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A NEW NTSC GRATICULE FOR THE 1480 WAVEFORM MONITOR

(Operational
Measurements Using
a New NTSC
Composite Graticule)
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The modern display features of the TEKTRONIX 1480 Waveform Monitor have been further enhanced by a new, versatile NTSC graticule. Many linear transmission distortion measurements that have been difficult or inconvenient can now be made with relative ease. The uncluttered scale design and well thought out organization of this new graticule yield consistently accurate results with a minimum of control setting changes.

Graticule A

Vertical Scales. The vertical scale of this new NTSC composite graticule extends from −50 to +120 IRE Units in 10 IRE Unit increments. In addition, three separate 2 IRE Units/div scales are provided at strategic locations for rapid, precise measurements of key signal parameters. A dashed line at 7.5 IRE Units, or 7.5%, is provided for use as a black level setup reference.

The right-side scale, for measuring transmitter % of modulation, extends from 0%, at the +120 IRE Unit line, to 100%, at the −40 IRE Unit line. The 0 (zero) IRE Unit reference line, which contains horizontal divisions, is subdivided for measurement of time.

Horizontal Scales. The horizontal reference line at 0 IRE Units is 12.7 divisions long. Using the 5 µs/DIV time base, the time base line is 63.5 µsec (1H) long. The 10 µs/DIV time base provides a time base of 127 µsec (2H). This makes it possible to calibrate the 5 and 10 µs/DIV time bases using the TV signal.

The −30 IRE Unit line contains nine divisions, which correspond to one-half of the period of a cycle of NTSC burst at 100 nsec/div. At 200 nsec/div, the divisions or "tick marks" equal the period of one cycle of burst. These relationships make it possible to accurately calibrate the 100 and 200 nsec/div time bases, using the convenient NTSC color burst.

Also located on the 0 IRE Unit horizontal reference line are points T and B. Point T is for use in measuring rise and fall-time. It lies directly below point R and denotes the time zero when the 90% point of a 100-IRE Unit rising transient, or 10% of a 100-IRE Unit falling transient, intersects point R (at the 80-IRE Unit line).

If there is any serious tilt of the blanking level, there is ambiguity in the setting of the blanking level to the 0 IRE reference level. To remove that ambiguity, a study group of the CCIR (CMTT/187-E) has recommended that insertion gain be measured between the center of the white bar and a blanking level reference point. On Graticule A, this blanking level reference point is labeled B.

Internal and External Graticules. Two graticules are installed in each 1480. Selective illumination of either graticule allows the user to, in effect, choose the appropriate graticule for his measurement.

Parallax errors are entirely avoided when an internal graticule is used. The external graticule, however, is subject to parallax error. This error can be eliminated, when taking waveform photographs, by using an external graticule designed to correct for parallax. Tektronix provides such graticules and strongly recommends them for waveform photography. Labeled Photographic, they should only be used for waveform photography because they are designed to compensate for about 3% parallax error. Using an external graticule (same scale size as the internal graticule) for visual monitoring will provide a parallax error of 1% or less. Visual (unmarked) graticules should not be used for waveform photography.

Using Graticule A

The primary test signal in this application note is an NTSC composite test signal, generally a Vertical Interval Test Signal (VITS). The composite test signal can be either the one required by the FCC (§73.669) for remote transmitter control or the CCIR composite VITS for international program exchange (CCIR Recommendation 473, Annex II, 525-line systems, adopted 1974).

While the graticule special scales provide 2% resolution increments at 1.0 VOLTS FULL SCALE, greater resolution is provided by the 1480 Waveform Monitor's calibrated vertical expansion. A 1.0 volt video signal can be expanded 2X or 5X without loss of accuracy, providing direct resolution of up to 0.2% for some of the measurements that follow.

Calibration Checks. Time base calibration accuracy can be checked with just the video signal. The 5 and 10 µs/DIV time bases are checked by measuring the time duration of 1 or 2 lines (63.5 µsec or 127 µsec). The 0.1 and 0.2 µs/DIV time bases are checked by measuring burst period against the scale (tick marks) on the −30 IRE Unit line.

Vertical gain, which may be reset from the front panel, is easily checked by using the 1480's built-in calibrator. Television Application Note 11, "The Measurement of Signal Level With the 1480-Series of Waveform Monitors," by L. E. Weaver, discusses an extremely accurate method of setting vertical gain.

Insertion Gain

In all measurements using television test signals, whether full field or VITS, signal level or insertion gain must be checked first. The vertical sensitivity of the 1480 should first be checked, 1.0 V equals 140 IRE.

Use the 5 µs/DIV time base to display

the composite test signal. Position the leading edge of the bar to the ascending arrow. Vertically position the blanking level to point B on the 0 IRE Unit reference line.

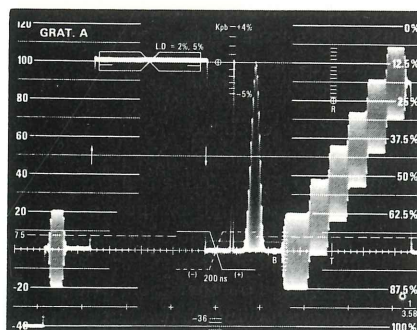Insertion gain is measured at the bar midpoint, see *Figure 1*.

Figure 1. *Checking Insertion Gain and Line Time Distortion, Insertion Gain = unity, L.D. = 0%.*

Line Time Distortion

Position the composite test signal bar leading edge to the ascending arrow, with blanking level on point B. If insertion gain is off, set the VARiable VOLTS FULL SCALE so that the bar top passes through 100 IRE at its midpoint. See *Figure 1*. To measure line time distortion, check the largest deviation of the bar top (tilt or rounding) within the box. This box ignores the first and last 1 μsec where short time distortions may be observed. The box provides 2% and 5% L.D. (line time distortion) scales.

To increase resolution, change the VOLTS FULL SCALE (without changing VARiable VOLTS FULL SCALE) to 0.5 for 2½% and 1% limits to the L.D. measurement box, or to 0.2 for 1% and 0.4% limits. See *Figure 2*.
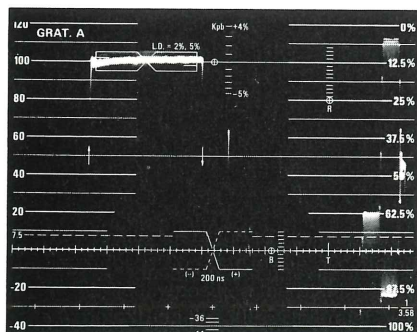

Figure 2. *Line Time Distortion with increased gain, L.D. = 0.4%.*

Short Time Distortion

At the time of this writing, the weighting characteristics to be used to develop an outline for the 2T pulse and the T step

transition are under discussion by industry committees. For this reason, Graticule A does not contain the traditional outline for the 2T pulse. Instead, an external graticule (Graticule B), containing a scaling of the outline given in CCIR Recommendation 421-1, is provided for 1480's equipped with Graticule A. If a different weighting factor is adopted for 525/60 standards, new graticules and different nomenclature will be required. Current plans call for changing the 2T pulse distortion nomenclature to P_{2T}, and T step distortion nomenclature to S_{1T} to reflect these different weighting factors.

Many broadcast organizations presently use and are familiar with (2T) pulse-to-bar amplitude ratio measurements and, for this reason, the K_{pb} scale is included on this new graticule. The K_{pb} scale is non-linear. It conforms with CCIR Recommendation 421-1.
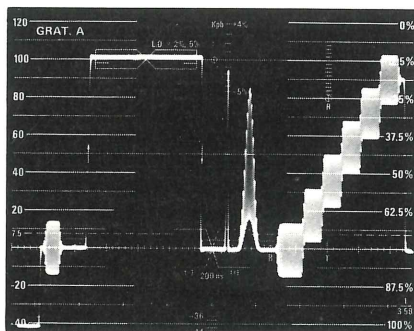

Figure 3. K_{pb} *measurement,* K_{pb} = − 1.5%.

K_{pb}. To measure pulse-to-bar ratio, place the composite test signal bar leading edge over the ascending arrow and the blanking level at point B on the 0 IRE Unit reference line at point B. If insertion gain is incorrect (bar midpoint not at 100 IRE), use the 1480 VARiable VOLTS FULL SCALE to correct this condition.

The pulse-to-bar measurement is from bar midpoint to peak 2T pulse amplitude expressed in + or − percent. See *Figure 3*.

K_{2T}. If insertion gain is incorrect, adjust the VARiable VOLTS FULL SCALE to compensate. Use a 200 nsec/div time base and position the 2T pulse beneath the K_{pb} scale. This measurement uses Graticule B. To illuminate the external Graticule B, pull the Scale Illumination knob. *See Figure 4*.

The mask corresponds to 5%. If greater resolution is desired, change the VOLTS FULL SCALE (without moving VARiable) to 0.5 for 2½% or 0.2 for 1% mask limits. See *Figure 5*.
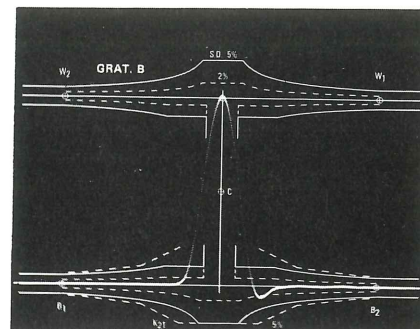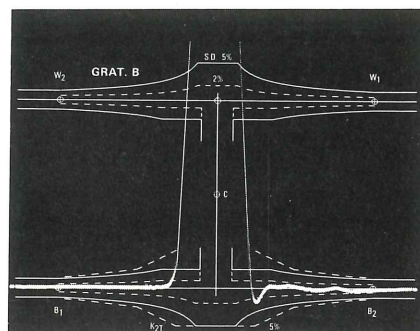

Figure 4. K_{2T} *measurement,* K_{2T} = 2%.

Figure 5. K_{2T} *measurement with increased gain,* K_{2T} > 1%.

Short Time Waveform Distortion (SD).

IEEE Trial Standard 511-1974 describes the technique for measuring short time waveform distortion (SD) in detail. Graticule B includes the mask prescribed in the Trial Standard. The 1480's POSITION controls are adjusted so that the transition passes through points B (blanking) and C, and the vertical gain is set so that white level of the bar passes through point W. Some control interaction will take place. Using the 200 nsec/div time base, an undistorted 1T transition will lie perfectly centered in the mask. See *Figure 6*.
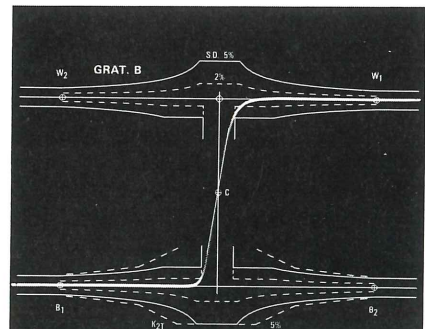

Figure 6. *S.D. using 2T pulse rising transient, S.D.* $\approx$ *2%.*

The FCC Composite VITS (§73.699, *Figure 15*) provides for a 2T bar. This signal cannot be used to measure SD. It does, however, include a 2T pulse which

may be used to measure SD using the 2T pulse mask of Graticule B. See *Figure 4.*

A 5% value of SD is used as the basis of the mask in Graticule B, again this is in conformity with the IEEE Trial Standard 511-1974.

In a linear system, one need only measure one transition (rising or falling), but in practical circuits, non-linear distortions may affect the transitions very differently. This provides a clue to the presence of such non-linear distortions. It is good, therefore, to measure both transitions. Each might be characterized by a different value of SD.

Chrominance—Luminance Gain Inequality

Check insertion gain. If it is not unity, use the VARiable VOLTS FULL SCALE to get a 100-IRE Unit blanking-to-bar center amplitude. Use a 1 μs/DIV time base and check the peak amplitude and baseline offset of the 12.5T modulated sine-squared pulse. If other forms of distortion are not present, the variation in peak amplitude and the baseline offset, at pulse center, will be equal. See *Figure 7.*
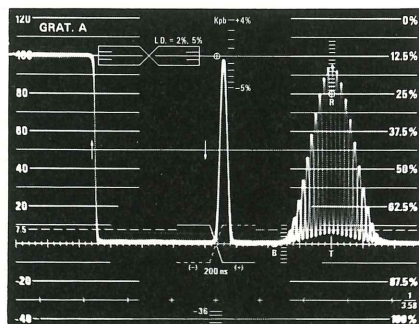

Figure 7. *Chrominance to Luminance Gain Inequality measurement, C/L Gain Inequality = 9%.*

Assuming that the 12.5T pulse baseline is symmetrical (negligible chrominance—luminance delay), as shown in *Figure 7,* gain inequality can be measured using either the vernier scale (−10 to +10 IRE) or the R scale to the right of the pulse. Each division of these scales equals 2 IRE Units. Chrominance—luminance (chrominance-to-luminance) gain inequality is equal to twice the difference between 100 IRE Units and peak displayed amplitude of the 12.5T modulated sine-squared pulse, expressed in percentage.

This measurement can also be made by using a TEKTRONIX 1478 Calibrated Chrominance Level Corrector in the 1480 Aux Video Out-Aux Video In

configuration. (See Television Application Note #17, "The Auxiliary Video Facility of the 1480-Series of Waveform Monitors," by L. E. Weaver.)

Chrominance—Luminance Delay

If the chrominance—luminance gain inequality is negligible, or has been annulled, for example, using the TEKTRONIX 1478 Calibrated Chrominance Level Corrector (See Television Products Application Note #10, "Chrominance to Luminance Gain Correction and Delay Measurements"), chrominance—luminance delay inequality can be read directly from Graticule A.

Use a 1 μs/DIV time base and horizontally center the 12.5T modulated sine-squared pulse. Set displayed pulse amplitude for 100 IRE Units (blanking level to pulse peak amplitude), if necessary. Vertically set the blanking level on the graticule 0 IRE Unit reference line. See *Figure 8.*
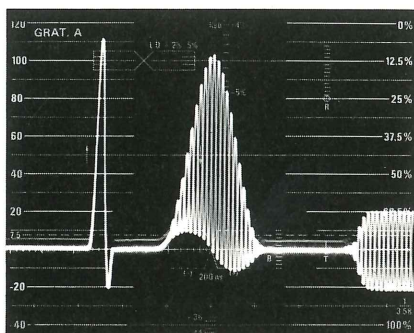

Figure 8. *Chrominance to Luminance Delay Inequality measurement, C/L Delay Inequality = 200nsec.*

If, as in *Figure 8,* chrominance—luminance gain inequality is negligible, chrominance—luminance delay inequality is easily measured by comparing the symmetrical sinusoidal baseline abberation to the special delay scale. The plus-to-minus transition (solid line) is used with a positive chrominance delay (chrominance lag), while the minus-to-plus transition (dashed line) is for negative chrominance delay (chrominance lead). A full scale symmetrical transition, such as the one in *Figure 8,* equals 200 nsec of delay inequality.

Since chrominance—luminance delay inequality may be considerably less than 200 nsec, the calibrated vertical expansion of the 1480 Waveform Monitor allows two and five times resolution increase. Setting VOLTS FULL SCALE to 0.5 changes the delay scale to 100 nsec peak-to-peak; 0.2 VOLTS FULL SCALE increases the delay inequality
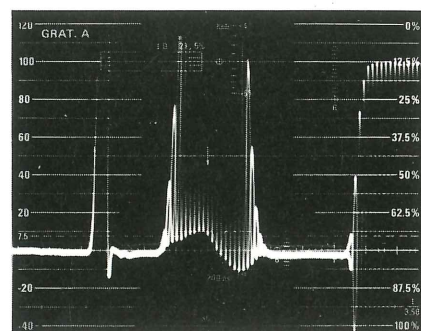
scale resolution to 40 nsec. See *Figure 9.*

Figure 9. *Chrominance to Luminance Delay Inequality measurement, with increased gain, C/L Delay Inequality = 40 nsec.*

Luminance Non-linearity

Luminance non-linearity is easily measured using the differentiated step display mode of the 1480 Waveform Monitor. Position the composite waveform staircase to graticule center and switch to DIFF'D STEPS. Adjust the VARiable VOLTS FULL SCALE for a 100 IRE Unit amplitude of the largest step (spike). See *Figure 10.*
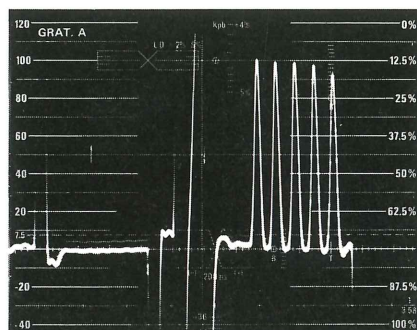

Figure 10. *Luminance Non-linearity measured with the Differentiated Step Display, Luminance Non-linearity = 6%.*

Horizontally position the smallest step (spike) to the R scale (2 IRE Units/div) and read the percentage of non-linearity directly. The formula for determining luminance non-linearity, in %, according to the CCIR, is $1 - \frac{m}{M} \times 100$. M is the amplitude of the largest step, and m is the smallest step. This formula is conveniently simplified by holding M at 100 and subtracting m, or 100 − m.

It is also possible to fold back the 1480's sweep to display m and M overlayed. (See Television Application Note #13, "Time Base Fold Back, A Novel Improvement Over Double Triggering for Video Testing" by Charles W. Rhodes.)

Risetime and Falltime

Graticule A has built-in rise and fall time measurement capability. Point R at 80 IRE Units aligns with T on the 0 IRE Unit reference line. See *Figure 11*.
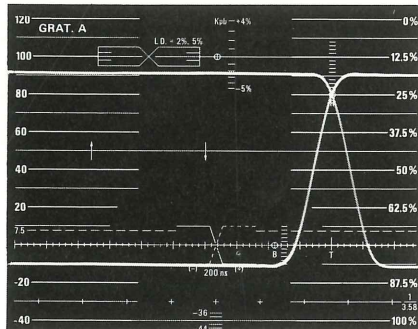

Figure 11. *Double exposure showing the measurement of rise and fall times of a T step, T_r and $T_f = 120nsec$.*

To measure rise or fall time, set the transition amplitude to 100 IRE Units (use the VARiable VOLTS FULL SCALE). Vertically position the display so that the transition is from the −10 IRE Unit line to the +90 IRE Unit line. Use the 100 nsec/div time base and horizontally position the rise (or fall) of the transition through point R on the short 2 IRE Unit/div scale. Measure the distance from point T on the 0 IRE Unit reference line to where the transition crosses the reference line. Time/div is 100 nsec; the T step transitions shown in *Figure 11* have a rise and fall time of 125 nsec.

In a linear system, risetime and falltime of the bar signal are equal. Non-linearities may affect risetime and falltime unequally. Measuring both by the above method detects such non-linear effects.

Bar Trail or Smear

Bar trail occurs after a transition from white to black. It is discussed in some detail in CMTT Document/189E; however, it need only be discussed here as the picture impairment appearing as streaking, following white-to-black transitions. To measure bar trail, use the 100 nsec/div time base. Position the trailing edge of a 100-IRE Units step transition (0-100 IRE Units on graticule) through the descending arrow (at the 50 IRE Unit line intersection) and measure displacement on the + and −10 IRE scale just to the right of point B. This scale is properly located for 525/60 standards.

Figure 12 shows the bar trail measurement using the white-to-blanking level transition of the staircase. A transition of 250 nsec falltime must be used because faster falltime (1T) may display ringing,
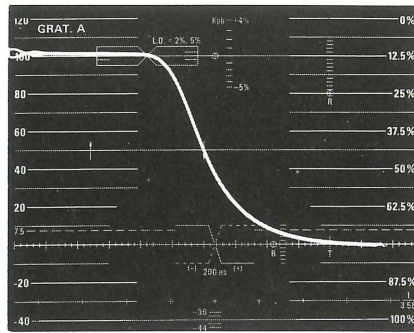
which would confuse the measurement.

Figure 12. *The Bar Trail measurement, Bar Trail = 5%.*

The remote transmitter control composite VIT Signal (FCC §73.669) has 250 nsec step transitions for the white bar and the falling transition of the bar may be used.

Measuring Half-Amplitude Duration of a Pulse

Adjust the VARiable VOLTS FULL SCALE for a pulse amplitude of 100 IRE Units. Shift the pulse down until the peak is at the 50 IRE Unit line. See *Figure 13*. The Graticule 0 IRE Unit reference line now intersects the pulse at the half-amplitude point.
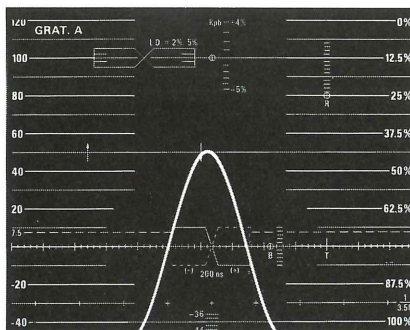

Figure 13. *Half-amplitude Duration (H.A.D.) measurement of a 2T pulse, H.A.D. = 245nsec.*

By selecting the proper time base, the half-amplitude duration (HAD) of the pulse is directly measured on the 0 IRE Unit reference line. Use a 100 nsec/div time base for a T or 2T pulse, and a 500 nsec/div time base for a 12.5T modulated sine-squared pulse.

Sync Amplitude

Sync amplitude error can be read directly, using the scale at the center of the −40 IRE Unit graticule line. This scale is marked at −36, −38, −40, −42, and −44 Units, or −10%, −5%, 0%, +5%, and +10%, respectively. It is located in time so that it can be used with either the 10 µs/DIV or 2 FIELD
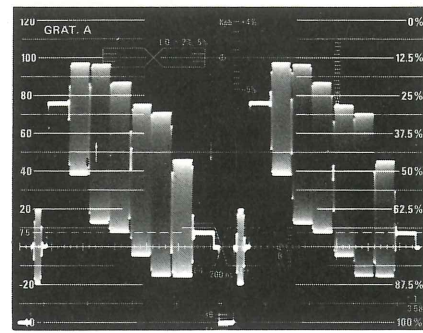
DISPLAY with equal accuracy.

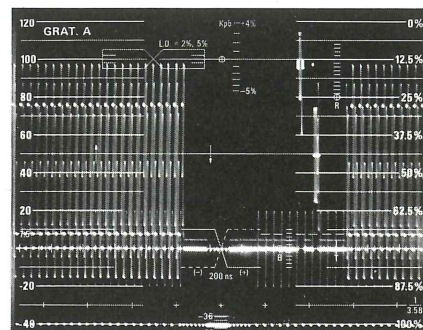**Figure 14a.** *Horizontal (line) Sync Amplitude measurement, Sync Amplitude = 40 IRE.*

Figure 14b. *Vertical (field) Sync Amplitude measurement, Sync Amplitude = 40 IRE.*

Vertically place the blanking level of the composite video waveform on the graticule's 0 IRE Unit reference line. Check insertion gain and then read horizontal sync amplitude using the 10 µs/DIV time base *(Figure 14a)*, or vertical sync amplitude using the 2 FIELD DISPLAY *(Figure 14b)*.

Tests With Other Signals

Amplitude Versus Frequency Response. A simple technique for checking frequency responses uses the multiburst signal to check for amplitude variations at the different frequencies. See *Figures 15a and 15b*. Care must be used in interpreting results of measurements made with the multiburst signal because it is not uncommon to note harmonic distortion on one or more of the bursts.

Even-order harmonics cause inequality between positive and negative peaks. Therefore, if the amplitude of only one of the peaks is measured, incorrect results will be obtained. Measure both the pedestal to positive peak and pedestal to negative peak to determine if even-order harmonic distoration is present.

Odd-order harmonic distortions affect

both peaks in the same manner, causing the peak-to-peak amplitude to be either too high or too low. The peak-to-peak amplitude depends on whether the 3rd harmonic can pass through the system. High frequency phase shift of this 3rd-order harmonic will cause the peak-to-peak amplitude of the burst to be distorted.
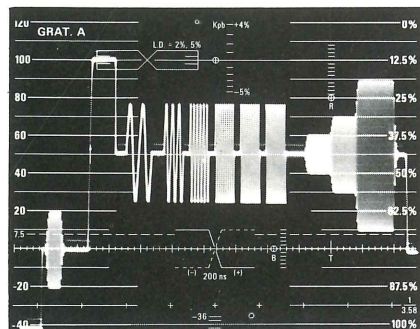

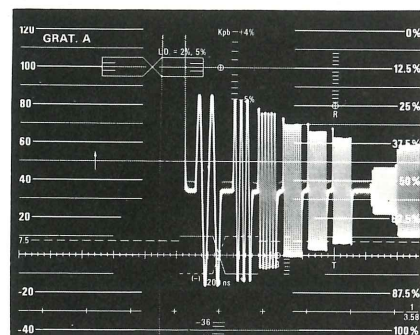**Figure 15a.** *Combination of Multiburst and Modulated Pedestal signals.*

Figure 15b. *Amplitude/Frequency Response 3 dB down at 3 Mhz.*

The multiburst signal shown in *Figures 15a and 15b* is the combined multiburst and modulated pedestal signal also described in CCIR Recommendation 473, Annex II. Vertically position the multiburst signal blanking level to the 0 IRE Unit reference line and use the VARiable VOLTS FULL SCALE to adjust for a white flag amplitude of 100 IRE Units. Set the 1480 VOLTS FULL SCALE to 0.5 (burst amplitude equals 100). Check for equal amplitude of the multiburst packets above and below the pedestal (even-order harmonic distortion). To measure the frequency response, successively position the negative peak of each multiburst packet to the 0 IRE Unit reference line and measure the peak positive amplitude of the packet.

Color Bar Chrominance Amplitude

The chrominance amplitude of 75% amplitude color bars can be rapidly checked on the new graticule using the

R scale. There are only three chrominance amplitudes present in the six color bars: 62, 82, and 88 IRE Units. See *Figure 16.*
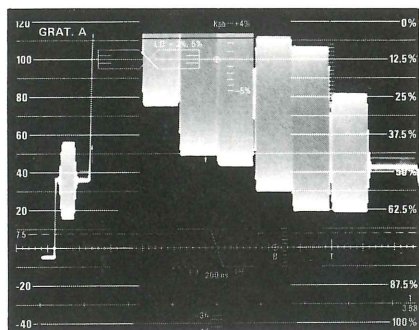

Figure 16. *Measuring Color Bar Chrominance Amplitude of the red and blue color bars, Amplitude = 88 and 62 IRE respectively.*

To measure each color bar amplitude, place the negative peak of the bar on the 20 IRE Unit graticule line, below the R scale. The displayed peak amplitudes become 82, 102, and 108 IRE Units respectively for the 62, 82, and 88 IRE-Unit-amplitude color bars.

Using Burst for Waveform Monitor Timing Check. Timing accuracy can be quickly verified by comparing the duration of burst cycles against the timing scale on the −30 IRE Unit graticule line. See *Figure 17.*
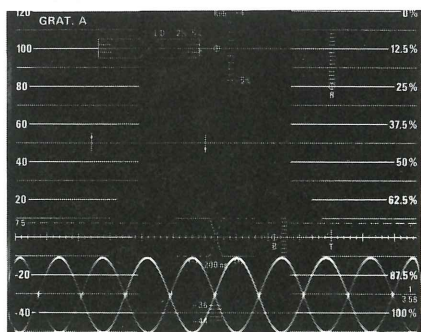

Figure 17. *Time Base Accuracy check at 100 ns/division sweep rate.*

Use either a 100 or 200 nsec time base and check for duration of each cycle of burst. This is a very accurate method to verify or calibrate (see 1480-Series Waveform Monitor Instruction Manual) the 1480 time base without special test equipment.

The discussion of test methods in this application note points out that proper design of the graticules for waveform monitors promotes versatility and accuracy. The new Graticule A used with the 1480 Waveform Monitor, provides

great versatility and accuracy without clutter—a feature operating personnel will appreciate. Some early 1480-Series Waveform Monitors (including 1485 Dual Standard models) may not be equipped with this graticule. If you desire an external version of this graticule, contact your nearest TEKTRONIX field office or representative for assistance.

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