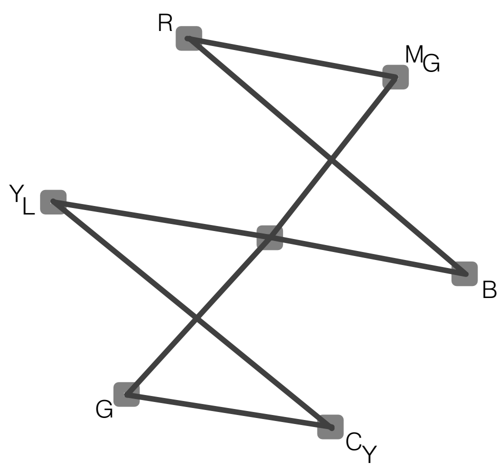


Figure 1-25: Vector color bar display with electronic graticule.

13. Picture Monitor Display

The PICTURE display mode allows the operator to verify the signal source. Press the PICTURE button to select monochrome display. Check that the display changes to a picture monitor display of the Color Bar signal. See Figure 1-26.

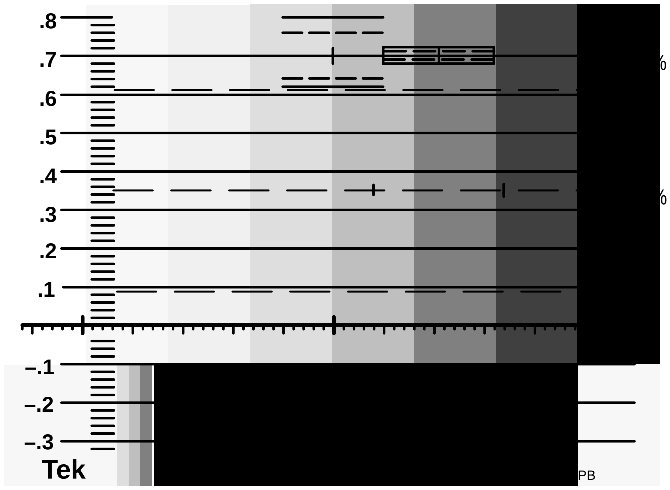


Figure 1-26: Picture monitor display of the color bar signal.

14. Lightning Display

The LIGHTNING display mode displays either a lightning or diamond component waveform as chosen from the configuration menu.

The DIAMOND display shows the relationship of R, G, and B color components and is primarily used to verify RGB Gamut. The LIGHTNING display shows the relationship of the Y, P_B, and P_R components. Information on how to use these two displays is contained in ***Measurement Applications.***

Press the VECTOR/LIGHTNING button to select LIGHTNING. Check that the LIGHTNING indicator lights and that the display changes to the LIGHTNING display. See Figure 1-27.

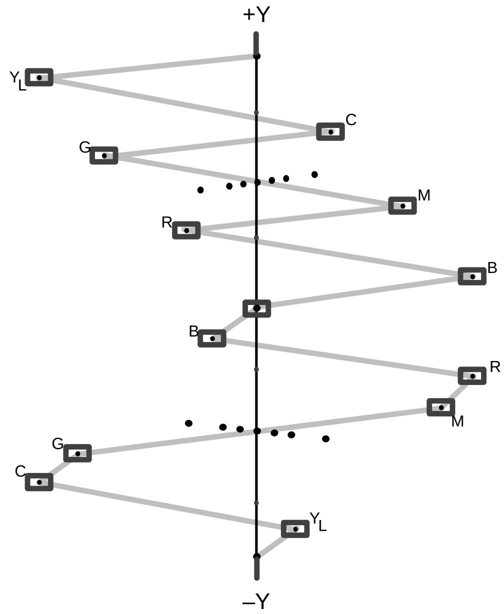


Figure 1-27: Lightning display of component color difference signals.

15. Diamond Display

Press the CONFIG button to enter the CONFIGURATION menu. In the WFM/VEC submenu, press the bezel button corresponding to LIGHTNING/DIAMOND DISPLAY. Check that DIAMOND is highlighted and the display changes to the DIAMOND display. See Figure 1-28.

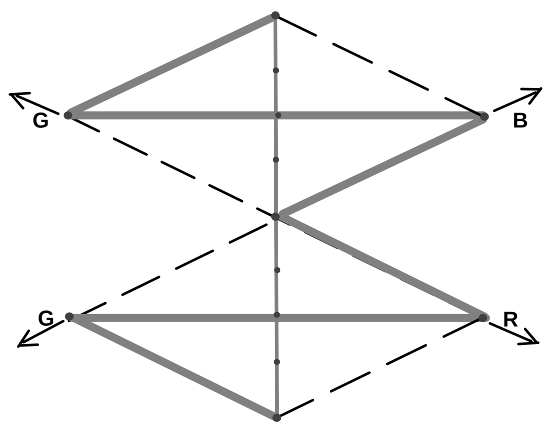


Figure 1-28: Diamond display.

Exit the CONFIGURATION menu by either pushing CONFIG or CLEAR MENU.

16. Bowtie Display

The BOWTIE display provides a two-line display of component signals: the first line displays CH 1 minus CH 2, the second line displays CH 1 minus CH 3.

Select the timing signal from the Digital Component Generator. Make sure it is the low frequency (500 kHz) signal with markers.

Press the BOWTIE DISPLAY button. Check that the BOWTIE indicator lights and the display changes to the BOWTIE display. See Figure 1-29.

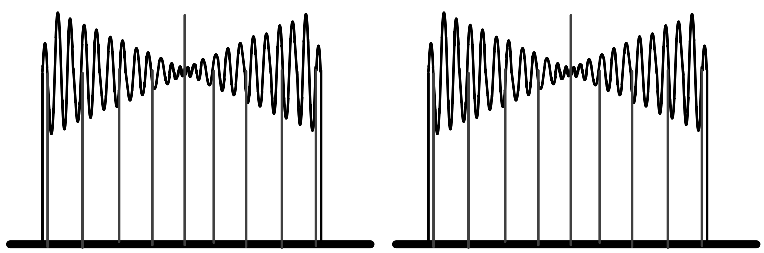


Figure 1-29: The Bowtie display.

Operating Basics

At A Glance

The following is an overview of the front–panel controls and rear–panel connectors for the WFM 601i Serial Component Monitor.

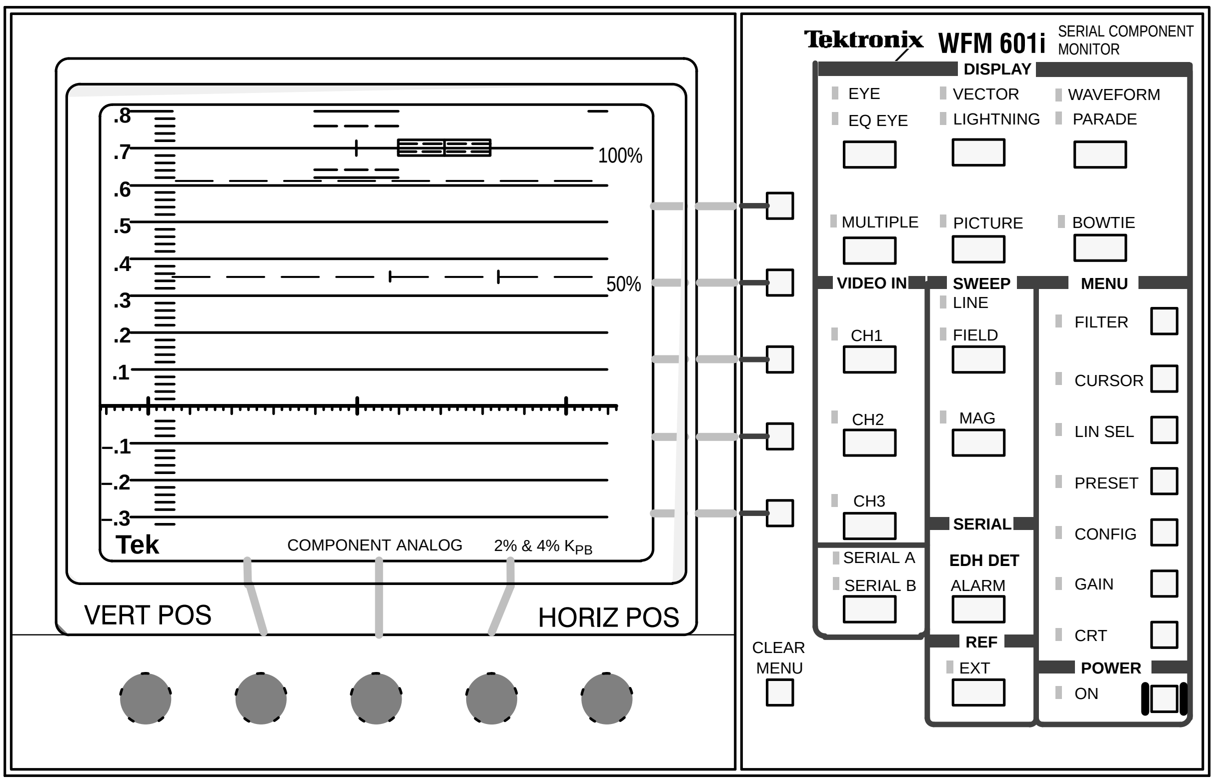


Figure 2-1: WFM 601i front panel.

Front Panel Controls and Indicators

Multi-Use Controls

Bezel Knobs
The center three knobs located under the CRT have multiple functions that are assigned through on-screen menus and readouts. The outside knobs are the Vertical and Horizontal Position controls.

Bezel Buttons
Five small buttons along the right side of the CRT enable users to make selections when on-screen menus are in use. The buttons either scroll through a list of two or more items or turn a function on or off.

Buttons

The front–panel buttons are arranged in seven major categories: DISPLAY, VIDEO IN, SWEEP, MENU, SERIAL, REF, and POWER.

DISPLAY — Six buttons control the video display format.

EYE — Selects the eye pattern display.

EQ EYE — Selects the equalized eye pattern display.

VECTOR — Selects the vector display.

LIGHTNING — Selects lightning or diamond display as selected through the CONFIGURE menu.

WAVEFORM — Selects a waveform overlay display.

PARADE — Displays the selected inputs in a multi-line parade.

BOWTIE — Selects the bowtie display.

PICTURE — Selects the monochrome picture monitor mode.

MULTIPLE — Allows the following simultaneous displays:
waveform + vector or lightning
parade + vector or lightning

VIDEO IN — These three buttons turn on or off CH 1 (Y/R), CH 2 (P_B/G), and CH 3 (P_R/B). At least one channel is always on.

SERIAL A / SERIAL B — Selects the signal from one of the two rear-panel bnc serial inputs for display.

SWEEP — These two buttons select the waveform monitor's sweep rate.

LINE / FIELD — Toggles through four sweep rates (1-Line (5 µs/division), 2-Line (10 µs/division), 1-Field, and 2-Field). In Parade mode, the LINE/FIELD button becomes a two-way switch, toggling between line and field. In EYE modes the LINE/FIELD button toggles between a 1 or 3 ns/Div sweep and a field rate sweep.

MAG — The MAG button is used with LINE/FIELD to provide horizontal magnification of each rate as follows:

EYE modes = 0.5 ns/Div

One line sweep rate = 200 ns/division

Two line sweep rate = 1 µs/division

25X magnification for 1- and 2-field sweep rates.

SERIAL — Displays a status screen providing EDH error statistics and format error reporting.

REFERENCE (REF) — Selects either internal serial digital or external composite video input for the instrument's synchronization reference.

MENU — Push the desired menu button to enter that menu and enable the associated functions. Push the button again to exit the menu and disable the function. Refer to page 2–15 for more information about using the menus.

POWER — Changes the instrument between standby and operational modes.

CLEAR MENU — Turns off menu readout without affecting any of the menu selections.

Indicators

Two front-panel indicators show the characteristics of the incoming video. When the serial input signal has the Error Detection and Handling (EDH) signal embedded in it, the EDH Detection label is illuminated. When an error occurs the ALARM label is illuminated. The error conditions that light this indicator can be setup in the CONFIGure SER ALARM menu.

These two indicators appear above the SERIAL button. They are visible only if the indicators are illuminated.

EDH DET — The incoming serial digital signal has the SMPTE RP165 specified EDH signal.

ALARM — Lights when a serial video data or format error occurs, or the serial signal is lost.

A GAMUT ERROR readout will appear at the lower left CRT corner when an RGB gamut error is detected by the WFM 601i. This indicator can be turned off in the CONFIGURE\GAMUT menu.

Rear Panel Connectors

The following is an overview of rear-panel connectors.
Figure 2-2 shows the WFM 601i rear panel.

Power Connector

This instrument is intended to operate from a single-phase power source with one current-carrying conductor at or near earth-ground (the neutral conductor). Only the line conductor is fused for over-current protection. Mains frequency is 50 or 60 Hz. Operating voltage range is continuous from 90 to 250 Vac.

⚠ ***WARNING.*** *Do not connect power to the WFM601i if it is not enclosed in a prescribed cabinet. Dangerous potentials are present on the Power circuit board.*

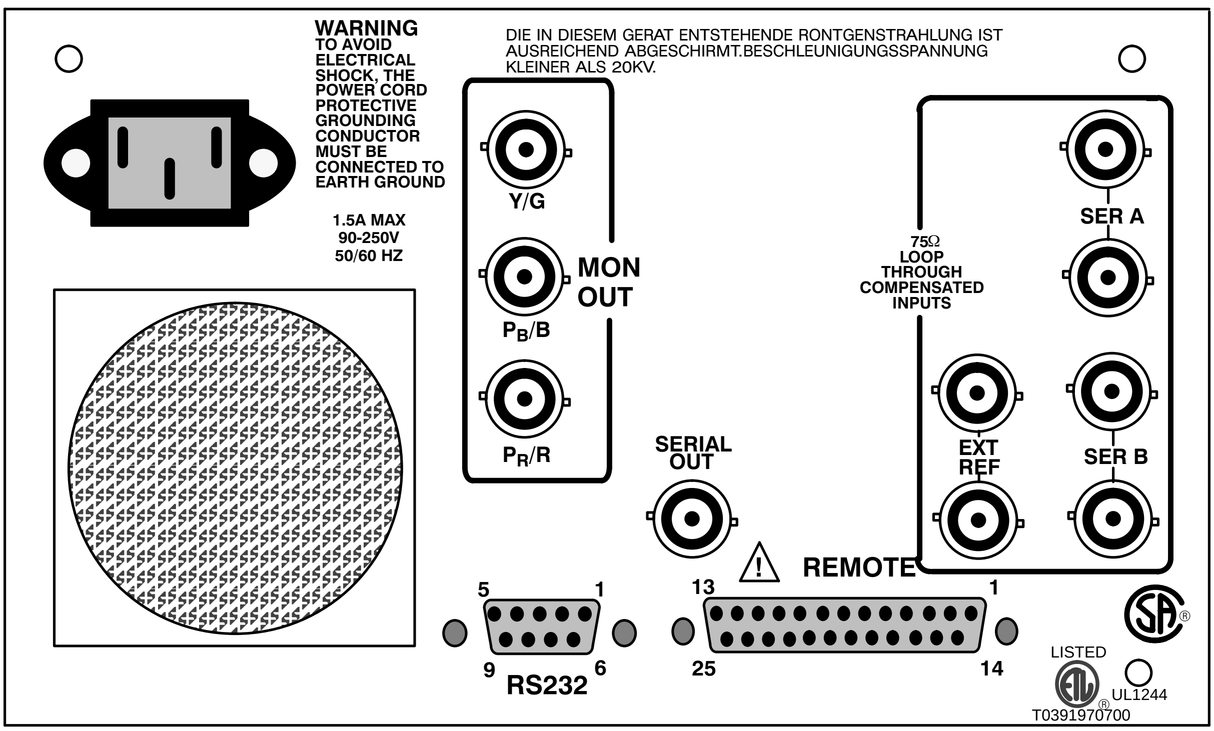


Figure 2-2: Rear panel of the WFM601i Monitor.

Loop-Through Inputs

SER A and **SER B —** Passive loopthrough serial digital component inputs, compensated for 75Ω.

EXT REF — Loopthrough synchronization input (compensated for 75Ω), selected by the front-panel REF switch. The input signal may be black burst, or composite video.

Outputs

MON OUT (Y/G - P_B/B - P_R/R) — Three 75Ω outputs that are designed to drive a component picture monitor. Invalid signals cause a blinking bright-up of the monitor display. This gamut error bright-up signal is present on the Y (or G) and can be turned off by menu selection.

SERIAL OUT — Reclocked serial output of selected signal input (SER A or SER B).

Multi-pin Connectors

RS232 — A 9-pin subminiature D-type connector that provides a serial interface for calibration.

REMOTE — A 25-pin subminiature D-type connector that provides limited remote control functions.

Functional Overview

Functional Overview describes instrument functions in greater detail than ***At A Glance.*** This section includes the following topics: Video Display Modes, Eye Pattern Display, Serial Readout Screens, and Using the Menus.

Video Display Modes

- **WAVEFORM**
- **PARADE**
- **VECTOR**
- **LIGHTNING** and **DIAMOND**
- **BOWTIE**
- **PICTURE**
- **MULTIPLE** displays

Waveform

The waveform monitor portion of the instrument provides a voltage-versus-time display of the video signal. The selected input can be displayed in one or two line, or one or two field sweeps. In Line Select mode, identified lines of any field can be selected and displayed. Time and Voltage cursors can be activated and positioned for reference or measurement.

Parade

Parade displays up to 3 channels in succession, The LINE/FIELD button offers only two choices: one line and one field.

Vector

Vector mode presents an XY plot of the P_B (B–Y) and P_R (R–Y) color difference components. The angle represents chrominance phase and the distance from the center represents chrominance amplitude.

Lightning

The front-panel LIGHTNING button is used to select either the Lightning display or the Diamond display. To select which one to display, go to the

CONFIGure WFM/VEC menu and select either Lightning or Diamond. Push the CLEAR MENU button to clear the menu readout.

The Lightning display is useful for viewing the amplitude and timing relationship between the Y, P_B, and P_R signals.

The Diamond display evaluates the RGB signal for gamut limit violations. Signals which are inside the electronic diamond graticule are within gamut limit. For signals outside the diamond, the graticule is labeled with G, B, and R to determine the color problem area.

Bowtie

Bowtie mode is used in conjunction with the Bowtie test signal. It is useful for determining the timing between Y and P_B (Ch. 1 and 2), and Y and P_R (Ch. 1 and 3).

In Bowtie mode, the left half of the display shows Channel-1 minus Channel-2 and the right half shows Channel-1 minus Channel-3. If the timing between channels is matched, the centers of the bowties will be centered and not skewed. If Channel-2 is delayed with respect to Channel-1, the skew moves to the right. If Channel-2 is advanced with respect to Channel-1, the skew moves to the left.

Picture

The Picture mode allows the operator to verify the signal source. In Picture mode with Line Select on, a bright-up marker identifies the selected line in the picture.

Multiple

When Multiple display is selected, Waveform or Parade can be displayed at the same time as Vector or Lightning (or Diamond).

When exiting Multiple display, the instrument will return to the previous display settings. When multiple is re-selected, the previous Multiple display settings will be restored.

Eye Pattern Display

The eye pattern display is a voltage-verses-time display of the serial bit stream. This mode is used to observe the amplitude, rise time, aberrations, and jitter of the serial signal.

EYE and EQ EYE

In EYE mode the serial signal that is applied to the rear panel loop-through input is directly displayed. In EQ EYE the serial signal is displayed after equalization.

Trigger Modes

Two trigger modes are available: OVERLAY and 10-EYE. The trigger mode is indicated by a readout in the upper left corner of the CRT.

The trigger mode is selected in the CONFIGure\EYE PATTERN menu. Press the CONFIG key, then move the “selector box” to the EYE PATTERN menu selection. Pressing the bezel button adjacent to DISPLAY will cause the trigger mode to toggle between OVERLAY and 10 EYE.

OVERLAY – In OVERLAY all of the bits of a serial word are overlaid at each eye location. This shows peak jitter at each eye crossing. Approximately three eyes are shown on screen, with the horizontal deflection calibrated at 1 ns/div (It is actually a “9-eye” mode with the sweep running at a 3H rate). Figure 2-3 shows the Overlay Eye display.

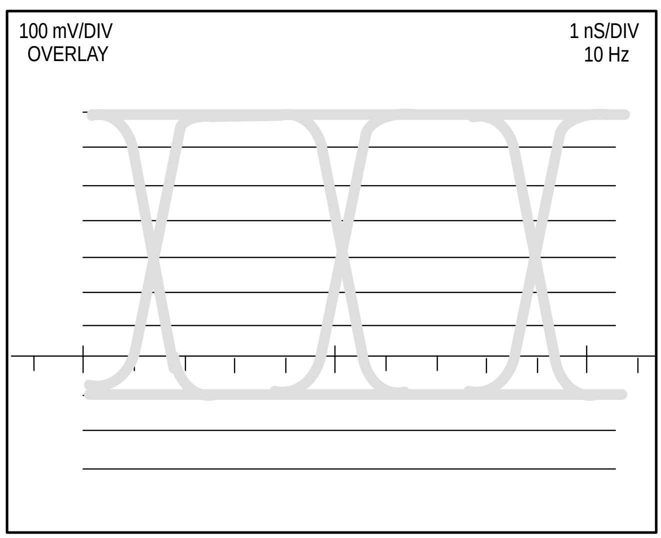


Figure 2-3: Overlay Eye display.

10 EYE – In 10-EYE every tenth bit of the scrambled serial signal appears at a fixed location in the display. Events that are correlated with the serial word rate, or horizontal line rate, can be observed in this mode. The horizontal deflection factor is calibrated at 3 ns/div.

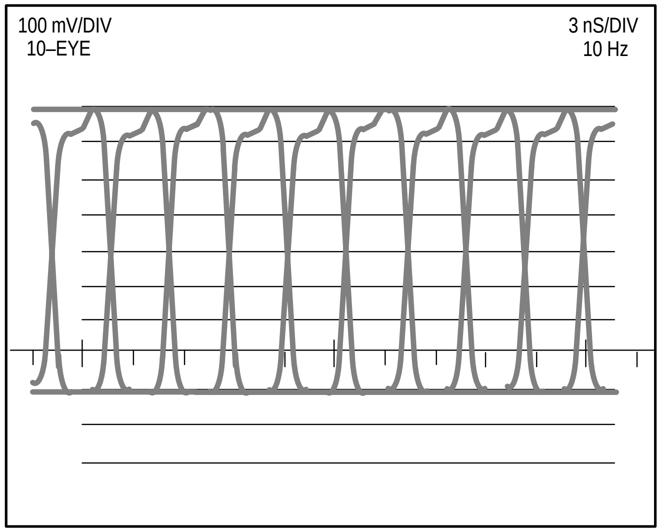


Figure 2-4: 10-EYE display screen.

In Figure 2-4 the eye display has been changed to the 10-EYE mode. Approximately 10 eyes are displayed per horizontal sweep, and the horizontal scale is 3 ns/Div. The display is triggered so that a given bit of the scrambled serial word always appears in the same location; the display is *word correlated*. Systematic errors that repeatedly affect certain bits in the word can be observed in this mode.

Jitter Filters

Both EYE pattern displays can be set to attenuate jitter via three different jitter high-pass filters. Filter choices are 10 Hz, 100 Hz, and 1 KHz, and are selected in the CONFIGURE\EYE PATTERN menu. Each filter will suppress jitter terms below the indicated 3 dB point, allowing medium and high frequency jitter to be separated from low frequency jitter. The 10 Hz and 1 KHz filters allow jitter measurements according to the proposed SMPTE standard.

The selected jitter high pass filter is indicated in a readout field directly below the horizontal deflection factor as 10Hz, 100Hz, or 1KHz**.**

Vertical Gain

Calibrated vertical gain for the EYE and EQ EYE modes is 100 mV/div. The deflection factor is displayed in the upper left corner of the CRT screen. Both X5 and X10 vertical gains are available via the Gain menu. The deflection factor readout shows 20 mV/div in X5 and 10 mV/div in X10. Variable Gain also works in the EYE pattern modes. When Variable Gain is enabled, a ">" is placed in front of the deflection factor to indicate the uncalibrated condition: e.g. **"**>*100 mV/DIV.*"

Horizontal Gain

In Line Sweep mode, the OVERLAY eye mode is calibrated at 1ns/div and the 10-EYE mode is calibrated at 3 ns/div. Pressing the MAG button gives a calibrated 0.5 ns/div display for either OVERLAY or 10-EYE. The proper deflection factor, e.g. 1 ns/DIV, 3ns/DIV, or 0.5 ns/DIV, appears as a readout in the upper right corner of the screen.

In Field Sweep mode the eye signal is swept at a 1 field rate. Normal 1 field mag is available. The deflection factor readout changes to “FIELD” in this mode.

Display Position

The EYE pattern mode vertical position is independent from other vertical position settings in the instrument. The position value is saved when the mode is exited, and recalled when either EYE or EQ EYE is re-entered. It is adjusted with the Vert Pos control.

The EYE pattern horizontal position is shared with the Waveform/Parade horizontal position settings. It is adjusted with the Horiz Pos control.

Cursors

Both amplitude and time cursors are available via the CURSOR menu.

Line Select

The EYE PATTERN displays can be “windowed” around specific segments of the video frame by using the line selector. Both 1H and 15H modes are available.

Serial Readout Screens

The WFM 601i has two readout screens that display information about the serial signal. The STATUS screen provides basic information about the signal, such as signal presence, line rate, Audio and Anc Data presence, and error rate. The FORMAT screen displays the results of several data format checks. The readout screens are activated by pushing the SERIAL button. The STATUS and FORMAT screens are toggled via the DISPLAY soft key.

STATUS Screen

The basic STATUS screen is divided into three parts; see Figure 2-5. The upper third of the screen provides general information on the content of the serial signal. This particular screen shows that a 525-line rate signal, with 10 active bits is present. One or more format errors have been detected, and ancillary data other than EDH and embedded audio is present. Also, 8 channels of embedded audio have been detected.

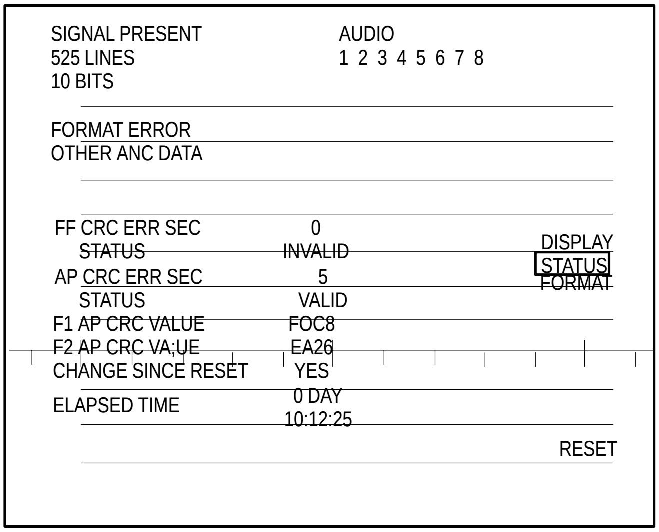


Figure 2-5: Basic Status Screen

The middle half of the screen gives error rate information. EDH is supported with full field and active picture asynchronous errored seconds readouts. Also, the computed active picture CRCs for both monochrome fields is given, and a flag indicates if they have changed in value (this is useful for error detection with a fixed pattern source when incoming EDH is not available). Finally, the elapsed time since the errored seconds readouts were last cleared (via the RESET soft key) is shown. This particular screen shows that only the AP CRC in the incoming EDH error status packet is valid so only AP errors can be counted via EDH. 5 AP errored seconds have been counted since the last reset, 0 days, 10 hours, 12 minutes, and 25 seconds ago. The present F1 and F2 APCRC's are F0C8 and EA26, respectively. The value of one or both CRCs has changed at least once since the last reset (CHANGE SINCE RESET = YES).

The *embedded audio*, *format error*, and *other anc data* fields are not displayed when these conditions are missing. Figure 2-6 shows how the STATUS screen would look in this case. Only EDH anc data is present. Both full field and active picture CRCs are incoming for error monitoring.

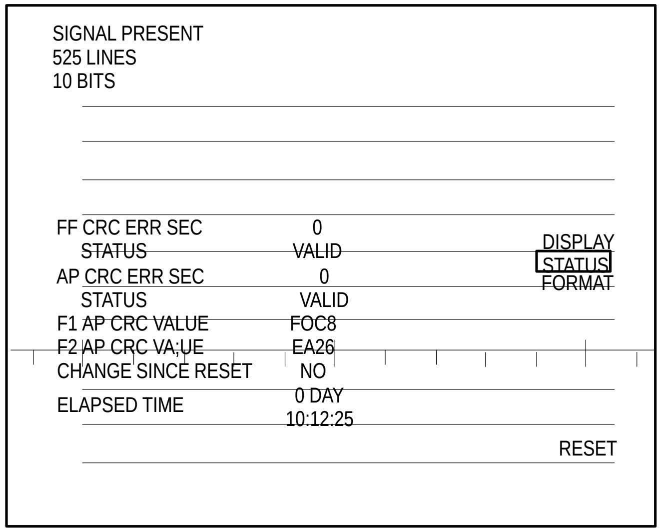


Figure 2-6: Status screen with 525 line, 10-bit video.

When the serial receiver detects a no-signal condition, the STATUS screen indicates SIGNAL MISSING. Under this condition the line rate and active bits readouts are blanked. See figure 2-7.

In Figure 2-7 loss of signal condition is indicated. Note that the FF and AP EDH status says “missing” because of the absence of the error status packet.

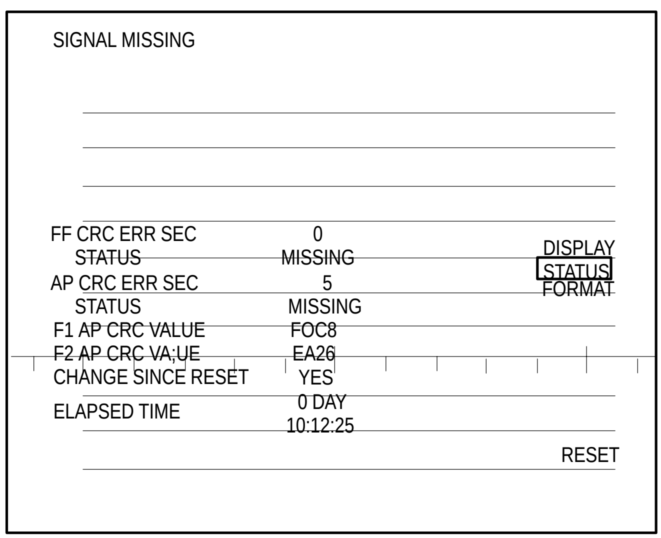


Figure 2-7: Loss of signal condition is indicated.

FORMAT Screen

The FORMAT screen presents the results of seven signal format checks. A given check reports back either “OK” or “ERROR”. The checks are continuously made and the results are *not* “sticky”: once an error condition clears, the indicator returns to “OK”.

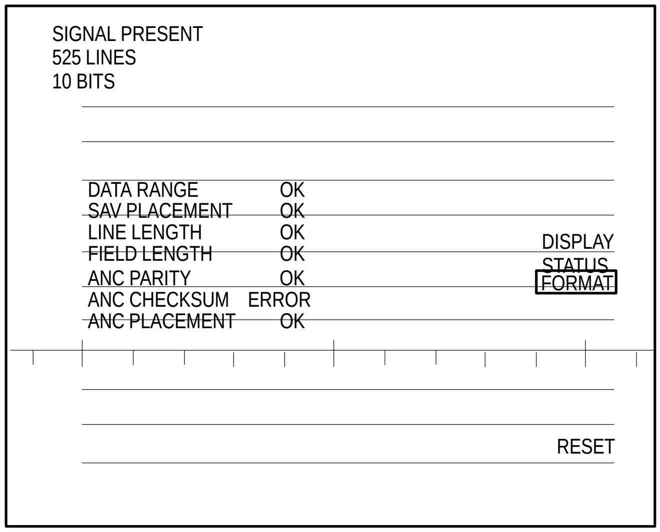


Figure 2-8: Basic FORMAT Screen.

DATA RANGE Indicates an error if the reserved values of 000h–003h or 3FCh–3FFh are used incorrectly.

SAV PLACEMENT Indicates an error if SAV is improperly placed with respect to the preceding EAV.

LINE LENGTH Indicates an error if there are an incorrect number of samples from one EAV to the next.

FIELD LENGTH Indicates an error if there are an incorrect number of lines in a field.

ANC PARITY Indicates an error if a parity error has occurred in ancillary data.

ANC CHECKSUM Indicates an error if an ancillary data checksum error has occurred

ANC PLACEMENT Indicates an error if ancillary data is improperly placed with respect to active video.

Using the Menus

The instrument has a set of front-panel selectable MENU buttons that call up CRT readout menus that operate in conjunction with the 5 bezel buttons and 3 controls directly beneath the CRT. See Figure 2-9.

Enabled menu selections are surrounded by a rectangle to indicate that they are active.

Pressing the CLEAR MENU button turns off the menu readout while leaving the functions that were set up by that menu.

Pressing a MENU button when its menu is displayed turns off both the menu readout and in the case of Line Select, Cursor, Filter, and Gain disables the function. When selecting Line Select, Cursor, Filter, or Gain the last settings are returned. For example, if X5 and variable were the last gain selections pushed, the GAIN MENU will turn on X5 gain and variable gain (variable gain level also returns to the setting previously set up).

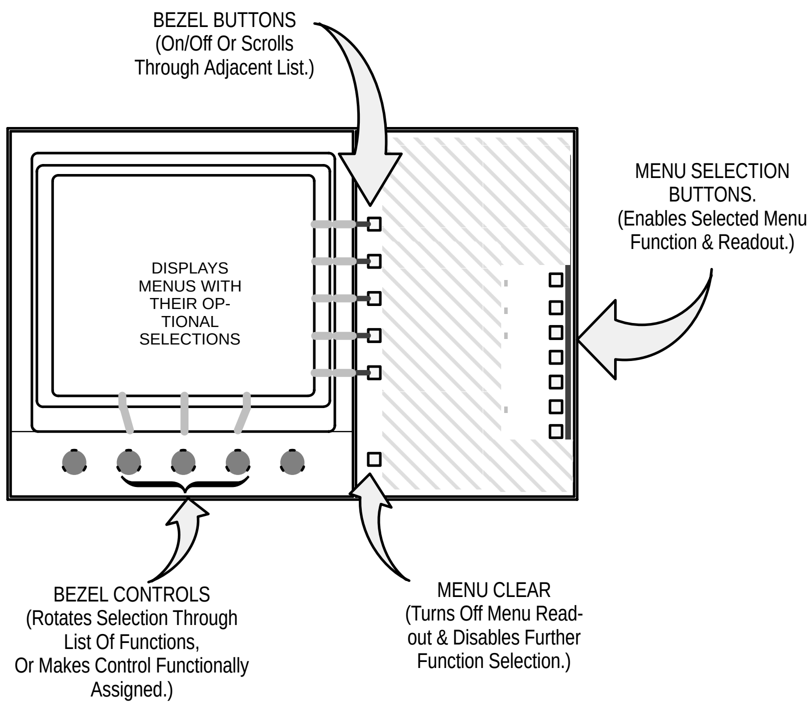


Figure 2-9: Elements of the WFM601i menu driven selections.

Filter Menu

This menu provides three selections: FLAT (unfiltered), LPASS (1 MHz low pass filter), and the DIFF (differentiated steps filter). Turning off the FILTER returns the monitor to the unfiltered (FLAT) setting. If either the LPASS or DIFF filter is selected when the menu is turned off, the selected filter will be turned on again when the FILTER menu is reselected.

Pressing CLEAR MENU turns off the filter selection readout.

Cursor Menu

The Cursor menu allows the operator to choose Voltage Cursors, Time Cursors, Markers, or both Voltage and Time Cursors. With Voltage and Time cursors the three controls below the CRT are assigned to control cursor 1, cursor 2, and cursor tracking. The difference in the settings of cursor 1 and cursor 2, when voltage or time is selected is reported with CRT readout as Δ V or Δ T. In the both mode (V+T) a CONTROL selection allows the three controls to be used with either the voltage or time cursors.

Markers operate in the vertical direction only. There are three markers identified by the type of dashed lines:

Mark 1 is the longest dash.

Mark 2 is double dash.

Mark 3 is the shortest dash.

The markers have no readout associated with them.

CLEAR MENU removes the readout associated with the cursor selection, but the cursors, difference readout (voltage or time) and control assignments remain active and on screen. To restore the menu readout, push the CURSOR menu button again. To turn off the cursors, push the CURSOR menu button when the menu readout is displayed (two pushes of the CURSOR button, if the menu readout is not displayed).

Line Select Menu

The Line Select menu provides a means of displaying a specified portion of the signal. In the field rate sweeps one line out of field 1 or field 2, or the same line in both fields can be displayed as a bright up of the display. A readout in the upper left corner identifies the line. If 15H is selected the intensified portion of the sweep increases in size and the read out now gives a range of lines (Field plus starting and ending line).

In the line rate sweeps the display will be one or two lines long and will display the selected line first. In 15H mode the display will consist of 15 lines overlaid. Again the readout will be a range of lines.

The NEXT FIELD selection comes up when 1 OF 2 FIELD is selected and allows the operator to toggle between fields 1 and 2.

A special condition exists when PARADE or WAVEFORM overlaid mode display is selected. The first line in the display corresponds with the LINE SELECT readout. The second is the from the next line and finally the last third of the display is from the third line in the sequence. See Figure 2-10.

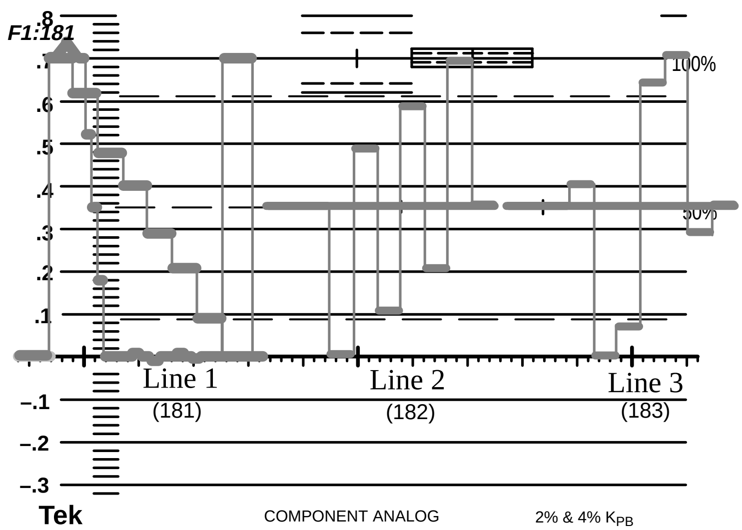


Figure 2-10: Parade display of YP_BP_R shown in line select.

CLEAR MENU removes the readout associated with the line selection, but the line number readout and Line Sel control assignment remain active and on screen. To restore the menu readout, push the LINE SEL menu button again. To turn off the function push the LINE SEL menu button when the menu readout is displayed (two pushes of the LINE SEL button if the menu readout is not displayed).

Preset Menu

The Preset menu makes it possible to recall a preset measurement from a list of 10 possible front–panel setups. Nine of these front–panel set ups can be used for storage of front–panel setups. The remaining one is factory programmed to assist in the calibration of the instrument.

When the PRESET menu button is pushed a list of the 10 presets appears over the 2nd knob below the CRT. Rotating this knob moves the highlight box up or down the list. Once the desired preset location is selected, one of four actions can be taken:

RECALL – Sets the front panel to the stored settings previously loaded into that memory location.

STORE – Wipes out the currently stored settings, in the selected memory location, and replaces them with the current front–panel settings.

RENAME – Calls up a set of alpha-numeric characters, plus a limited set of symbols that are used to change the name of the current preset selection.
In the Rename submenu the two bezel controls to the right of the preset scroll are assigned as LOCATION and LETTER. The Location control is used to select the character (within the current name) that you wish to make a change to. The Letter control scrolls through the list of characters to select the naming choice. The blank space is located immediately following the letter Z. When renaming is complete, pressing the ACCEPT button locks the selection. Press the RETURN button to bring back the original PRESET menu.

RECOVER – Returns to the previously selected choice. (Assume that Preset 1 was the previous choice and Preset 8 has now been selected but not recalled. Pushing RECOVER returns to Preset 1).

To restore the Preset menu, push the PRESET menu button again. To turn off the function Recall a Preset, press CLEAR MENU, or press the PRESET menu button.

Configure Menu

There are six separate submenus included in the Configure menu: WFM/VEC, EYE PATTERN, SER ALARM, GAMUT, FORMAT, and CALIBRATE. Access to these menus is through the list above the second CRT control. Turning the knob clockwise causes the “selection box” to scroll upward; counterclockwise moves it downward. The Configure menus are overlaid on the currently selected display mode, even though they may have no effect on that particular display.

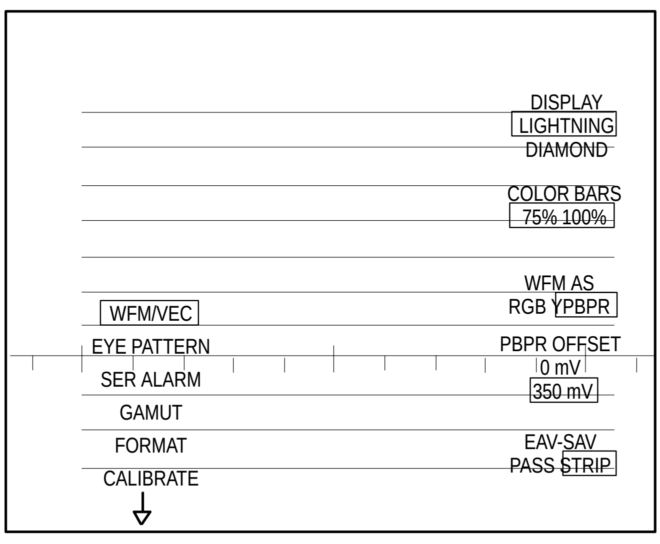


Figure 2-11: Configure menu screen.

In addition to the functions enabled by the CONFIG menu, the software and coprocessor version number are found on the CALIBRATE submenu.

WFM/VEC Selection choices for the Waveform, Parade, Vector, and Lightning video displays.

DISPLAY – Selects whether Lightning or Diamond is displayed when the front-panel LIGHTNING button is pressed.

COLOR BARS – Selects either 75% or 100% graticules for the Lightning and Vector modes.

WFM AS – In Waveform or Parade modes, determines if channels 1, 2, and 3 are displayed in their native Y, P_B, P_R format (YP_BP_R) or transcoded to R, G, B (RGB). Does not affect the picture monitor out signal.

PBPR OFFSET – Allows adding a 350 mV positive offset to the P_B and P_R channels to facilitate comparison with the Y channel (*350 mV* selected). Does not affect the transcoded RGB display or the picture monitor out signal.

EAV-SAV – In Strip mode, only digital signals between the SAV and EAV sync words are passed to the D/A converters and subsequently to the display and the picture monitor output. In Pass mode all digital data is sent to the converters.

EYE PATTERN Selection choices for the EYE and EQ EYE display modes.

DISPLAY – Selects between OVERLAY and 10-EYE displays when in Eye or EQ EYE modes.

JITTER HPF – Selects between 10 Hz, 100 Hz, and 1 kHz jitter high pass filters.

See the ***Eye Pattern Display*** description for more information; starts on page 2–9.

SER ALARM A front–panel *Alarm* light can be activated by up to four different serial video event conditions. This submenu allows selecting which events, when true, cause the indicator to light. Alarms are turned on or off by the push of the adjacent bezel push button.

Once activated, the Alarm light will stay on for a minimum of one second. If selected alarm conditions occur at a frequency greater than once per second, the Alarm light will stay continuously lit. One second after the last selected alarm condition clears, the light will go out.

When the alarms are enabled the following conditions will turn on the alarm indicator:

MISSING VID – The Alarm light is turned on when the the input serial signal level drops below a preset threshold (determined by the serial receiver).

FULL FIELD CRC ERROR – The transmitted cyclical redundancy checksum (CRC) does not match the actual CRC for the last video field.

ACTIVE PIC CRC ERROR – The transmitted CRC does not match the actual CRC for the last active picture region.

FMT ERROR – A serial format error has been detected.

GAMUT Provides the means to turn on or off the gamut error alarm. This submenu has only two bezel button options.

MONITOR OUT – When set to *Alarm*, detected gamut errors will cause a blinking "bright-up" of the out-of-gamut areas on the picture monitor out signal.

SCREEN MSG – When set to *Alarm*, detected gamut errors will turn on a GAMUT ERROR readout in the lower left corner of the CRT.

FORMAT Selects the format of the picture monitor out signal and the scanning standard expected by the WFM 601i.

MONITOR OUT AS – Configures the analog component picture monitor out signal as either Y, Pb, Pr, (YPBPR) or as GBR (GBR). Composite sync is added to the Y or G channel.

STANDARD – Selects the scanning standard that the waveform monitor expects. This choice affects the monitor sweep rates and the line selector. In AUTO the monitor itself selects either 525 or 625 line operation, based upon the detected field rate (60 Hz vs 50 Hz).

CALIBRATE Allows vertical and horizontal gain calibration, with the aid of a 700 mV, 100 kHz calibrator signal. The *V CAL* knob adjusts vertical gain calibration while the *H CAL* knob adjusts the horizontal gain calibration. Selections for the CALIBRATE menu are only present when the instrument is operating in the Waveform or Parade display modes.

CAL SIG – Turns on or off the calibrator signal. Calibrator signal is synchronized in order to provide an accurate 100 kHz horizontal timing standard.

GAIN CAL – Enables or disables the V CAL and H CAL controls. If the current calibration is misadjusted, readout adjacent to two of the bezel buttons assigns them to reset the calibration. Pushing the RESET V or H CAL returns the corresponding gain to original calibrated setting. When the original calibration is restored, the reset readout and the function of the buttons goes away.

The following two items appear only in the Vector/Lightning and Waveform/Parade display modes.

Software Version Number – The lower right corner of the CRT has the version number for the software loaded in this instrument. The software version number is preceded by a “V”. If in doubt of the software level, check this menu.

Coprocessor Code Version – The lower right corner of the CRT also has the version number of the serial coprocessor code in the instrument. The coprocessor version number is preceded by a “C”.

Gain Menu

The GAIN menu allows a change to the vertical gain for all display modes except PICTURE. X1, X5, and X10 fixed gains are selected by the bezel buttons adjacent to the gain selection. Variable gain is also selected by bezel button push. In Vector, variable gain changes both horizontal and vertical gain equally. Lightning and Diamond displays have both horizontal and vertical variable gain.

CLEAR MENU turns off all of the menu readout, except the VAR GAIN label (if turned on). Variable gain remains active as long as the front–panel GAIN indicator is lit.

When GAIN is pressed to turn it off, Variable gain is returned to the calibrated setting and the Vertical gain returns to X1.

CRT Menu

There are five functions that can be controlled from this menu; Focus, Scale, Intensity, Readout Intensity, and Trace Rotation. The functions of the three assignable knobs are determined by the menu adjacent to the top bezel button.

Readout intensity can be turned below the minimum viewing level, which makes all CRT menus disappear. If this happens, there is a method to recover. Press the CRT menu button and note that the menu does come up, at a reduced intensity. Pushing the top CRT bezel button once moves the cursor to READOUT and again reduces the intensity; however, the control next to the HORIZ POS is now the readout intensity control and turning it clockwise increases the readout intensity.

Pressing either the CLEAR MENU or the CRT menu button exits the menus.

Remote Operation

The 25-pin rear-panel REMOTE connector is a subminiature D-type connector. For remote controlled functions like preset/recall a TTL low or ground closure is the enabling level.

The user can store and recall up to eight front-panel setups through the remote. Remote connector pin assignments are described in Appendix B.

Using Presets through the Remote

The WFM 601i has 10 presets capable of storing front-panel setups. Presets one through eight are accessible through the rear-panel REMOTE connector. A TTL low or ground closure on one of the PRESET pins selects the front-panel setup stored at that preset location.

When STORE (pin 25) is grounded along with one of the preset pins, the current front-panel setup is stored at the selected preset location.

LINE SELECT STROBE

Pin 15 outputs an active-low TTL pulse during selected lines when in Line Select modes. This signal can be used as a logic analyzer trigger.

SERIAL VIDEO ALARM

Pin 16 outputs an active-low TTL level whenever the front–panel ALARM light is illuminated.

Calibration

Instrument gain may require readjustment for special monitoring applications. To reset the horizontal or vertical gain, follow these instructions.

Resetting Vertical Gain

1. To reset the vertical gain, select the Waveform display mode and push the CONFIG menu button. Select CALIBRATE, then CAL SIG ON and GAIN CAL ON.

- **a.** Use the VERT POS control to place the calibrator signal between the 0 and approximately 0.7 graticule lines (may will be exactly 700 mV).
- **b.** If the RESET V CAL readout is on, push the adjacent bezel button.
- **c.** Pushing RESET V CAL reinstates the gain setting established at the last calibration.
- **d.** Check to see that calibrator signal is now displayed as exactly 700 mV.

Resetting Horizontal Gain

1. To set horizontal gain, push the CONFIG menu button. Select CALIBRATE, then CAL SIG ON. Select GAIN CAL ON.

   a. In 1 LINE SWEEP (5 μs/div) there should be one-half cycle per major graticule division; in 2 LINE SWEEP (10 μs/div) there should be one full cycle per major division.

   b. If the RESET H CAL readout is on, push the adjacent bezel button.

   c. Pushing RESET H CAL reinstates the gain setting established at the last calibration.

   d. Check to see that there is one half cycle/division (1-line sweep) or one cycle/division (2-line sweep).

Reference

Graticules

This monitor uses an internal graticule for waveform measurements. The internal graticule scales are on the same plane as the CRT phosphor, eliminating parallax errors. Graticule illumination can be adjusted through the CRT menu to provide optimum brightness for viewing or photographing displays.

In addition to the CRT graticules, the WFM 601i displays electronic graticules in the Vector, Lightning, and Diamond display modes. See Page 3–3 for a discussion of the electronic graticules.

Internal Etched Waveform Graticule

This is the graticule that is permanently etched on the CRT faceplate glass. It has controlled illumination, which varies between off and a level sufficient to make measurements in the presence of normal room light.

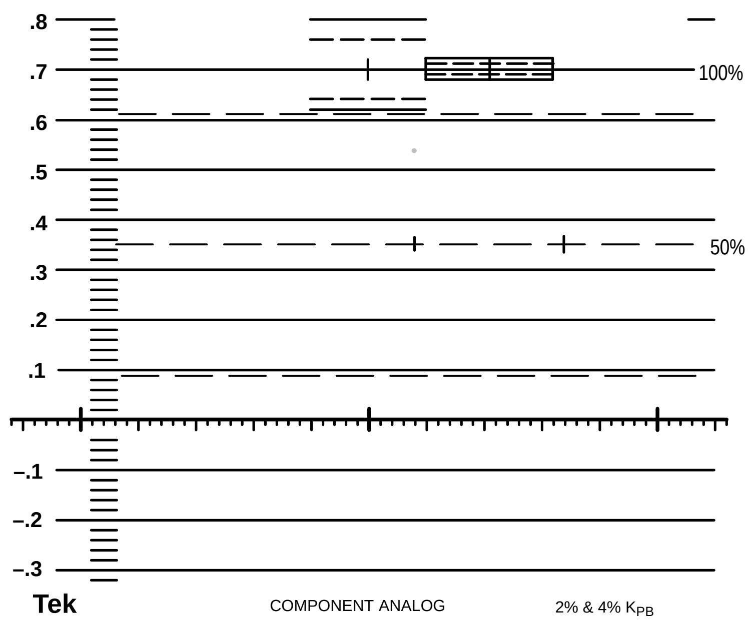


Figure 3-1: Waveform measurement graticule.

Vertical Scale This graticule scale facilitates Waveform, and Parade measurements. See Figure 3-1. The scale is marked in millivolts (mV) and extends from –300 mV to +800 mV in 100 mV increments. Each major division is divided into 5 minor divisions which equal 20 mV each.

There are three dashed lines on the graticule. The line at 50% amplitude is the center line for the color difference signals. The lines at 90 mV and 610 mV correspond to the peak excursions for 75% amplitude color difference signals. 100% amplitude color difference signals extend from the baseline (0V) to 700 mV, centered on the 50% graticule line.

K-Factor line-time distortion is measured from the largest deviation of the bar top (tilt or rounding) within the structure located just right of center, on the 700 mV line. The structure is designed to ignore the first and last 1 µs of the bar where short-time distortions (ringing, overshoot, undershoot, etc.) occur. The solid outer box equals a 4% K factor, while the dashed line inner box equals a 2% K factor. For signals with a bar half-amplitude duration that exceeds 18 µs, measure the bar top in increments by positioning the bar to the left or right from the leading or trailing edge.

2T pulse-to-bar measurements are made using the solid and dashed lines located to the left of K Factor box. These lines are scaled according to the following formula:

$$\frac{1}{(1-4K)} \quad \text{and} \quad \frac{1}{(1+4K)}$$

Where:

K = 0.02 for 2% K Factor (using the dashed lines)

K = 0.04 for 4% K Factor (using the solid lines)

The VERTICAL X5 GAIN increases the resolution to 0.4% and 0.8%.

Horizontal Scale. The horizontal reference line is also referred to as the reference line, base line, 0% line, 0 mV, zero line, blanking level, and black level. The reference line is 12 major divisions long with main marks at the 1st, 6th, and 11th divisions for timing and linearity measurements within the center ten divisions on the scale. When the sweep button is set to 1 line, each major division represents 5 µs, minor divisions equal 1 µs; when set to 2 line sweep, each major division represents 10 µs, minor divisions equal 2 µs.

When the sweep is magnified the scale on the baseline equals 1µs per major division and 200 ns per minor division in 2 line sweep, and 500 ns per major division and 100 ns per division for 1 line sweep.

Electronic Graticules

There are three measurement specific electronic graticules available. Lightning and vector graticules are available with the signal amplitude scaled to the graticule for 100% and 75% amplitudes. The scaling factor is selected from the CONFIGure WFM/VEC menu, with CRT readout to indicate the signal amplitude.

Vector Graticule

The polar display permits measurements of hue in terms of the relative phase of the chrominance signal. Amplitude of chrominance is the displacement from center (radial dimension of amplitude) towards the color point which corresponds to 75% (or 100%) amplitude for the color being measured.

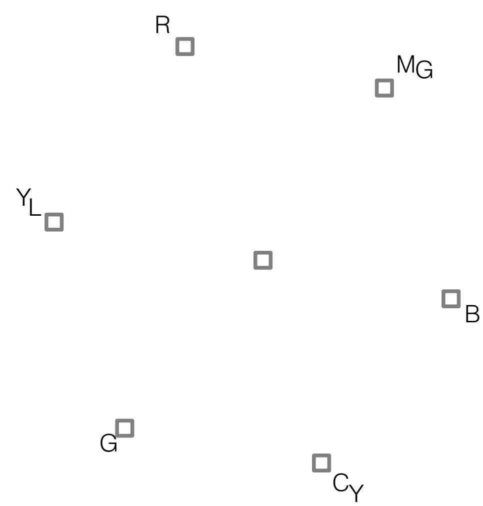


Figure 3-2: Vectorscope graticule.

On the WFM 601i electronic component vectorscope graticule, each chrominance vector terminates in a target. See Figure 3-2. The dimension of each target box equals 2% of the 700 mV, or ±14 mV.

Lightning Graticule

Figure 3-3 shows the graticule that appears when the WFM 601i is operating in the Lightning mode. This graticule matches the format of the display when component signals are applied to the instrument. The graticule targets indicate a tolerance of ±14 mV. The closely spaced small dots provide a guide for checking transitions. These dots are spaced 40 ns apart while the dots that are spaced further apart represent 80 ns.

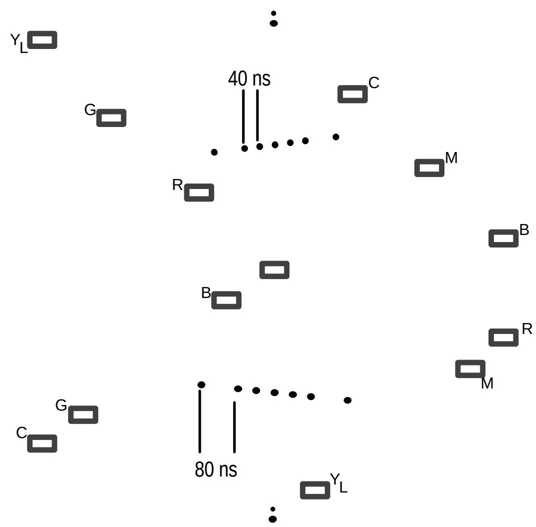


Figure 3-3: Lightning display graticule.

Diamond Graticule

The Diamond graticule is not intended as a measurement graticule, rather it is intended to convey that the RGB signal is either within or outside valid gamut limits. Signals contained within the diamonds are within gamut limits. The two identical diamonds are used to convey amplitude errors. Errors in green amplitude affect both diamonds equally, while blue amplitude errors affect only the top diamond and red errors affect only the bottom diamond. See Figure 3-4.

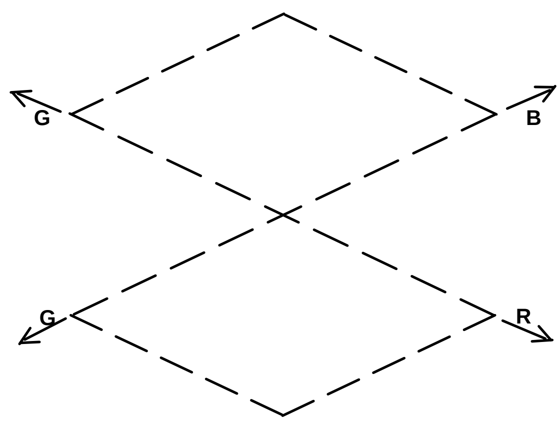


Figure 3-4: Graticule for the Diamond display.

Measurement Applications

The WFM 601i is capable of making a broad variety of measurements, ranging from the familiar analog component measurements to methods for evaluating the wideband serial digital channel. This section will describe several representative measurements.

Measuring Serial Sources

A typical serial transmission system consists of a transmitter (source), the coaxial cable channel, and a receiver. To facilitate signal interchange, standards organizations have established specifications for these three components. Many of the specifications describe the acceptable output waveform from a serial source. These include signal amplitude, aberrations, risetime, and jitter.

The WFM 601i can accurately make these four measurements using the EYE mode. Connect the serial source to the monitor with a short (<2 meter) length of 75 Ω cable. High quality, low loss coaxial cable, such as Belden 8281, should be used. A 75 Ω terminator with at least 25 dB return loss to 300 MHz should be placed on the other side of the loopthrough input. Figure 3-5 shows a typical test connection.

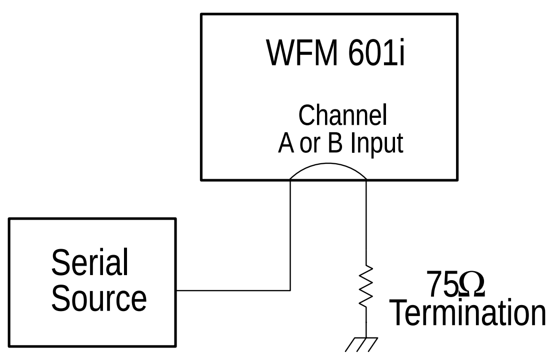


Figure 3-5: Measuring a source.

Measuring Amplitude

Select the desired input channel (SERIAL A or B) and select EYE mode. Either the graticule or the voltage cursors can be used to make the measurement. For quick, approximate measurements, use the graticule. Select the desired vertical gain, making sure that variable gain is off. For most measurements X1 gain, giving 100 mV/div, will be used. Note that the volts/div is indicated in the upper left screen corner, and that a “>” symbol is added if the variable gain is turned on.

For more accurate measurements, use the voltage cursors. Any gain setting, including variable gain, can be used since both the waveform and the cursors are affected by the gain. Higher gain settings, such as X5, can often facilitate matching the cursor to the waveform. Use the on-screen readout to determine the voltage difference between the two cursors.

Either the OVERLAY or 10-EYE display mode can be used. Since time jitter can obscure the measurement, particularly if waveform aberrations are present, the “JITTER HPF” should be set to 1 kHz.

Signal sources should measure 800 mV_{p-p} ±10%. Signal amplitudes outside this range can degrade receiver performance. Experience has shown that proper amplitude is important.

Measuring Aberrations

Serial sources should produce good signal transitions, with a minimum of overshoot and ringing. Otherwise, automatic equalizer circuits in receivers may not perform properly. While there is presently no specification for this, Tektronix recommends that aberrations be held to 10%. At this level they are not likely to degrade system performance.

To measure aberrations with the WFM 601i, use the Variable Gain to obtain a 10 division display. Aberrations should not exceed ±1 division.

Since the Eye display bandwidth is 450 MHz, it will not faithfully display aberrations that are faster than this. Most receiver circuits are band limited and usually ignore very fast transients. Accordingly, the WFM 601i is a good indicator of problem sources in systems.

Measuring Risetime

Adjust the variable vertical gain for an Eye display of exactly 10 divisions. Position the bottom of the display to the “–.3” graticule line and check that the top is aligned with the “.7” line. Activate the timing cursors and align the first cursor to the intersection of the waveform rising edge and “–.1” line. Align the second cursor to the intersection of the waveform rising edge and the “.5” line. The indicated Δt time value is the risetime from 20 – 80%. Use the horizontal MAG for greater accuracy when adjusting the cursors. Falltime is measured in a similar manner. See Figure 3-6.

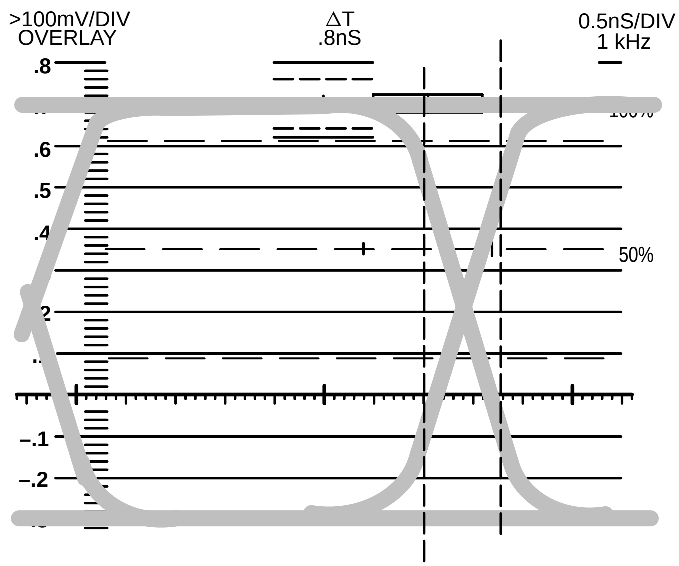


Figure 3-6: Measuring 20–80% Risetime using cursors.

The WFM 601i Eye display has a –3 dB bandwidth of approximately 450 MHz. This is a 20 – 80% risetime of 500 ps. This finite risetime must be considered when determining the actual risetime of the source being measured. The actual risetime of the source being measured can be calculated using the following formula:

$$T_{R(source)} = \sqrt{(T_{R(measured)})^2 - (0.5ns)^2}$$

$T_{R(source)}$ = the actual 20 – 80% risetime of the source (in ns);

$T_{R(measured)}$ = the 20 – 80% risetime measured on the WFM 601i (in ns)

Table 3–1 gives some conversion values between actual risetime and measured risetime for the WFM 601i.

Table 3–1: Risetime conversions for WFM 601i.

20–80% Risetime measured on WFM 601i in EYE mode	Actual 20–80% Risetime
640 ps	400 ps
710 ps	500 ps
780 ps	600 ps
860 ps	700 ps
900 ps	750 ps
940 ps	800 ps
1.0 ns	900 ps
1.1 ns	1.0 ns
1.2 ns	1.1 ns
1.3 ns	1.2 ns
1.4 ns	1.3 ns
1.5 ns	1.4 ns
1.6 ns	1.5 ns

Risetime has a more pronounced effect on system performance at 270 Mb/s than at either 143 or 177 Mb/s. This is because of the shorter minimum time between bit transitions. Although current specifications allow for 20 – 80% risetimes of 750 ps to 1.5 ns, risetimes of 1ns or less are recommended for 270 Mb/s systems.

Measuring Jitter

Timing jitter is the deviation of signal transitions compared to those of a reference clock. Ideally, all transitions should occur at equal intervals. But additive noise, pulse distortion, and variations in bit patterns all combine to cause jitter. Jitter results in eye closure along the time axis, narrowing the window in which the data values can be accurately determined. Data errors result if the eye opening becomes too small.

Jitter is characterized by both its magnitude and frequency. That is, the signal transitions deviate from their ideal position by some peak amount and at some rate. The frequency of the jitter is important in determining its effect on the system. Typically, only high frequency jitter affects data recovery. But low frequency jitter can affect operations such as signal multiplexing and D/A conversion.

The WFM 601i incorporates three different jitter high pass filters: 10 Hz, 100 Hz, and 1 kHz. With these filters the Eye pattern display will only show those jitter terms above the selected high pass. For example, if 1 kHz is selected, a 50 Hz jitter term would be heavily attenuated and would not deviate the displayed eye crossings while a 10 kHz term would appear unattenuated.

To make a jitter measurement, select the EYE display. Choose the OVERLAY display mode (located in the EYE PATTERN CONFIGure menu). In this mode, each of the ten bits of a scrambled serial word are overlaid in the same location, showing peak jitter at each eye crossing. Select the appropriate jitter high pass filter. Normally, two measurements are made: one with the 10 Hz filter, showing total broadband jitter, and one with the 1 kHz filter, removing the low frequency jitter. Use the timing cursors to measure the width of the eye zero-crossing. This is often easier to do if X5 vertical gain is used. Use the horizontal MAG for more resolution.

Jitter measurement is the subject of continuing standards committee work. EBU tech 3267 specifies 740 ps p-p, measured over one horizontal line. Interim SMPTE standards specify a maximum jitter of 500 ps p-p, measured over one horizontal line. This specification has created some confusion and is currently under review. Many experts favor a revised specification, where jitter is measured over specified frequency bands. This is the approach taken by the WFM 601i. Suggested jitter limits are 740 ps p-p, measured with the 1 kHz jitter HPF. If composite D/A conversion will be done, a 740 ps p-p limit with the 10 Hz jitter HPF is suggested.

To date, many of the jitter problems in systems have been the result of genlocking clocks to other references such as horizontal sync. House sync may contain several nanoseconds of jitter, and genlocks typically have control loop bandwidths between 20 and 100 Hz. Because of this, reference jitter transferred by genlocks into a serial system is generally between 20 and several hundred Hertz. Also, the phase detection process used by the genlock may be noisy, and this noise is transferred to the output up through the control loop bandwidth of the genlock phase lock loop. The net result is added jitter in the 10 Hz to 1 kHz range. By using the appropriate jitter high pass filter in the WFM 601i, genlock jitter can be included or rejected from a jitter measurement.

Monitoring Transmission Channels

The high data rate of the serial system (270 Mb/s) places severe demands on a coaxial channel. Impedance discontinuities in the cable path will create reflections, causing pulse distortion and eye pattern closure. Further, the coax loss, expressed in dB, is assumed to increase with the square root of frequency. Variations in this loss characteristic can cause problems for receiver equalizers.

The WFM 601i can help locate channel problems. Its passive loopthrough allows monitoring an operating system at a variety of points. By observing the system at several locations, from the signal source to the destination receiver, channel problems can be discovered and pinpointed. This is especially useful when “proofing” a newly installed system.

Recommended Monitoring Connections

The WFM 601i, with its passive loopthrough serial inputs, can either be used as a bridging or terminating input device. Depending on the measurement application, one connection may be more effective than the other. Please see “Installing the WFM 601i in a Serial Video System,” in the ***Installation*** section of this manual, for recommendations.

Checking Return Loss

The WFM 601i, in conjunction with a serial signal source, can inspect serial interface points for return loss problems. This time domain return loss measurement uses the serial signal as the step generator, and the WFM 601i as the bridging sampler.

Connect a serial source having low aberrations to one of the WFM 601i serial inputs. Place a high return loss (>25 dB to 270 MHz) 75 Ohm terminator on the other side of the loopthrough. The terminators supplied with the WFM 601i (p/n 011–0163–00) are recommended. Select EYE mode and observe the eye pattern. Check for a minimum of overshoot, ringing, or other aberrations. These artifacts will limit the accuracy of the measurement; under 5% is recommended. Choose a better signal source if aberrations are excessive; both the Tektronix TSG-422 and the TSG-601 handheld generator are suggested.

Using Variable Gain, adjust the eye pattern for a 10 division display. Now remove the terminator and connect the open side of the loop-through to the serial interface point being examined, using a short length (<2 meters) of high quality coax (if a source is being measured, the output signal must be removed). Any reflections from the serial interface point under test will distort the eye pattern. These amplitude distortions, expressed as a percentage of the original 10 division display, are the reflection coefficient.

Most serial equipment return loss is specified in the frequency domain, for example 15 dB to 270 MHz. How this maps to a time domain reflection coefficient measurement depends on the magnitude and phase of the individual frequency components. While there are no standards for the time domain measurement, properly designed serial interfaces should achieve reflection coefficients of under 0.1 (10% or 1 div of a 10 division display).

Checking Signal Continuity

When the output of a video processing chain is a black picture instead of the expected program material, the video engineer must start searching for where the signal was lost. For baseband analog video this is reasonably straightforward to do with the aid of a waveform monitor. In serial video, however, the video information is modulated onto a digital carrier. Loss of *either* the modulating input (video applied to the serializer) or the digital carrier (the serial video signal) can lead to the black picture. Determining which is the case can be a trial-and-error affair unless both the digital carrier and the video coded onto it can be viewed.

Use the WFM 601i in PICTURE, WAVEFORM, or PARADE mode to check for signal presence and content. If no signal is observed, switch to the EYE or EQ EYE display to view the digital carrier. If no eye pattern is seen, then a serial channel problem is the likely culprit. Continue moving toward the source until the fault is found. If a proper eye pattern is seen, then look for a problem where the video is serialized.

EYE and EQ EYE Displays

The eye pattern can be viewed with or without equalization. The choice of display mode depends primarily on where in the coax channel the signal is being inspected. For measurements directly on the output of sources, or with only short lengths of cable, EYE mode is recommended. In this mode the serial signal, as it appears at the rear-panel loopthrough connector, is displayed. Accurate assessments of amplitude and pulse shape can be made in EYE mode (see “Measuring Serial Sources,” page 3–5).

In situations where the signal is being inspected near the end of a long cable run, the EYE mode will show what appears as a band of noise. The serial signal is still there, but has been heavily attenuated by the coaxial cable loss. Serial receivers compensate for this by employing equalization. Ideally, this restores the wave shape to what it was at the source. In EQ EYE the output of the WFM 601i serial receiver equalizer is displayed. This allows the eye pattern to be viewed after even several hundred meters of coax.

The EQ EYE mode is most useful for establishing serial signal continuity in a long cable. Interpretations on the EQ Eye pattern shape can be misleading, however, since the WFM 601i conditions the receiver input signal to improve performance with specific video patterns. This causes peaking of the EQ Eye signal even with normal amplitude serial inputs. While an experienced operator can learn to “read” this display and infer information on the link performance, EQ EYE should be regarded as an uncalibrated, qualitative measurement mode.

A good rule of thumb is: use EYE mode whenever possible. Use EQ EYE when EYE mode fails to provide a useful signal.

Measuring Error Rate

The WFM 601i features two methods of determining if a serial video system is operating error free. The first uses the CRC check-word system documented by SMPTE RP 165, often referred to as EDH. The second uses a fixed pattern test signal.

Error Rate Measurement with EDH

The EDH system computes a CRC check-word for each field of video, and sends this along with the video in an ancillary data field. At the EDH receiver, a CRC is calculated for the received field of video, and compared against the transmitted CRC. If they do not match, then one or more errors have occurred during that field.

To measure a serial digital link, the source must insert EDH. Any serial repeaters or processing equipment between the source and the destination receiver (where the error measurement is being made) must pass ancillary data on the lines where the EDH CRC is inserted. For 525 line standards this is lines 9 and 272, and for 625 line standards this is lines 5 and 318. If the source does not insert EDH, an alternate source such as the Tektronix TSG-422 option 1S generator can be used. This substitution is allowed because the output waveforms of sources are standardized. The WFM 601i is connected to the regenerated serial output of the destination receiver. See Figure 3-7.

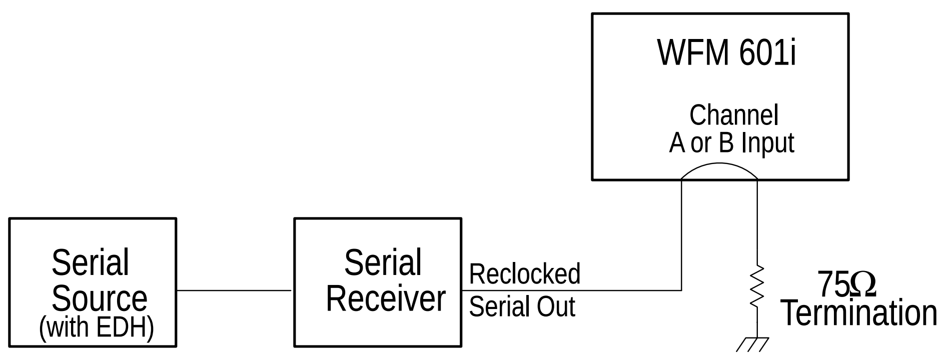


Figure 3-7: Connection for point-to-point error measurements.

Check that the “EDH DET” LED is illuminated on the WFM 601i. This signifies that EDH information is incoming. Activate the SERIAL STATUS screen. In the middle portion of the screen, the number of program seconds that contained errors (errored seconds) is indicated. Error information is separately tabulated for the active picture area (AP CRC ERR SEC) and the full video field (FF CRC ERR SEC). An elapsed time indicator gives the total time (days, hours, minutes, seconds) since the error counter displays were last reset. This makes it possible to calculate statistics such as percentage errored seconds. Pushing the RESET soft key will zero both errored seconds readouts and the elapsed time counter.

Note that there is a STATUS field just below each ERR SEC readout. These fields will indicate either “Valid,” “Invalid,” or “Missing.” “Valid” means that a transmitted CRC is available to check for errors. “Invalid” means that some EDH information is present but that the CRC used to check for errors is not available. “Missing” means that no EDH information is present. In this case the EDH DET LED will also be off. To check error rate, the EDH CRC being used – either FF (full field) or AP (active picture) – must be “Valid.” Note that if a CRC goes “Invalid” while error rate is being determined, there is no change to the ERR SEC readout; it will hold the current value. But any errors that happen while the CRC is “Invalid” will not be detected.

This measurement method is possible because the destination receiver’s regenerated serial output is typically derived after the receiver has equalized the input signal, recovered clock, and latched the data. Any detection errors affecting the receiver will also appear in the regenerated serial output, and will be detected by the WFM 601i.

This ability to measure a receiver’s error rate by monitoring its regenerated output has tremendous practical significance. Although most equipment does not yet include EDH error detection, almost all has regenerated (or reclocked) serial outputs. Thus an EDH-equipped monitor can bring error rate measurement capability to virtually any point in a facility. Strategic placement of these monitors can help keep track of a plant’s performance. Similarly, a single EDH error monitoring instrument can proof an entire digital chain, by moving from one regenerated output to the next.

Error Rate Measurement with AP CRC Values

The WFM 601i calculates CRC check-words for the active picture area of each video field. The two CRC values are displayed on the SERIAL STATUS screen: one for field 1 (F1) and one for field 2 (F2). With a fixed pattern test signal, these CRCs will have constant values. Any change in the CRC indicates an error. This forms a “single ended” error detection system that does not require EDH.

Connect the WFM 601i as shown in Figure 3-7. The source does not need EDH, but it must be a fixed pattern signal (repeating every two fields). Display the SERIAL STATUS screen. Note that there are two hexadecimal CRC values given, one for field 1 (F1 AP CRC VALUE) and one for field 2 (F2 AP CRC VALUE). Directly below the CRC values is a flag (CHANGE SINCE RESET) which indicates if either CRC value has changed since the RESET soft key was pushed. Press the RESET key and check that the CHANGE SINCE RESET flag reads “No.” If an error occurs, a CRC value will momentarily change, and the CHANGE SINCE RESET flag will toggle to “Yes.” The elapsed time counter indicates the length of time since the flag was last reset to “No.” Note that the flag can only indicate that one or more errors has occurred, so an “error rate” cannot be calculated. But it does differentiate between zero errors and at least one error.

Comparing the Two Methods

Of the two methods described above, the EDH system is the most powerful. First, it works with any video program material, since the source-end CRC is calculated on a field-by-field basis. It does not matter if the source is a fixed pattern test signal or moving pictures. Thus, EDH can monitor error rate while a facility is in service. Second, the error information gathered by the WFM 601i is the most comprehensive when using EDH, with errored seconds readouts for both the active picture and full field. The big disadvantage of EDH is that it requires calculation and insertion of the CRC at the source. At present, there is very little equipment available that does this.

The AP CRC Value method does not require any special signal insertion at the source, and therefore gets around this problem of the EDH system. But its limitation is that it only works with fixed pattern signals, such as those from a test signal generator. This precludes its use for in-service error monitoring. Also, the error information is limited, with the only indicator being whether or not there were zero errors. The AP CRC Value method is most useful for manufacturing test environments and for situations where a zero error rate condition is being verified.

Since the WFM 601i gives the AP CRC Values, this can be used to verify proper operation of a video processor given a specified test signal. For example, a manufacturer could specify the expected CRC values for various operating modes with a given test signal. Any disagreement may indicate a problem. This is analogous to “signature analysis” that is sometimes used to troubleshoot digital logic.

Advanced Eye Pattern Modes

The WFM 601i eye pattern system was designed to facilitate comparison between the serial rate signal and the video information it represents. Three applications that highlight this capability are described below.

Observing Word Correlated Behavior

When video is serialized, a 270 MHz rate serial clock is derived from the 27 MHz rate parallel word clock. Often there will be slight phase modulation of the serial clock between the transitions of the parallel clock. That is, if the eye pattern formed between adjacent parallel clocks were viewed, ten eyes would be displayed, but the spacing of the eye crossings might vary from one eye to the next. This jitter is not random but *correlated* to the parallel word rate. Also, the video patterns applied to the serializer may change at a 27 MHz rate or an integer fraction of 27 MHz (for example, luminance samples may change at a 13.5 MHz rate and color difference samples at 6.75 MHz). Thus any video pattern related effects in the serial system typically show up at fixed locations with respect to the parallel word. Because the 10-eyes are reconstructed over one tv-line, tv-line correlated phase errors are superimposed over the 10-eyes. If the pattern repeats often enough, and if the eye pattern display is triggered on parallel word boundaries and tv-lines, these *word/tv-line correlated* effects can be observed.

The WFM 601i has two trigger modes for the Eye pattern displays: 10-EYE and OVERLAY. In 10-EYE the Eye pattern display is triggered on parallel word/tv-line boundaries, with 10 eyes shown per sweep. Parallel word and tv-line correlated behavior can be seen in this mode. If a serial system is experiencing a disturbance that appears related to video patterns, either word or tv-line, use the 10-EYE mode in either EYE or EQ EYE to try and identify the problem. Use line select (see below) to window the Eye pattern display to the area of interest in the video field.

In OVERLAY trigger mode, the Eye pattern display is purposely decorrelated with the parallel word boundaries. That is, each of the 10 eyes that occur between parallel word clocks are all overlaid, with equal probability of occurrence, at a fixed location on the screen. This causes each of the three displayed eyes to appear identical, with peak jitter shown at each eye crossing.

The choice of the 10-EYE and OVERLAY trigger modes is made in the EYE PATTERN CONFIGure menu. The chosen trigger mode is indicated with a CRT readout in the upper left corner of the screen.

Observing Field Rate Behavior

The Eye pattern displays can be swept at field rate. While individual eyes cannot be seen in this mode, low frequency changes in the envelope of the serial signal can be observed. Some video patterns, such as the Equalizer SDI Check Field Signal defined in SMPTE RP-178 (also known as the “pathological” signal) can contain a large low frequency component. Serial equipment with inadequate coupling time constants may not properly pass this signal without errors. Sweeping the eye pattern at field rate can help locate these sources. Other disturbances, such as mains hum, can be seen in field sweep.

Use the SWEEP button to toggle the eye pattern between the normal 3 ns/1 ns displays and field sweep. When in field sweep, the time/div display in the upper right screen corner will say FIELD. Normal one field magnification (X25) is available with the MAG button. Also, the line selector (see below) can be used in this mode, with the selected lines identified with a z-axis bright-up.

Using the Line Selector in Eye Pattern Modes

The unique eye pattern triggering used in the WFM 601i allows the familiar video line selector to be used just as it is with standard video waveforms. One line and 15 line displays, on either or both fields, are available. The line selector can be used to correlate events seen on the picture monitor, the analog waveform display, and the Eye pattern display.

For example, suppose a disturbance is observed on the picture monitor. Activate the line selector, in 15 LINE mode, and adjust the line selector knob until the bright-up strobe overlays the picture defect. Select an Eye pattern display, and choose FIELD sweep mode. Observe that 15 lines of the eye pattern envelope are intensified. Check for any disturbances of the envelope in the intensified region. Push the SWEEP button to return to a normal Eye pattern display. Only the eye pattern corresponding to the 15 selected video lines is displayed. Similarly, if some problem behavior is noticed in the eye pattern, and it occurs for only a fraction of the field, use the line selector to highlight it and then observe the corresponding bright-up on the picture monitor. Of course, the windowed displays can also be observed with the WAVEFORM, PARADE, VECTOR, and LIGHTNING display modes.

Using the Diamond Display

The WFM 601i features the Tektronix "Diamond" display. The primary use of this display is to check video signals for proper RGB Gamut, and to assist in RGB signal manipulation.

RGB Gamut

Ultimately all color video signals are coded to RGB for display on a picture monitor. To be predictably displayed all three components must lie between peak white, normally 700 mV, and black, normally 0 V. Excursions outside this range will be produced differently by different picture monitors, depending on where they clip. Proper RGB Gamut means that R, G, and B independently always assume values between 0 V and 700 mV.

Diamond Explained

Diamond is simply a method of showing the relationship between the R, G, and B signal values. These three independent components describe a three dimensional space. To show this in two dimensions, G and B are displayed in one X-Y plot, while G and R are displayed in a second plot. These two separate plots are rotated 45 degrees and overlaid at their origins. See Figure 3-8.

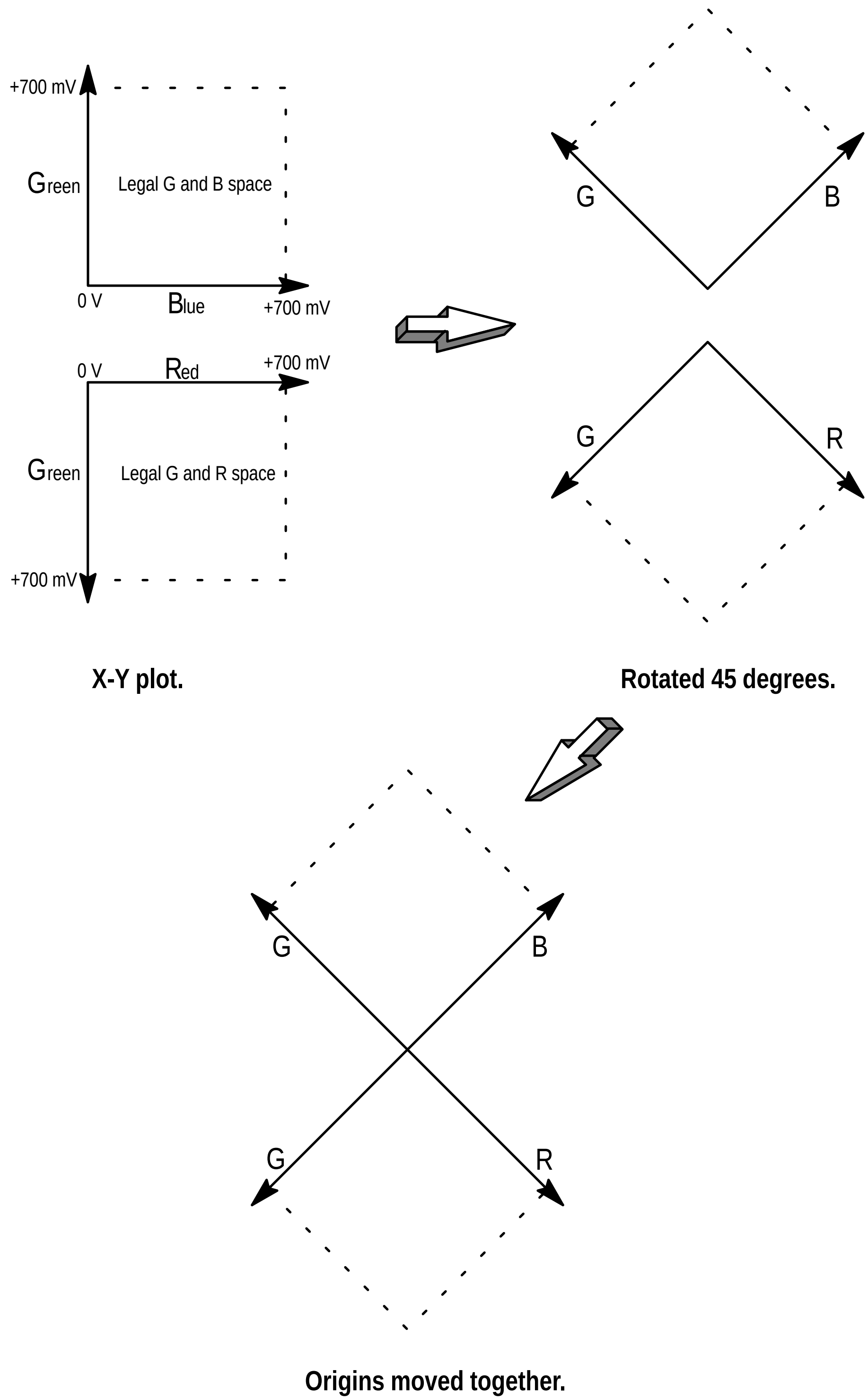


Figure 3-8: Construction of the Diamond Display.

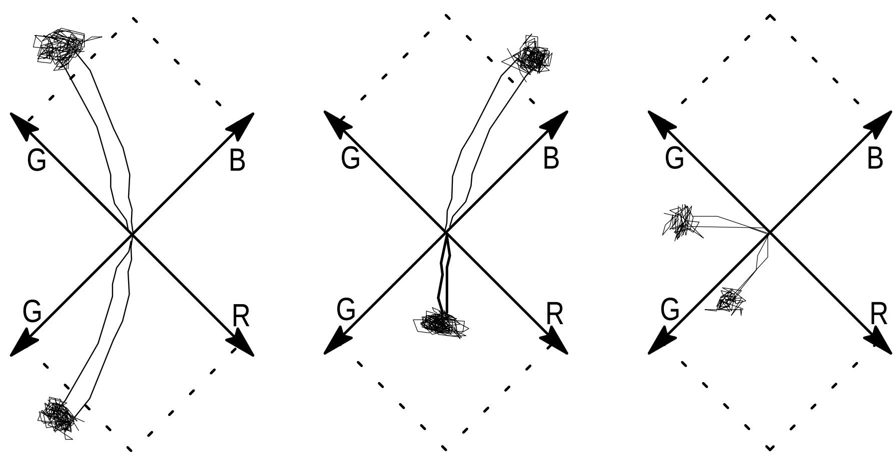
Note that since R, G, and B can independently assume any value between 0 V and 700 mV, the “in RGB Gamut” is described by squares in each of the two X–Y plots. When rotated, the squares produce two diamond-like shapes that show the legal RGB space.

Checking Gamut

For a signal to be in Gamut, all signal vectors must lie within the diamonds. Conversely, if a vector extends outside the diamond, that signal is out of gamut. The intensity of the vector indicates its duration; therefore, a momentary out-of-gamut condition will show as a faint trace. Long duration violations will show as a bright trace. The video operator can then determine which violations are significant and in need of correction.

Correcting Gamut

When an out-of-gamut condition exists that requires correction, the Diamond display can aid in determining which component (R, G, or B) is out, and in which direction. By remembering that Diamond is just two rotated X–Y plots, and using the labeled axis that appear on the electronic graticule, it quickly becomes apparent how to correct the signal. Figure 3-9 gives some sample out-of-gamut signals displayed with Diamond.



G > 700 mV, B and R OK. **B > 700 mV, G and R OK.** **B < 0 V, G and R OK. R is just slightly above 0 V. G is about 350 mV.**

Figure 3-9: Out-of-Gamut signals as displayed by Diamond.

When to Use Lightning

The Lightning display plots luminance against each of the color difference components. It should be used when manipulating signals by varying the luminance and color difference components. Diamond is the best choice when manipulating signals with R, G, and B controls.

Measurement Theory

Eye Pattern Display

Eye pattern displays are commonly used to view binary coded digital signals. The display shows the voltage levels used to represent the two logic states, and the transitions between them. Proper "distance" between the logic levels, as well as proper position of the transitions, is important for error-free data transmission.

Eye patterns are typically formed by triggering an oscilloscope at some fraction of the serial clock frequency while applying the serial bit stream to the scope's vertical channel. Sometimes the serial signal is holding at a "low" or "high" logic level, and sometimes it is transitioning between levels. These combinations end up producing an overlaid display showing both logic levels and all the different ways to transition between them. In between these transitions, the separation or "distance" of the two logic levels must be sufficient for the receiver to clearly detect whether a "high" or "low" occurred. This separation is the so called "eye opening" of the signal.

Eye patterns are often used in conjunction with a template or "mask" to estimate system error rate. Serial video systems operate at such low error rates however, that eye closure masks are not practical. Instead the eye pattern is used to check signal parameters such as amplitude, risetime, and jitter, as well as to identify signal distortions such as those caused by transmission channel reflections.

The WFM 601i uses an equivalent time sampler to create the eye pattern display. Equivalent time samplers are used where waveforms are repetitive. The waveform voltage is sampled at many different points at a rate much slower than the basic repetition rate of the signal. Over many cycles of the signal, a representation of the waveform is created. Although the serial bit stream may not be repetitive, the eye display formed by overlaying the bit patterns is repetitive. In the case of the WFM 601i, the eye pattern sampler samples at 7 MHz, with an equivalent time bandwidth of at least 450 MHz.

Vector Display

The vectorscope and its XY Cartesian display has long been a staple of the television industry. In its more familiar configuration it presents a display of the two color difference signals (R–Y & B–Y in NTSC, or V & U in PAL) that are decoded from the composite video signals. In the composite world a sample of subcarrier (burst) is supplied with each line of video to synchronize the decoding of the coloring information contained in the color subcarrier. This provides a display where it is possible to measure color phase errors (angular displacement) and color signal amplitude errors (radial displacement). The system is based on the accuracy of the color burst(s), which are placed at the correct phase and then any variance in the color bar vectors is measured by the mislocation of the dots from the appropriate targets. Figure 3-10 shows how the decoded color difference signals draw the vector display commonly used throughout the television industry.

Note that color burst is not shown in Figure 3-10. It would normally be shown at 180° on the B–Y axis for NTSC or ±45° from the negative U axis for PAL. Although this measurement technique originated with composite video signals, there is a great deal of information about the component signals that can be derived from vector displays. Not only can the encoder accuracy for both phase and amplitude be checked, but some rough approximations about the relative timing delays between the color difference signals can be made.

In the composite domain the transitions between the vector tips display timing differences. But, because these timing differences include the delay in the decoder output filtering they are largely ignored, unless they become too gross. In the component domain there is no decoding required and therefore useful information can be derived from the color bar transitions. These variations in timing between the two color difference signals show up as looping or bowing of the transitions. Theoretically, it would be possible to measure the amount of bowing and convert the results to a delay value, but there are better methods available. If the transition looping appears to be too much, use the lightning display to determine the full amount of delay.

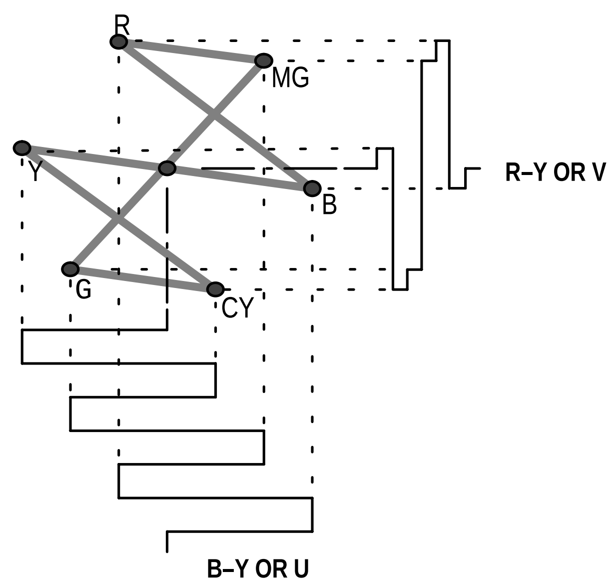


Figure 3-10: Vector display relationship of the R–Y (V) and B–Y (U).

The electronic graticule for the WFM 601i provides vector targets that are ±2% of B–Y and R–Y amplitudes. This differs from composite vectorscope targets, which are sectors indicating a polar, magnitude and phase error. These are the errors most often caused by the coding, transmission and decoding of the composite signal. In a component format, utilizing R–Y and B–Y the errors are most likely to be in amplitude and timing. The most obvious short coming of using the color vector display is that there is no convenient method of relating the color difference signals to the luminance signal, which is the third element of the component signal necessary for determining color saturation.

Lightning Display

In order to overcome the shortcomings of not being able to plot the color difference signals against the luminance signal, the lightning display was created. The three signals are back porch clamped and identically low pass filtered to provide a common point and identical delay through the system. Next the color difference signals are line alternated and the luminance signal inverted on alternate lines.

The B–Y (P_B) signal is applied concurrently with the positive luminance signal (Y); the R–Y (P_R) signal is then applied with the inverted luminance signal. This provides a display that compares B–Y to Y on the top half of the display and R–Y to –Y on the lower half of the display. See Figure 3-11.

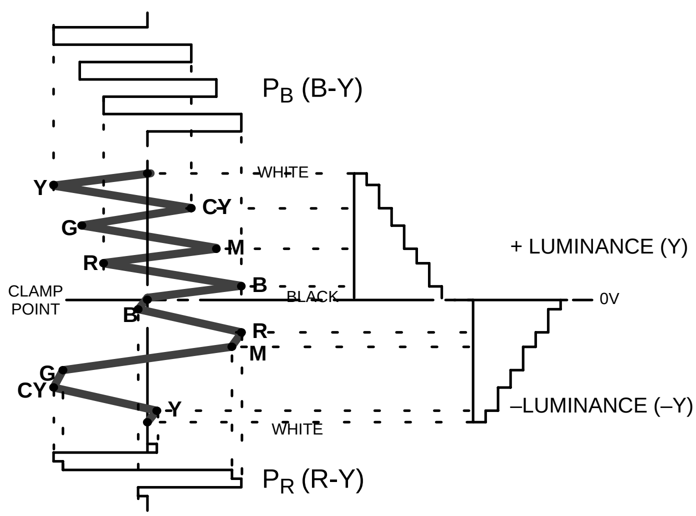


Figure 3-11: Construction of the Lightning waveform.

Valuable gain and timing information is recoverable when a graticule is added to this display. By using an electronic graticule the effects of CRT nonlinearity are eliminated. The information that we can obtain from this display is color difference signal accuracy (horizontal displacement of either half of the display), luminance gain (vertical displacement between the black and white levels), timing delay between either color difference signal and luminance (bending of the green/magenta transitions). Figure 3-12 shows the graticule and the measurement targets and timing delay scales.

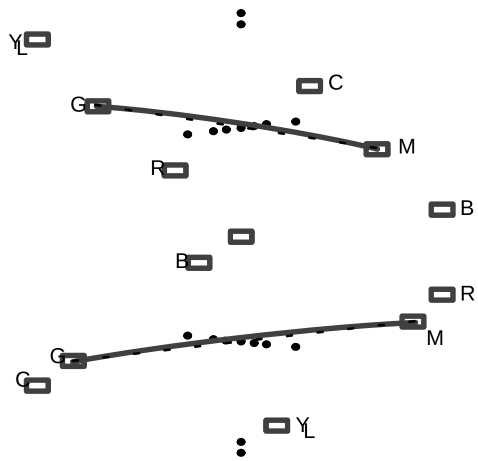


Figure 3-12: Lightning graticule showing interchannel timing errors.

Luminance Gain – The vertical axis above and below the center box is the luminance signal. The lower half is inverted. The luminance gain is correct when the center dot (clamped black level) is centered in the target box and the end of positive and negative excursions end at the top and bottom of the graticule. Perfect monochrome signals appear as a thin vertical line. Any deviation or bending off the center line indicates a color tinting away from the monochrome setup of the display monitor. Luminance gain alone can be measured more accurately in either the waveform or parade display modes of the monitor.

Interchannel Timing – The scale between the green and magenta targets is used to check interchannel timing (CH-2 to CH-1 and CH-3 to CH-1) or signal delay. If the color difference signal is not coincident with luminance, the transitions between color dots will bend. The amount of this bending represents the relative signal delay between luminance and the color difference signal. The upper half of the display measures the P_B-to-Y timing, while the bottom half measures the P_R-to-Y Timing. If the transition bends in toward black, the color difference signal is delayed with respect to luminance and if it bends out toward white, the color difference signal leading the luminance.

P_R and P_B Gain – The horizontal deflection of the top half of the display is an indication of the P_B gain and the lower half indicates the P_R gain. If the color bar signal dots are within the horizontal dimensions of the appropriate graticule targets, the P_B and P_R gains are within 2% of the correct amplitude.

***NOTE**. Since the vertical dimension of the graticule target boxes indicate a 2% luminance gain error and the horizontal dimension a 2% color difference gain error, each color bar can be evaluated for encoding accuracy with these limits. Peak-to-peak gain can be evaluated with the parade display mode, but only the lightning display shows the relative level or coding accuracy of Y, P_B, and P_R for each of the eight primary colors.*

Diamond Display

The WFM 601i converts the Y, $P_{B,}$ and P_R components recovered from the serial signal to R, G, and B to form the Diamond display.

The diamond display is a simplified vector display for the GBR (RGB) format. Like the lightning display, it is an alternating line display. The first half of the display is made up of B+G on the vertical axis and B–G on the horizontal axis. The second half of the display is made up of inverted R+G on the vertical axis and R–G on the horizontal axis. The resulting display is the vertices of two diamonds which form the RGB gamut limits. See Figure 3-13.

The graticule used with this display has no targets or specified tolerances. It consists of dotted lines that scribe the two diamonds, which defines the color gamut. Any signal outside the gamut limits, scribed by the graticule, may not be reproducible by a color monitor, or is subject to clipping. This robust system of gamut limits is an accurate method of determining whether the gamut limit violation will cause a serious picture degradation.

Monochrome signals appear as a vertical line. Nonlinear component processing, such as from a gamma corrector that destroys white balance, will cause the vertical axis to deviate. B–G errors will affect the top diamond and R–G errors will affect the lower diamond.

As with the lightning display, any bending of the transitions indicates timing delays. When a color bar signal is applied, the vertical axis becomes an indicator of delay errors. B to G timing errors affect only the upper diamond while R to G timing errors affect only the lower diamond.

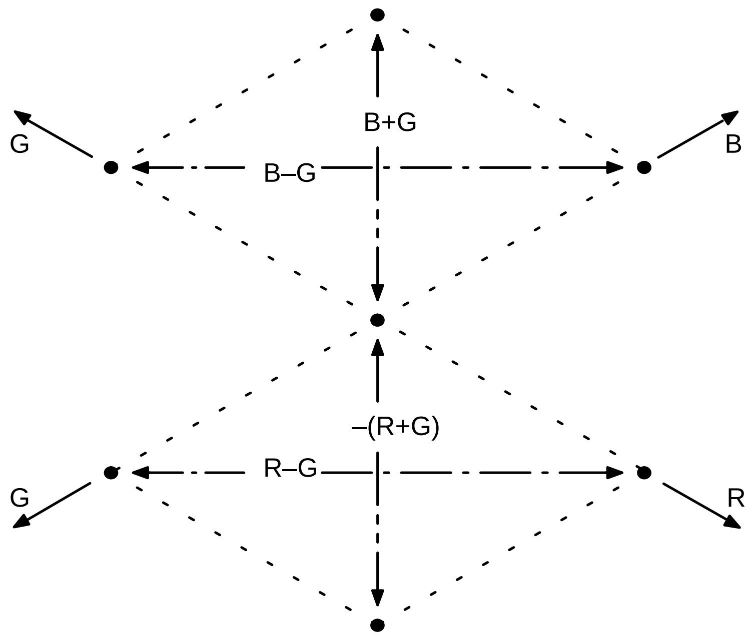


Figure 3-13: Construction of the Diamond GBR display.

Bowtie Display

The bowtie display provides a means of making a quick evaluation of relative amplitudes and timing through the three channels. A special test signal is required for this display. The Tektronix TSG-422, Option 1S provides this type of signal and a set of time marks to aid in signal evaluation. The signal is a 500 kHz sinewave on channel 1 (luminance) and 502 kHz sinewave on channels 2 and 3 (color difference signals). The display is made up of two separate waveforms. See Figure 3-14. The first waveform compares channel 1 to channel 2. The second waveform compares channel 1 to channel 3. The generator provides a center marker, which should correspond with the null point if interchannel timing is correct. The time markers are from the generator and are 20 ns apart.

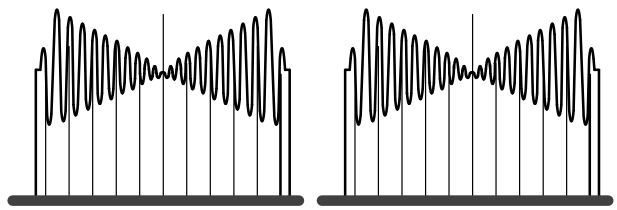


Figure 3-14: Typical Bowtie display on the WFM 601i.

The bowtie test signal and display method provides better resolution and is easier to use than the color bar test signal with the waveform or lightning display to make relative channel timing measurements. Changes in location of the null indicate a difference in the relative timing. If the null shifts two full time markers, the relative timing error between channels would be 40 ns. The direction that the null is offset identifies the signal that is delayed. If the null is to the left of the center marker, luminance is delayed. When either of the nulls is shifted to the right, that color difference signal is delayed when compared to luminance channel timing.

In addition to measuring the interchannel timing differences, the bowtie measurement provides a method of determining whether the relative channel gain is correct. If the gains are not equal, the null point will not be a complete null; instead it will increase in amplitude. If the gain error is in channel 1, both halves of the display will not produce a “good” null. If channel 2 gain is off, the first waveform will not null all the way down, but the second one will. If the gain is off for channel 3, the left waveform will be normal and the right one will not null as far.

Appendices

Appendix A: Specifications

The items listed in the following tables describe the performance of the WFM 601i Serial Digital Component Monitor. Performance Requirements are generally quantitative and can be tested by the Performance Verification Procedure, contained in the Service Manual.

Reference information (RI) is valuable data pertaining to the operation and measurement capabilities of this instrument. Only a few of the items listed in this category are testable in the Performance Verification Procedure.

Performance Conditions – The Requirements listed in the electrical specification portion of these specifications apply over an ambient temperature range of 0° C to +40° C. The rated accuracies are valid when the instrument is calibrated at an ambient temperature range of +20° C to +30° C, after a warm–up time of 20 minutes. Test equipment used to verify Performance Requirements must be calibrated and working within the limits specified under the Equipment Required list.

These instruments are intended to operate from an ac power source that will not apply more than 250 V rms between the supply conductors or either supply conductor and ground. A protective ground connection by way of the grounding conductor is essential for safe operation.

Calibration Interval The recommended calibration interval is 12 months.

Environmental specifications are listed toward the back of the following tables. In addition a list of appropriate safety and electromagnetic interference (EMI) standards also can be found there.

Table A–1: Waveform Vertical Deflection

Characteristic	Performance Requirement	Reference Information
Deflection Factor	For digital input: 700 mV digital input = 700 mV ±2% screen display, any magnifier setting.	Any one of the three channels. RGB on screen accuracy ±3%.
Variable Gain Range		0.2X to 1.4X.
Frequency Response	Luminance channel (Y), to 5.0 MHz ≤2% Color difference channels (P_B & P_R) to 2.5 MHz ≤2%	Typically ≤1% to 5.75 MHz luminance (Y) channel and ≤1% to 2.75 MHz for the color difference (P_B or P_R) channel. Line sweep from a 4:2:2 digital signal generator.
Transient Response		Preshoot ≤1%. Overshoot ≤1%. Ringing ≤1%. Pulse-to-bar ratio 0.99:1 to 1.01:1
Field Rate Tilt		≤1%.

Table A–1: Waveform Vertical Deflection (Cont.)

Characteristic	Performance Requirement	Reference Information
Line Rate Tilt		≤ 1%.
Offscreen Recovery		1% variation in baseline of a 5 MHz modulated pulse when positioned anywhere on screen. X1, X5, or X10 with any variable gain setting.
Voltage Cursor Accuracy	± 0.5% over 20–30° C. ± 1% over rated temperature range.	
Differentiated Step Filter		Amplitude of pulses ≤ 1% variation.
Low Pass Filter Gain Response		 1 ± 1%. ≤ 3 dB attenuation at 1 MHz. ≥ 40 dB attenuation at 4 MHz.

Table A–2: Serial Digital Video Interface (SER A & SER B)

Characteristic	Performance Requirement	Reference Information
Format		270 Mbit/s component. Complies with SMPTE 259M & CCIR 656.
Input Type		Passive loop through 75Ω compensated.
Input Level		800 mV peak-to-peak ± 10%. Input voltages outside this range may cause reduced receiver performance.
Return Loss	≥ 25 dB 1–270 MHz, channels on or off, power on. ≥ 15 dB 1–270 MHz, power turned off.	
Insertion Loss	≤ 1.5%.	
Transmission Bandwidth	50 kHz – 300 MHz ± 1.0 dB.	–3 dB at not less than 500 MHz.
Loop Through Isolation		≥ 50 dB to 300 MHz.
Serial Receiver Equalization Range	Proper operation with up to 14.5 dB loss at 135 MHz using coaxial cable having $1/\sqrt{F}$ loss characteristics. 800 mV launch amplitude.	150 meters (490 feet) using Belden 8281 coaxial cable.

Table A–3: Serial Video Output (follows SER A/B channel selection)

Characteristic	Performance Requirement	Reference Information
Format		270 Mbit/s component. Complies with SMPTE 259M & CCIR 656.
Output Level	800 mV peak-to-peak ±10% into 75Ω load	Internal jumper can change output to 740 mV peak-to-peak ±10%.
Return Loss	≥15 dB 1–270 MHz	

Table A–4: Eye Pattern Display

Characteristic	Performance Requirement	Reference Information
Type		Equivalent Time Sampler
Bandwidth	50 kHz to 450 MHz: –3 dB to +1 dB	Low frequency –3 dB point is 500 Hz.
Rise Time		500 ps (20-80%), 775 ps (10-90%)
Aberrations		< 10%, 800 mV Step
Time Base Jitter		< 200 ps peak-to-peak
Jitter Attenuation		
10 Hz HPF		< 10% for frequencies > 20 Hz. –3 dB at approximately 10 Hz.
100 Hz HPF		< 10% for frequencies > 300 Hz. –3 dB at approximately 100 Hz.
1 kHz HPF		< 10% for frequencies > 3 kHz. –3 dB at approximately 1 kHz. Up to 3 dB jitter gain between 2–4 kHz.
Display Modes		
Overlay		Overlays bits 0-9 of a serial word to form each eye opening. Useful for observing peak signal jitter.
10-Eye		Parades bits 0-9 in a 10-Eye display. Useful for observing word and line correlated jitter.
Deflection Factor		
Vertical	800 mV ± 5% with an 800 mV_{p-p} input	
Horizontal		
Overlay Mode	1 ns/Div ± 3%	
10-Eye Mode	3 ns/Div ± 3%	
Mag On	500 ps/Div ± 3%	

Table A–5: Video Error Detection and Diagnostics

Characteristic	Performance Requirement	Reference Information
Video Error Detection		
Type		Active picture and full field. Field rate resolution. Uses CRC check-word system. System is known as EDH (Error Detection and Handling) in industry literature. Complies with SMPTE RP165.
Reporting Means		Front-panel ALARM lamp, rear-panel TTL line, and CRT readout.
Error Statistics		Asynchronous errored seconds. Active picture and full field statistics are separately compiled.
Diagnostics		
Embedded Audio		Identifies the presence of up to 16 channels of AES/EBU digital audio.
Ancillary Data		Identifies the presence of ancillary data (other than audio and EDH) and indicates if a checksum error has occurred.
Format Errors		Warns that a serial signal format error has occurred Detected Errors: 1. SAV placed incorrectly 2. Line length error 3. Field length error 4. Reserved values used improperly 5. ANC data checksum error 6. ANC data parity error 7. ANC data placement error
Signal Lost		Reports absence of serial video signal

Table A–6: External Reference

Characteristic	Performance Requirement	Reference Information
Input		Analog composite video or black burst
Maximum Operating Input Voltage		–1.8 V to +2.2 V, dc plus peak ac
Absolute Maximum Input Voltage		–8.5 V to +8.5 V, dc plus peak ac
DC Input Impedance		≥ 20 kΩ
Return Loss	≥ 40 dB to 6 MHz	Typically ≥ 46 dB to 6 MHz; ≥ 40 dB to 10 MHz

Table A–7: Waveform Horizontal Deflection

Characteristic	Performance Requirement	Reference Information
Sweep	Internal Sychronization: Proper horizontal and vertical synchronization with a component digital signal conforming to CCIR Rec. 601/656 and SMPTE 125M. External Synchronization: Proper horizontal and vertical synchronization with a composite sync signal of approximate line and field rate.	Sweep Length: ≈12 divisions Sweep freeruns without input
Sweep Timing Accuracy	1 Line: 5 μs/division ±1% 2 Line: 10 μs/division ±1%	1 Field displays one full field, including field rate sync. 2 Field displays two full fields and the field rate sync between them.
Sweep Linearity	±1%	
Magnified Sweep Accuracy	1 Line: 0.2 μs/division ±1% 2 Line: 1.0 μs/division ±1%	
Magnified Sweep Linearity	±1%	
Timing Cursors	Accuracy: ±0.5% at 25° C. ±1% over operating temperature range	
Horizontal Position Range	Any portion of the synchronized sweep can be positioned on screen in all sweep modes	

Table A–8: Calibrator

Characteristic	Performance Requirement	Reference Information
Waveform Square Wave	Amplitude: 0.700 V ±1% Frequency: 100 kHz ±0.1%	Crystal-controlled 10 μs square wave

Table A–9: Component Vector Mode

Characteristic	Performance Requirement	Reference Information
Vertical Bandwidth		≥1.0 MHz
Horizontal to Vertical Bandwidth Matching	≤2° at 500 kHz and 2 MHz	
Vertical Gain Accuracy	±1%	
Horizontal Gain Accuracy	±1%	
Display to Graticule Registration	≤0.25 box with the color bar black display dot centered in target.	

Table A–9: Component Vector Mode (Cont.)

Characteristic	Performance Requirement	Reference Information
Electronic Graticule Shape		Minimal visible gaps or tails at corners of target boxes.
Vector Display		P_B is displayed on horizontal axis and P_R is displayed on vertical axis.

Table A–10: Lightning and Diamond Mode

Characteristic	Performance Requirement	Reference Information
Vertical Gain Accuracy	± 2%	
Electronic Graticule Display Lightning		Y is displayed vertically. P_B is displayed horizontally on top half of display. P_R is displayed horizontally on bottom half of display.
Diamond		GBR Deflection axis indicated.

Table A–11: Bowtie Mode

Characteristic	Performance Requirement	Reference Information
Common Mode Rejection Ratio		≥ 34 dB at 2.5 MHz
Accuracy		± 3%
Interchannel Timing Match		± 2.0 ns

Table A–12: Picture Monitor Outputs

Characteristic	Performance Requirement	Reference Information
Signal Format		EBU/N10
Active Video Accuracy	700 mV ± 3%	Typically <1%
Sync Amplitude Accuracy		300 mV ± 10%
Monitor Output Impedance		Nominally 75Ω; back porch clamped to 0 V.

Table A–13: Power Source

Characteristic	Performance Requirement	Reference Information
Electrical Rating	90 – 250 V, 50/60 Hz, 1.5 A maximum	Continuous range from 90 to 250 Vac
Supply Type		Single Phase
Supply Connection		Detachable cord set
Power Consumption		< 110 VA (75 watts)

Table A–14: CRT Display

Characteristic	Performance Requirement	Reference Information
CRT Viewing Area		80 X 100 mm Horizontal: 12.5 divisions Vertical: 1.19 V
Accelerating Potential		Nominally 13.75 kV
Trace Rotation Range	$> \pm 1°$ from horizontal	Total adjustment range is typically $\geq 8°$.
Graticule		Internal with variable illumination.

Table A–15: Environmental Characteristics

Characteristic	Performance Requirement	Reference Information
Operating Temperature	0° to 40°C (+32° to 122°F)	
Storage Temperature	–40° to 75°C (–40° to 158°F)	
Operating Altitude	To 15,000 feet (4572 meters)	IEC 1010–1 compliant to 2000 meters.
Storage Altitude	To 50,000 feet (15,240 meters)	
Vibration	5 minutes at 5 – 15 Hz with 0.060 inch displacement 5 minutes at 15 – 25 Hz with 0.040 inch displacement 5 minutes at 25 – 55 Hz with 0.020 inch displacement Military Specification: Mil–T–28800D, Paragraph 1.2.2, Class 3	
Mechanical Shock	Non Operating: 50 g's 1/2 sine, 11 ms duration 3 shocks per surface (18 total)	
Transportation	Qualified under NSTA Test Procedure 1A, Category II (24 inch drop)	
Equipment Type		Measurement
Equipment Class		IEC 1010–1, Annex H, Class III

Table A–15: Environmental Characteristics (Cont.)

Characteristic	Performance Requirement	Reference Information
Installation Category		Category II (as defined in IEC 1010–1, Annex J) NOTE: Rated for indoor use only.
Pollution Degree		Pollution degree 2 (as defined in IEC 1010–1)
Humidity	Proper operation at 95% +0, –5% Relative Humidity	Do not operate with visible moisture on the circuit boards.

Table A–16: Certification

Characteristic	Standard
Safety	**Designed to meet or exceed:** UL1244 CSA Standard 231 IEC 1010–1 (for operation up to 2000 meters)

Table A–17: Physical Characteristics

Characteristic	Description
Dimensions	Height: 5 1/4 inches (133.4 millimeters) Width: 8 1/2 inches (215.9 millimeters) Depth: 18 1/8 inches (460.4 millimeters)
Weight	Net: 8 pounds (3.8 kilograms) Shipping: 15.7 pounds (7.2 kilograms) approximate

Appendix B: Multipin Connectors

REMOTE Connector

The rear-panel REMOTE connector is a 25-pin, D-type connector that is the remote control interface.

Remote functions, which provide switching and recalling of stored front-panel setups from a remote location, are enabled by ground closures (TTL lows). Functions with "overbars" indicate an active low state. Eight of the menu selectable front-panel RECALL SETUPs can be called up remotely. Pin assignments for the REMOTE connector are shown in Figure B-1 and discussed in Table B-1.

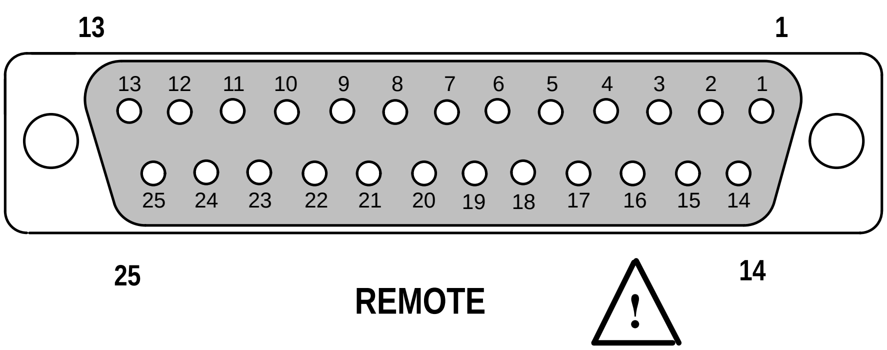


Figure B–1: REMOTE connector.

Table B–1: Remote Connector Pin Assignments and Functions

Pin Number	Function	Signal Requirement	Miscellaneous Information
1	Not Used	– – –	
2	Ground	– – –	
3	Not Used	– – –	
4	External Blanking Input	TTL Low	
5	Ground	– – –	
6	−Y Audio Out (Left)	– – –	Audio Option Only
7	+Y Audio Out (Left)	– – –	Audio Option Only
8	Ground		

Table B–1: Remote Connector Pin Assignments and Functions (Cont.)

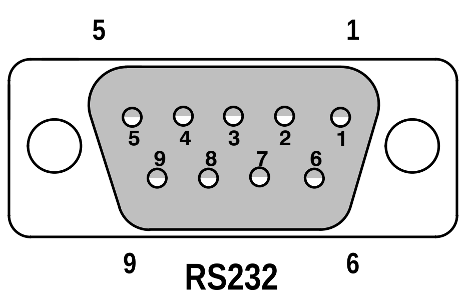
Pin Number	Function	Signal Requirement	Miscellaneous Information
9	−X Audio Out (Right)		Audio Option Only
10	+X Audio Out (Right)		Audio Option Only
11	Ground		
12	+ Time Code		Reserved for future applications.
13	− Time Code		Reserved for future applications.
14	Ground		
15	$\overline{\text{Line Strobe}}$	In Line Select Modes, goes low during selected lines	
16	$\overline{\text{Serial Video Alarm}}$	Goes low when front panel ALARM indicator is illuminated.	
17	$\overline{\text{Preset 1}}$	Ground (TTL low)	Recalls the stored front-panel setup from this location, or selects the Preset 1 memory location to store the current front-panel settings.
18	$\overline{\text{Preset 2}}$	Ground (TTL low)	Recalls the stored front-panel setup from this location, or selects the Preset 2 memory location to store the current front-panel settings.
19	$\overline{\text{Preset 3}}$	Ground (TTL low)	Recalls the stored front-panel setup from this location, or selects the Preset 3 memory location to store the current front panel settings.
20	$\overline{\text{Preset 4}}$	Ground (TTL low)	Recalls the stored front panel setup from this location, or selects the Preset 4 memory location to store the current front-panel settings.
21	$\overline{\text{Preset 5}}$	Ground (TTL low)	Recalls the stored front-panel setup from this location, or selects the Preset 5 memory location to store the current front-panel settings.

Table B–1: Remote Connector Pin Assignments and Functions (Cont.)

Pin Number	Function	Signal Requirement	Miscellaneous Information
22	$\overline{\text{Preset 6}}$	Ground (TTL low)	Recalls the stored front-panel setup from this location, or selects the Preset 6 memory location to store the current front-panel settings.
23	$\overline{\text{Preset 7}}$	Ground (TTL low)	Recalls the stored front-panel setup from this location, or selects the Preset 7 memory location to store the current front-panel settings.
24	$\overline{\text{Preset 8}}$	Ground (TTL low)	Recalls the stored front-panel setup from this location, or selects the Preset 8 memory location to store the current front-panel settings.
25	$\overline{\text{Store}}$	Ground (TTL low)	Grounding $\overline{\text{STORE}}$ enables storage of instrument settings. When $\overline{\text{STORE}}$ is low, and one of the $\overline{\text{PRESET}}$s is grounded the current front-panel setup will be stored in that Preset memory location.

RS232 Connector

The RS232 connector is a 9-pin D-type connector that is provided as the calibration interface. See Figure B–2. The WFM601i is intended to be calibrated with a Personal Computer (PC).



PIN NUMBER	DATA CONNECTION
1.	**DCD** (RECEIVED LINE SIGNAL DETECTOR)
2.	**RXD** (RECEIVED DATA)
3.	**TXD (**TRANSMITTED DATA)
4.	**DTR** (DTE READY)
5.	**SIGNAL GROUND**
6.	**DCR** (DCE READY)
7.	**RTS** (REQUEST TO SEND)
8.	**CTS** (CLEAR TO SEND)
9.	**NOT CONNECTED**

Figure B–2: RS232 REMOTE connector.

Appendix C: User Service

These instructions are primarily for user and preventive maintenance. If the instrument does not function properly, it should be referred to qualified service personnel or returned to Tektronix for service.

Cleaning or Replacing the Fan Filter

To ensure adequate air flow, it is essential to clean or replace the rear-panel fan filter regularly. The interval between filter cleaning or replacement is determined by the operating environment.

To remove the filter, take out the two screws that fasten the housing to the rear panel.

Remove the filter and wash it in a mild detergent and water solution. Place cleaned and dried filter (or new filter) in the housing and replace housing over the fan. Replace and tighten the two screws (8 in lbs).

Fuse Replacement

The line fuse for this instrument is located inside the cabinet, under a protective shield. Replacement of this fuse should only be undertaken by a qualified service technician, following the instructions in the WFM 601i Service Manual.

Graticule Light Replacement

Replacement Bulbs

Replacement bulbs are supplied with this instrument as Standard Accessories. Additional bulbs can be purchased from Tektronix or from local electronics distribution sources.

Required Equipment

1/16” Allen wrench
Small straight-blade screwdriver
Tweezers

***NOTE**. For graticule light removal and replacement, tweezers with curved, serrated tips are recommended. For example, Miltex PL312,6-100 (equivalent to PL312) or PL317 (longer than PL312).*

Procedure

1. Remove the five knobs below the CRT.

2. Insert a small, straight-blade screwdriver into the recessed area on either the right or left side of the panel. Pry gently until the panel snaps out of the front-panel frame. See Figure C-1 for panel and recess location.

***CAUTION.** Needle-nosed pliers are not recommended.*

3. To remove a bulb, position the tweezer tips on the thin, flat portion of the bulb (close to the plastic socket). Carefully pull the bulb straight out.

4. To install a new bulb, hold it with the tweezers as described in step 3, position it in front of the socket, and push the bulb until it snaps in place.

5. Replace the panel below the CRT, and press on both the right and left sides of the panel until it snaps into place.

6. Replace the five knobs below the CRT and tighten the set screws.

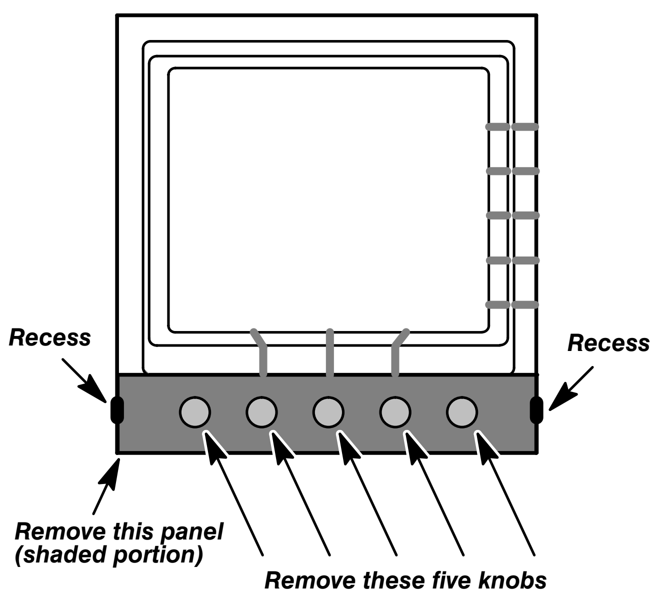


Figure C-1: Graticule light replacement.

Cleaning

The instrument should be cleaned often enough to prevent dust and dirt from accumulating. Dirt acts as a thermal insulator, preventing effective heat dissipation, and can also provide high-resistance electrical leakage paths between conductors or components in a humid environment.

CAUTION. *Do not allow water to get inside any enclosed assembly or component. Do not clean any plastic materials with benzene, toluene, xylene, acetone, or similar compounds, because they may damage the plastic.*

Exterior

Clean the dust from the outside of the instrument with a soft, clean cloth or small brush. A brush is especially useful for removing dust from around the selector buttons, knobs, and connectors. Hardened dirt can be removed using a soft cloth dampened with a mild detergent and water solution. Abrasive cleaners should not be used.

CRT

Clean the light filter and CRT face with a soft, lint-free cloth dampened in denatured alcohol. Abrasive cleaners should not be used.

Interior

Interior cleaning and maintenance should be performed by qualified service personnel only. Instructions for interior maintenance are provided in the WFM 601i Service manual.

Replacing the CRT Filter

A smoke-gray filter is installed over the face of the CRT. If the filter becomes damaged, it can be replaced in the following manner:

1. Remove the five knobs below the CRT.
2. Insert a small, straight-blade screwdriver into the recessed area on either the right or left side of the panel. Pry gently until the panel snaps out of the front-panel frame. See Figure C-1 for panel and recess location.
3. Remove the two Torx® screws that fasten the bezel to the instrument.
4. Grasping the bottom of the bezel, pull out and upward to remove the bezel from the instrument. (There are two hinges at the top of the bezel that hold it in place; once the bezel is at an approximate 45° angle with the front panel, they will disengage.)
5. Remove the damaged filter and snap the new filter into place on the back side of the bezel. Position the ridged side of the filter towards the CRT to eliminate unwanted visual effects on the CRT face.
6. Replace the bezel and bezel screws. Tighten screws (8 in/lbs).
7. Replace the panel below the CRT, and press on both the right and left sides of the panel until it snaps into place.
8. Replace the five knobs below the CRT and tighten the set screws.

Glossary

Glossary

Accuracy The closeness of the indicated value to the true value.

Bandwidth The range of frequencies over which signal amplitude remains constant (within some limit) as it is passed through a system.

Baseband Refers to the composite video signal as it exists before modulating the picture carrier. Composite video distributed throughout a studio and used for recording is at baseband.

Baseband Refers to the composite video signal as it exists before modulating the picture carrier. Composite video distributed throughout a studio and used for recording is at baseband.

Bowtie Bowtie display. A display used to assess relative timing and gain through a three-channel component system.

Color Difference Signals Signals used by color television systems to convey color information in such a way that the signals go to zero when there is no color in the picture. R–Y, B–Y, I, and Q are all color difference signals for the NTSC system; U and V are color difference signals for the PAL system. Component system color difference signal is Y, P_B, P_R as specified by SMPTE and CCIR standards.

Color Gamut The area between minimum and maximum reproducible limits for elements of the color difference or RGB signals.

Component Video Video which exists in the form of three separate signals, all of which are required in order to completely specify the color picture. For example, R, G, and B; or Y, R–Y, and B–Y.

Composite Video A single video signal containing all of the necessary information to reproduce a color picture. Created by adding quadrature amplitude modulated R–Y and B–Y to the luminance signal for NTSC systems or U and V to the luminance signal for PAL systems.

dB (Decibel) A decibel is a logarithmic unit used to describe signal ratios. For voltages, $dB = 20\ \text{Log}_{10}\ (V_1/V_2)$.

Diamond A simplified vector display for RGB signals that defines the valid gamut limits in the form of two diamonds.

Distortion If a sine wave of a single frequency is put into a system, and harmonic content at multiples of that frequency appears at the output, there is harmonic distortion present in the system. Harmonic distortion is caused by nonlinearities in the system.

Frame A frame (sometimes called a "picture") contains all the information required for a complete picture. For interlaced scan systems, there are two fields in a frame.

Gamma (NTSC) Since picture monitors have a nonlinear relationship between the input voltage and brightness, the signal must be correspondingly predistorted. Gamma correction is always done at the source (camera) in television systems: the R, G, and B signals are converted to $R^{1/\gamma}$, $G^{1/\gamma}$, and $B^{1/\gamma}$. Values of about 2.2 are typically used for gamma.

Gamma (PAL) Since picture monitors have a nonlinear relationship between the input voltage and brightness, the signal must be correspondingly predistorted. Gamma correction is always done at the source (camera) in television systems: the R, G, and B signals are converted to $R^{1/\gamma}$, $G^{1/\gamma}$, and $B^{1/\gamma}$. Values for gamma range from 2.2 to 2.8.

Gamut See Color Gamut.

GBR The same signals as RGB, but rearranged in sequence to correspond with SMPTE specification.

Graticule The scale which is used to quantify the information on a waveform monitor or vectorscope display. Graticules may either be screened onto the faceplate of the CRT itself (internal graticule), or onto a piece of glass or plastic which fits in front of the CRT (external graticule). They can also be electronically generated.

Lightning Lightning display. A display, for use with SMPTE specified color difference signals (Y, P_B, P_R), that plots the two color difference signals against luminance to create a display similar in appearance to a lightning bolt.

Linear Distortion Refers to distortions which are independent of signal amplitude.

Luminance The signal which represents brightness, or the amount of light in the picture. This is the only signal required for black and white pictures, and for color systems it is obtained as a weighted sum (Y = 0.3R + 0.59G + 0.11B) of the R, G, and B signals.

Nonlinear Distortion Refers to distortions which are amplitude-dependent.

NTSC National Television System Committee. The organization which developed the television standard currently in use in the United States, Canada, and Japan. Now generally used to refer to that standard.

PAL Phase Alternate Line. Refers to one of the television systems used in Europe and many other parts of the world. The phase of one of the color difference signals alternates from line to line to help cancel out phase errors.

RF Radio Frequency. In television applications, RF generally refers to the television signal after the picture carrier modulation process

RGB Red, Green, and Blue. Also referred to as GBR. The three primary colors used in color television's additive color reproduction system. These are the three color signals generated by the camera and used by the picture monitor to produce a picture.

R–Y One of the color difference signals obtained by subtracting luminance (Y) from the red camera signal.

Saturation The property of color which relates to the amount of white light in the color. Highly saturated colors are vivid, while less saturated colors have more white mixed in and, therefore, appear pastel. For example, red is highly saturated, while pink is the same hue, but much less saturated.

In signal terms, saturation is determined by the ratio between luminance level and chrominance amplitude. It should be noted that a vectorscope does not display saturation; the length of the vectors represents chrominance amplitude. In order to verify that the saturation of the colors in a color bar signal is correct, you must check luminance amplitudes with a waveform monitor in addition to observing the vectors.

Termination In order to accurately send a signal through a transmission line, there must be an impedance at the end which matches the impedance of the source and of the line itself. Amplitude errors and reflections will otherwise result. Video is a 75Ω system, so a 75Ω terminator must be put at the end of the signal path.

U The B–Y signal after a weighting factor of 0.493 has been applied. The weighting is necessary to reduce peak modulation in the composite signal.

V The R–Y signal after a weighting factor of 0.877 has been applied. The weighting is necessary to reduce peak modulation in the composite signal.

Vectorscope A specialized oscilloscope which demodulates the video signal and presents a display of R–Y versus B–Y in NTSC systems (or V versus U in PAL systems). The angle and magnitude of the displayed vectors are respectively related to hue and saturation.

Vertical Interval The synchronizing information which appears between fields and signals the picture monitor to go back to the top of the screen to begin another vertical scan.

Waveform Monitor A specialized oscilloscope that plots voltage versus time to evaluate television signals.

Y Abbreviation for luminance.

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