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Contents

Cover: Dr. Gail Massey of Oregon Graduate Center studies a YAG laser pulse stored and displayed on the 400 MHz 7834 Storage Oscilloscope.

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A big step forward for direct-view storage

State of the art direct-view storage takes a big step forward with the introduction of the TEKTRONIX 7834 Storage Oscilloscope. Up to now the maximum stored writing speed has been 1000 cm/μs in the 7633 plug-in oscilloscope and 1350 cm/μs in the 466 portable. Both are 100 MHz instruments.

The new writing speed mark is 2500 cm/μs, and it's coupled with 400 MHz bandwidth in the new 7834. This means you can now capture a 3.5 cm high, single-event risetime of 1.4 ns.

The 7834 is a general-purpose laboratory oscilloscope with all of the synergistic measurement power produced by the four plug-in capability of the 7000 Series. For example, real time and spectrum analyzer plug-ins can be housed to simultaneously present both time and frequency domain displays for a given signal. Using the 7834's variable persistence storage mode, a steady display of the time domain can be viewed while observing slow changes in the spectral content. In another configuration, logic analyzer and real time plug-ins can be combined to zero in on a logic fault and then display that fault in real time, even though it may occur only once.

Multimode storage

The 7834 features multimode storage—bistable, variable persistence, and fast modes for each, pioneered in the 7623 a few short years ago.

The bistable storage-display is characterized by having two intensity levels—the stored-image intensity and the background level. There are two such modes: BISTABLE and FAST BISTABLE. The chief advantage of both of these modes is long view-time. Once an image is

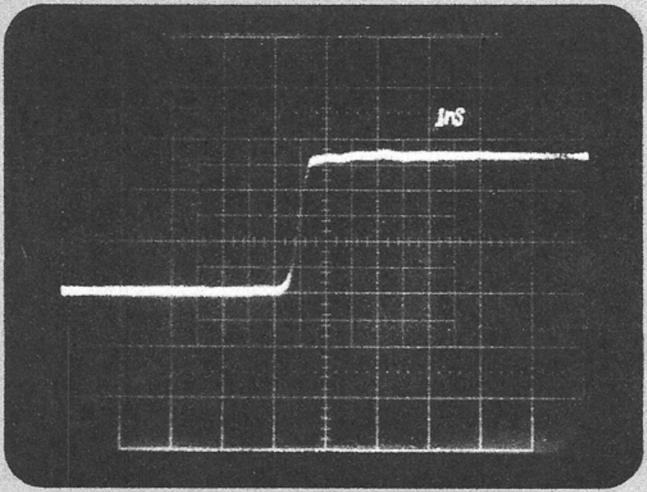

Fig. 1. Stored display of a single-shot, fast rise time signal.

stored, it can be viewed for an extended period. The BISTABLE mode is the simplest of all to use, with no adjustments for storage sensitivity other than the intensity control. Also, with a high resistance to blooming, this mode is unsurpassed for storing extremely low-frequency events that require a slow-moving spot on the crt. This mode, therefore, can capture waveforms with extreme differences in spot movement speed. The chief limitation is writing speed. The FAST BISTABLE mode also is resistant to blooming and overcomes the low writing-speed limitation. It is the second fastest mode of the instrument, with a writing speed of 350 cm/μs in reduced scan, and is useful in capturing single-shot information.

Variable-persistence storage displays are characterized by controllable persistence (the rate at which the stored display fades). Typically, this rate of fading may be adjusted from 1 or 2 seconds to well over a minute. There are two such modes: VARIABLE PERSISTENCE and FAST VARIABLE PERSISTENCE. The chief advantage of these modes is high writing speed. When the storage controls are optimized, writing speed is many times greater than in the corresponding bistable modes. The storage controls may also be adjusted to provide high-contrast displays that are especially advantageous for photography. In both variable persistence modes, view time (the length of time a stored trace is distinguishable from the background) is less than in the bistable modes, and is shortest of all when adjusted for highest writing speed. View time can be increased by using the SAVE mode as on other storage oscilloscopes.

The VARIABLE PERSISTENCE mode in the 7834 can convert a dim display of a fast, low-repetition-rate signal, into a bright, flicker-free display for easy viewing of signals that are beyond the display capability of non-storage instruments. By varying the persistence (or rate of fading), the best compromise can be reached between lack of flicker and ability to follow changes in the waveform.

The FAST VARIABLE PERSISTENCE mode provides the highest writing speed of all, 2500 cm/μs in reduced scan. This mode is most useful for capturing high-speed single-shot events such as fast rise pulses encountered in laser fusion research, destructive testing, and high speed computer development, that occur only once, or at very low rep-rates at best. The 7834 offers an unprecedented ability to display these pulses.

New operational features

The 7834 has several features not found on other storage oscilloscopes. These features add convenience and flexibility. For example, the MULTI-TRACE DELAY control extends the usefulness of the transfer-storage modes (FAST BISTABLE and FAST VARIABLE PERSISTENCE). When a time base operates in a repetitive manner (rather than single sweep), this control varies the display time between successive sweeps. An "infinite" position provides the same effect as single-sweep operation. One application of the multi-trace delay control is in making calibration adjustments. The operator simply sets the delay equal to the time required to change an adjustment. The new result is then automatically displayed (along with the old), freeing the operator from manually resetting the oscilloscope time base for each trace. Another application is to store a periodic waveform that occurs in a longer sequence of events. The multi-trace delay may be adjusted to blank out unwanted events and allow triggering only on the desired waveform.

The Remote-Storage inputs give the user control over several essential storage functions. With Remote Erase, Reset, and the new Remote Save inputs, the operator can conveniently conduct experiments at a distance from the oscilloscope, or control these functions automatically from other equipment.

A new Remote-Storage Gate input provides the user additional capability in the fast-storage modes. Use of this input, along with a second time base, permits capturing several closely spaced events on the same display, an ability not possible in fast-storage modes on previous instruments.

Two types of Auto Erase are available in the 7834. One is an adjustable periodic function that erases on a regular basis whether or not a stored display is present. The other type provides an adjustable display time after each stored event, and will not erase unless the time base has been triggered.

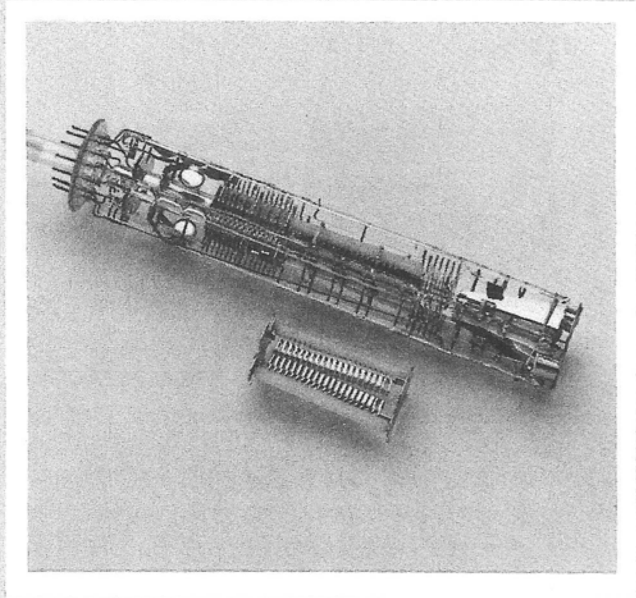

Fig. 2. Electron gun structure of the 7834 cathode ray tube. The vertical deflection structure, with the shield removed, is shown below the vertical deflection portion of the gun.

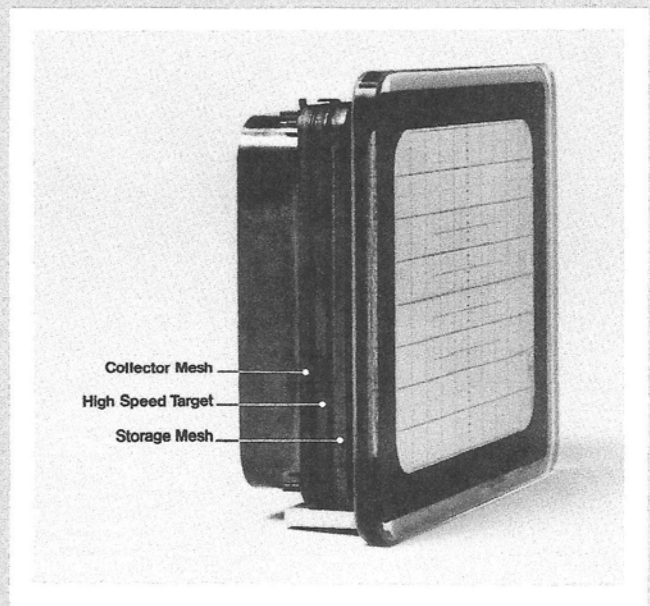

Fig. 3. A cutaway of the front portion of the 7834 cathode ray tube, showing the three-mesh structure used to achieve transfer storage.

Gated or Free Run readout selection is located on the front panel. This feature is especially convenient when switching between storage (where Gated is often used) and non-storage operation (where Free Run is typically more desirable). Previously, the Gated/Free Run switch had been located inside the mainframe, requiring removal of a sidecover to change modes.

Fast X-Y storage is possible in the 7834 because of a horizontal-mode selector switch and the availability of two horizontal plug-in compartments. Previously, X-Y storage was possible only in the slower, or non-transfer, storage modes.

Cathode ray tube

Much of the 7834's advanced performance is achieved through extending the capabilities of the cathode-ray tube (crt) to provide multi-mode storage. Both bistable and variable persistence designs are incorporated into the crt. In addition, a new focusing structure and improved electron-gun design are used to reach the high stored writing-rate. Further, a more sensitive deflection system was needed to reach the 400-MHz design goal for the vertical system passband.

In designing the crt, we built upon the experience gained with the 7633 transfer-storage tube. Transfer storage is the technique whereby two storage meshes are used to capture and display information, especially fast transients.

The writing beam stores an image on a highly sensitive short-view-time target. The image is then transferred to the second storage mesh, which has lower sensitivity but much longer view times. This second mesh can be operated in either a bistable or a variable persistence mode.[1]

A number of performance improvements were required of the crt to be suitable for a 400-MHz storage oscilloscope. These include both improved gun design and storage uniformity.

The gun design changes include a traveling-wave deflection system similar to that used in the TEKTRONIX 7904 Oscilloscope, the deflection sensitivity is improved to 1.7 V/cm/kV (a 50% improvement over the 7633 crt). To obtain a faster stored writing speed, an improved gun system was designed to deliver greater charge density to the target. The gun voltage was increased to improve the secondary-emission yield at the target and to reduce the space charge spreading of the writing beam. Independent X- and Y- focusing systems were designed, together with a vertical-only scan expansion lens, to obtain the required vertical-deflection sensitivity. The new focusing system results in improved trace width for the same beam current. More sensitive horizontal plates were designed to help in obtaining faster sweep speeds. An overall improvement in gun performance of 2.5 times was realized.

Additional gain in writing speed was obtained by improving the background uniformity of the display. Since a trace that will store on one part of the target may not store on another part, the writing speed specifications are quoted for the slowest portion of the target within the display area. To this end, the flood-gun collimation system was computer designed to improve landing characteristics and consequently improve background uniformity. This typically reduced the ratio between reduced scan and full scan variable persistence writing speeds from 8:1 to 6:1. Some performance gains over the previous fast-storage crt used in the 7633 are shown in Figure 4. This shows the typical writing speed expressed as tracewidths/second as a function of Intensity for the two fastest storage modes (variable persistence fast and bistable fast, in reduced scan). The reduced-scan mode of operation typically results in an eight-times improvement in writing speed over the full scan operation, due to the increased gun voltage and the reduced effect of target uniformity on writing speed. In the fastest mode, the writing speed approaches 10^{11} tracewidths/second. This compares with the photographic writing speed of the 7904. These stored traces are viewable for tens of seconds and are easily photographed.

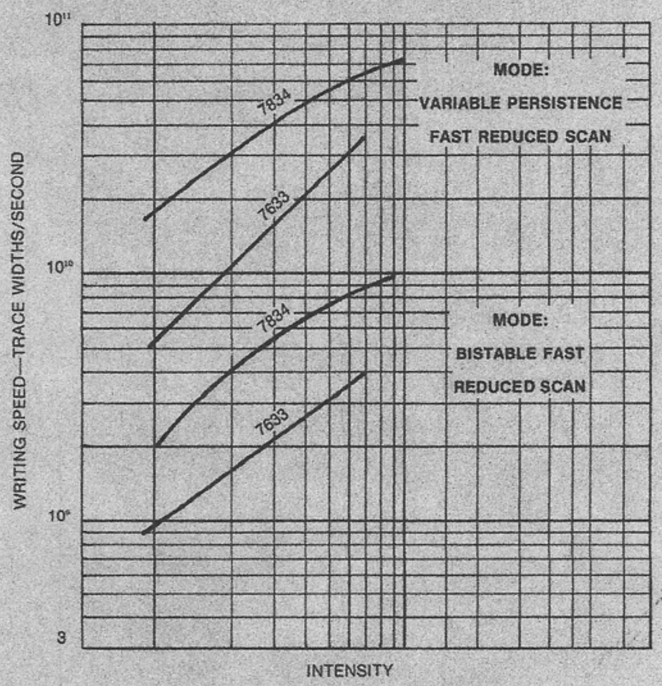

Fig. 4. Relative performance of the 7834 and 7633 Storage Oscilloscopes are shown in this graph of stored writing speed as a function of Intensity level setting.

Writing speed

Unless someone is very familiar with storage terminology, a writing speed specification may not be very meaningful except in a relative sense, where one storage oscilloscope is better than another. Therefore, a review of some basic storage concepts will better relate what the high performance of the 7834 does for your measurement needs. Writing speed is defined as the highest rate of spot movement on the crt face that will leave behind a stored image. Spot movement that is faster than writing speed will not leave an image, resulting in step response displays with no vertical edge, or sine wave displays with the center missing.

To be more precise, writing speed can be related to common waveforms by the equations:

$$(1)\ WS = \pi fA$$

$$(2)\ WS = \frac{kA}{T_r}$$

Equation (1) is for a sine wave of frequency, f, in megahertz, and peak-to-peak amplitude, A, in centimeters, yielding writing speed in cm/μs. Thus, a writing speed of 2500 cm/μs will store a 250 MHz sinewave with 3.2 cm peak-to-peak amplitude.

Equation (2) describes writing speed in terms of the vertical edge of a pulse or step response. The value of k ranges from 0.8 for a linear ramp, to 2.2 for a single-pole rc response. A value of 1.0 applies to a Gaussian or typical step response. T_r is the 10-90% rise time in μs and A is the amplitude in cm, to yield writing speed in cm/μs. Thus, a writing speed of 2500 cm/μs will store a 2.5 cm Gaussian step response with 1-ns rise time.

The 7834 achieves its maximum specified writing speed of 2500 cm/μs in a reduced scan mode, with 0.45 cm divisions. Writing speed in divisions is calculated by dividing by 0.45; thus, a 3.2-cm sine wave will be 7.1 divisions peak-to-peak. In these relationships, horizontal movement is not taken into account. However, for beam movement of more than three vertical divisions for every horizontal division, the effect of horizontal movement is less than five percent, and can usually be neglected.

General design features

Construction of the 7834 is much like the modular 7704A. The instrument is divided into two main modules that may be easily separated for ease of service. Like other 7000 Series four-plug-in mainframes, the 7834 has a high-efficiency power supply. This supply runs cooler and is much lighter than a conventional regulated supply. It is also more immune to electro-magnetic interference through the power line. The 7834 circuitry is highly protected from overloads such as a spurious short between various crt electrodes.

Acknowledgments

Project Engineer Chuck Scott directed the 7834 design. Electrical design was by John Durecka, Dave Morgan, Joe Peter and Jerry Rogers. Mark Anderson did the mechanical design. Gene Andrews was Project Manager.

The 7834 CRT development was headed by Project Manager Pete Perkins who did the collimation studies. Ken Hawken was CRT Project Engineer and Steve Blazo did the new CRT gun design. Dave Coffey did the CRT Manufacturing Engineering.

Marketing planning was done by Dave McCullough, and Mike Hurley is the Marketing Program Supervisor. Dwayne Wolfe is Manufacturing Manager.

1 See Tekscope July 1972