7/72

TEKSCOPE

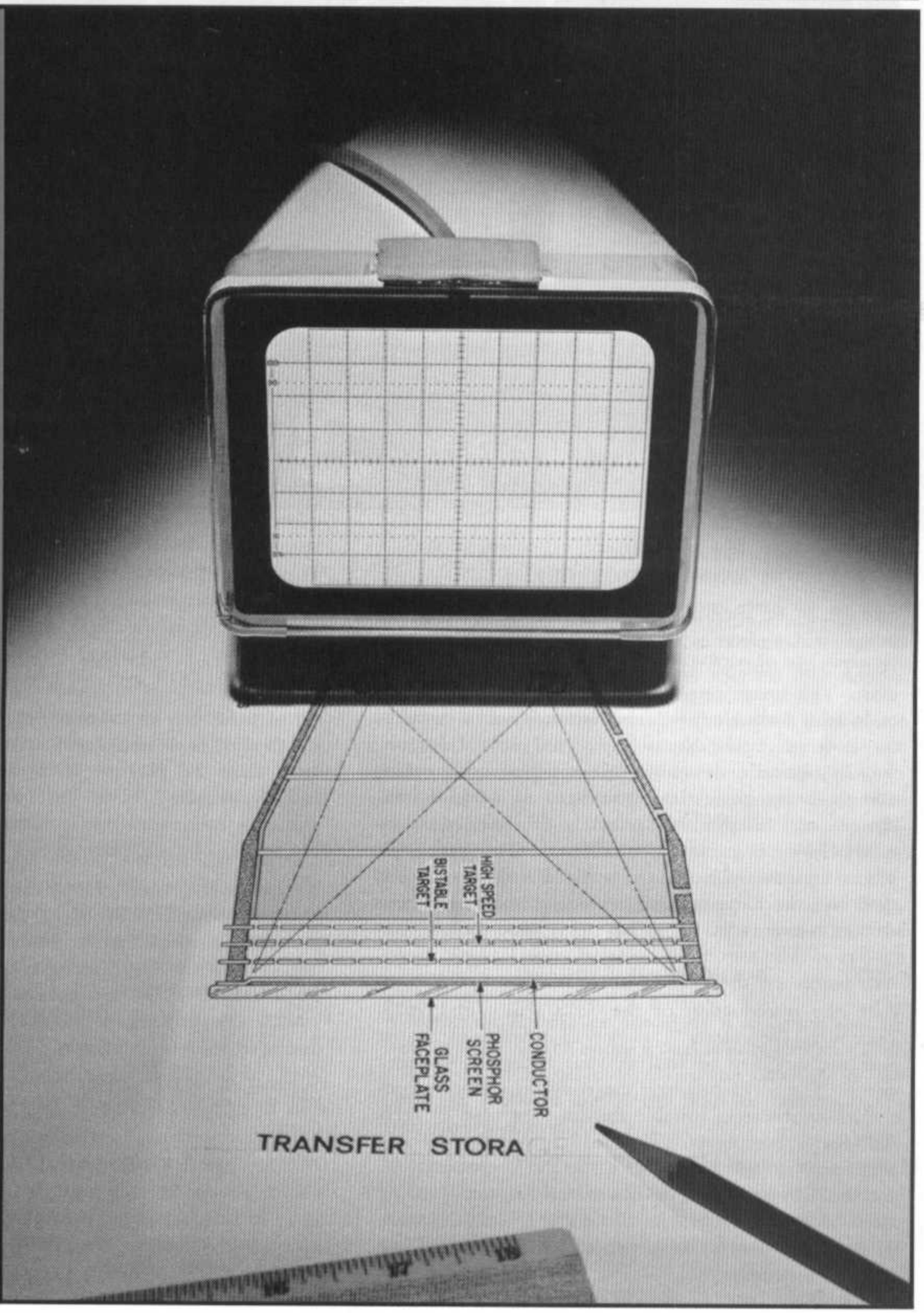
JULY 1972

THREE NEW INSTRUMENTS THREE KINDS of STORAGE

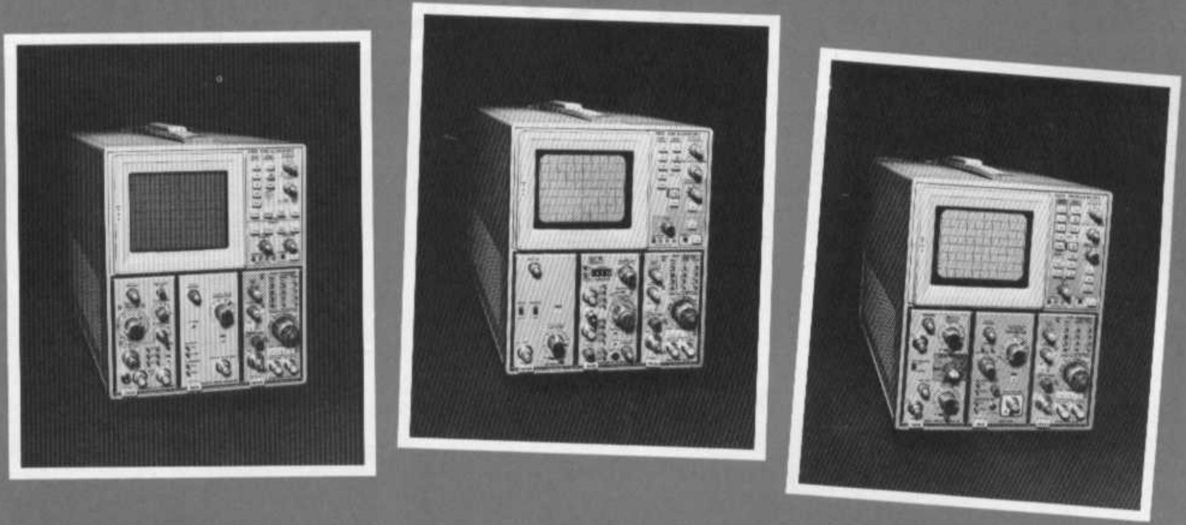
TEKTRONIX LOOKS AT LIGHT

IN CIRCUIT TESTING OF TUNNEL DIODES

WASHING YOUR TEKTRONIX INSTRUMENTS



COVER: The transfer storage CRT yields a phenomenal 200 cm/μs stored writing speed.



New Instruments 3 Kinds of Storage

WHAT IS STORAGE?

Storage, in an oscilloscope, is the ability to retain the image of an electrical event on the cathode-ray tube (CRT) for further analysis after that event ceases to exist. This image retention may be for only a few seconds with variable persistence storage, or it may be for hours with bistable storage. And now Tektronix, Inc. introduces a new ultra-fast storage concept which essentially combines the advantages of variable persistence and bistable storage while providing the fastest stored writing speed yet achieved. This article explains the basic principles of each kind of storage and describes the three new instruments which use these storage concepts.

A CHOICE OF STORAGE

With the introduction of the 7313, 7613, and 7623, Tektronix, Inc. offers a choice of storage to match your measurement as well as your budgetary requirements. The 7313 provides the convenience and economy of split-screen, bistable storage in a new 25-MHz 7000-Series instrument. The 7613 introduces variable persistence storage to the TEKTRONIX product line, and the 7623 provides ultra-fast storage for stored writing speeds as fast as 200 cm/μs. In addition, the 7623 combines bistable and variable persistence storage into one versatile instrument.

A FAMILY RESEMBLANCE

These new instruments take their place in the 7000 Series of instruments from Tektronix, Inc. Also new to this family is the 7603, a large screen, non-storage oscilloscope. The vertical deflection system bandwidth of the 7603, 7613, and 7623 is 100 MHz.

All of these new instruments share a common mechanical design; each instrument accepts up to three of the more than 20 plug-ins from the constantly growing 7000-Series plug-in line. Each instrument is also available in a rackmount configuration which occupies only 5¼ inches of rack height.

A prominent feature of each instrument in this family is the exclusive TEKTRONIX CRT READOUT which provides an alphanumeric display of measurement parameters on the CRT along with the waveform. The CRT READOUT circuit used in these instruments includes an adjustment to determine the size of the displayed readout characters. Also included in the 7603, 7613, and 7623 is an autofocus circuit to maintain a well-defined CRT display irrespective of intensity level changes.

Primary functional differences between these three new instruments is in their storage operation and capabilities. A basic description of the storage principles for each kind of storage is given in the remainder of this article.

PRINCIPLES OF DIRECT-VIEW BISTABLE STORAGE

The 7313 uses a direct-view bistable storage CRT. The basic structure of a storage CRT is the same as a conventional (non-storage) tube. However, several elements are added to make storage operation possible. The most important of these additional elements are the flood guns which cover the entire viewing area with low-velocity electrons. The collimation bands serve as an electro-static lens to shape the flood gun electron beam for uniform coverage of the target area. The storage target consists of a phosphor screen with a thin transparent conductive coating in front of it which serves as the collector. The storage target is split into two sections which allows two signals to be stored, viewed, or erased independently.

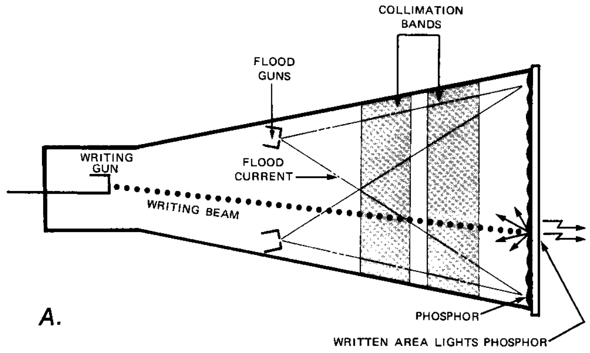
Direct-view bistable storage is based on a secondary-emission principle. When a stream of primary electrons strikes a phosphor, secondary electrons are dislodged from the phosphor surface. As the accelerating potential of the primary electrons increases, more secondary electrons are displaced for each primary electron that arrives. The ratio between primary and secondary electrons is called the secondary-emission ratio. When this ratio is less than one, the target area gains electrons and charges negative; when greater than one, it charges positive. The storage target has two stable potentials (bistable) where the secondary emission ratio is one; the first is near the flood-gun cathode potential, and the other near the collector potential.

In the storage mode, the flood guns provide a continuous stream of low-velocity electrons which cover the entire target area. This results in a slight background glow over the entire phosphor area. However, these flood electrons do not have sufficient energy to dislodge many secondary electrons from the phosphor so the target charges negative and remains in the first stable state.

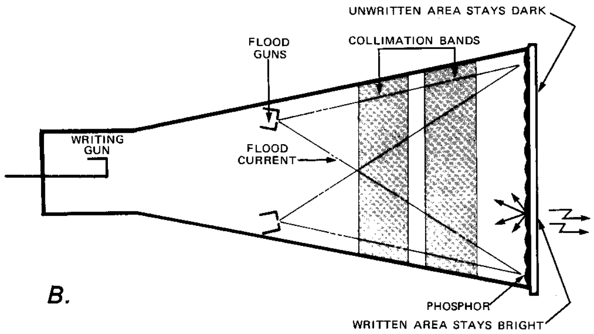
As the writing beam is scanned across the screen, it dislodges many secondary electrons (see Fig. 1A). The written area of the target shifts to the second stable state and the written area charges positive. Now, the flood electrons strike the written area with sufficient velocity to dislodge enough secondary electrons to keep the area charged positive and the written area remains visible (Fig. 1B).

As the sweep rate of the writing beam increases, a maximum limit is reached where it is difficult to store a display. This limit is specified as stored writing speed. There are two techniques which can increase the stored writing speed limit. For repetitive sweeps, integration can be used. In this technique, the flood guns are momentarily turned off and repetitive sweeps are allowed to build up the charge on the target. If the charge is allowed to build up sufficiently, the written area of the target shifts to the stored state. Then, the flood-gun beam is turned on again to view the display. The second method of increasing the writing speed is called enhancement. This method is intended for use with fast, single-sweep displays only. Again, the writing beam may not shift the target area positive enough to store the trace. To aid in storing the partially written trace, an enhance pulse is applied to the target area during the sweep time. This pulse raises the target positive enough to shift the partially written trace into the stored state.

Fig. 1. Direct-view bistable storage.



Writing beam dislodges many secondary electrons as it traces the waveform. The written area loses electrons and charges positive while the surrounding area remains negative.



Flood gun electrons hit unwritten areas too slowly to light phosphor and the target charges negative. The positively charged written area attracts electrons at higher speed, keeping the phosphor lit and dislodging enough secondary electrons to hold the area positive.

A stored display can be erased by first raising the collector positive so the entire screen is fully written. Then it is dropped negative to about the potential of the flood-gun cathodes and slowly returned positive to the ready-to-write level.

To operate either half of the screen in the conventional (non-store) mode, the collector is dropped to a level close to the flood-gun cathodes. This prevents the target from being held in the stored state by the flood-gun electrons.

PRINCIPLES OF HALFTONE TRANSMISSION STORAGE
(VARIABLE PERSISTENCE)

The halftone transmission storage tube has a basic structure similar to the direct-view bistable tube. Two mesh-type elements are added in this tube near the faceplate to achieve transmission storage. The mesh nearest the electron-gun structure is a fairly coarse mesh which serves as the collector electrode to accelerate electrons toward the storage target and to collect secondary electrons emitted by the storage target. The second mesh is very fine (about 500 lines/inch) and serves as the storage target. A highly insulative dielectric layer is deposited on this mesh using thin-film techniques. It is on this dielectric layer that storage occurs.

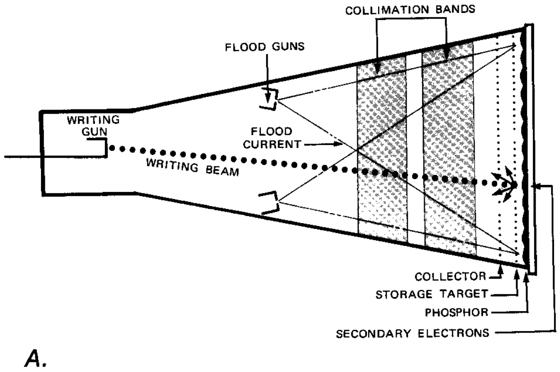
In the storage mode, the flood guns cover the entire storage target with a continuous stream of low-velocity electrons. However, these electrons are prevented from reaching the phosphor screen unless a display has been written on the storage target. As the writing beam is scanned across the storage target, it dislodges secondary electrons from the dielectric (see Fig. 2A). These written areas charge positive while the unwritten areas remain negative.

An accelerating potential of approximately 7 kV exists between the storage target and an aluminized layer which is deposited over the phosphor. This potential attracts flood electrons through the written area of the storage target, to the phosphor screen (Fig. 2B). The flood electrons are blocked by the unwritten areas of the storage target so these areas of the phosphor remain dark. The result is a bright, high contrast display of the image originally written on the storage target.

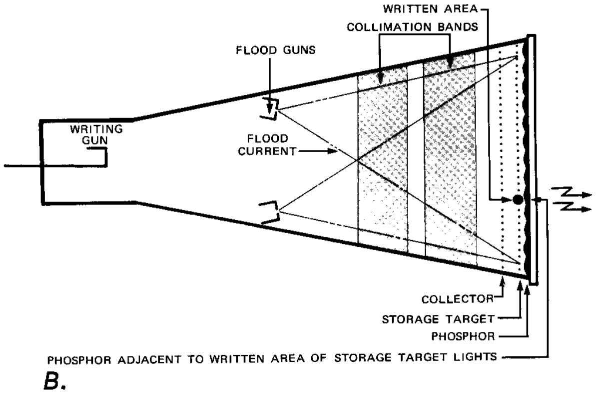
The density of the writing beam striking the storage target determines the amount of positive charge on the dielectric. This positive charge, in turn, determines the amount of flood electrons reaching the phosphor and thereby determines the brightness of the stored trace. It is this ability to store and display changes in intensity that leads to the name halftone transmission storage.

The entire stored image can be erased by applying a positive pulse of about 10 volts to the storage target mesh. Although the dielectric is insulated from the storage target mesh, it goes positive also by capacitive coupling. However, the dielectric immediately begins to discharge back to about zero volts due to the flood gun electrons which are striking it. After about one-half second, the positive erase pulse is removed and the storage target mesh drops back to a quiescent level near zero volts. Again by capacitive action, the dielectric follows negative to about −10 volts. The storage target is now in a ready-to-write state.

Fig. 2. Halftone transmission storage.



Writing beam dislodges secondary electrons from storage target. The written area charges positive while the surrounding area of storage target remains negative.



Flood gun electrons pass through written area of storage target and strike phosphor. Remainder of storage target blocks flood electrons.

A characteristic of the halftone transmission storage tube is that unwritten areas of the storage target begin to fade positive due to positive ion generation in the flood electron system of the tube. As a result, the entire screen reaches a stored condition after only a few minutes and the desired image is no longer visible. To prevent this from occurring and to provide for optimum viewing of the stored image, the entire screen is slowly erased during operation. This is done by applying variable-width erase pulses to the storage target every 10 ms. Each time a pulse is received, the storage target is partially erased. As the width of these pulses is increased, the display is erased more. Varying the setting of the front-panel PERSISTENCE control changes the width of the erase pulses and, hence, the time that a stored image can be viewed. The few flood electrons collected by the dielectric during each erase pulse cancel the effect of the ions, producing long term stability of the target.

A display can be retained for longer viewing by pressing the SAVE button. This interrupts the variable-persistence pulses and disables the ERASE button. Maximum retention is provided with the SAVE TIME control set to MAX. This removes the display completely from the screen. The display can be viewed by turning the SAVE TIME control clockwise until the trace is displayed at the desired brightness. The display will begin to fade positive after a short time due to positive ions. The viewing time in the SAVE mode is a function of the displayed intensity.

TRANSFER STORAGE

Principles of Transfer Storage

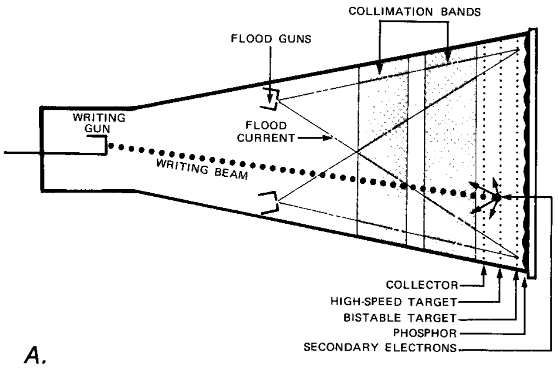
Recent developments in storage at Tektronix, Inc. yield the fastest stored writing speed yet achieved by a storage instrument—a phenomenal 200 cm/μs (222 div/μs at 0.9 cm/div) with the 7623 Option 12. Based on a transfer storage concept, the 7623 combines many of the advantages of both halftone transmission and bistable storage to produce this ultra-fast storage. Although similar types of storage have been used before to store relatively slow signals, Tektronix, Inc. has refined the techniques to make them applicable to storage of high-speed oscilloscope displays.

The transfer storage tube uses a third mesh in addition to the two used in the halftone transmission tube. The mesh closest to the electron gun serves as a collector. The second mesh is the high-speed target and is similar to the storage target in the halftone tube. The additional mesh is a bistable target which is constructed in a manner similar to the high-speed target but differs in the operating potentials applied.

Storage of a trace on the high-speed target is basically the same as in the halftone transmission tube (see Fig. 3A). This target is very sensitive so that even slight levels of writing beam current affect its charge level.

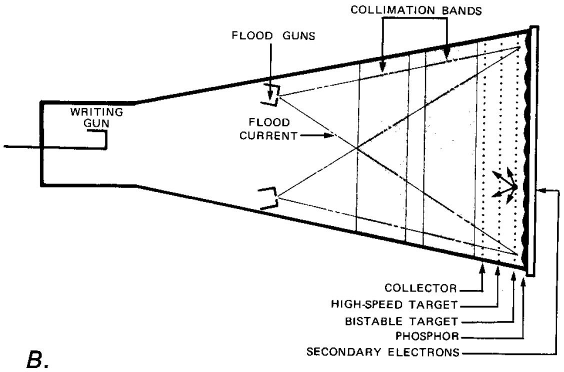
After the trace is stored on the high-speed target, it is transferred to the bistable mesh (Fig. 3B). If it were not transferred, it could be viewed for only a few seconds before the display would begin to fade positive. To transfer the stored image, a very high-level positive pulse is applied to the bistable target. In a normal bistable tube, this action would completely write the bistable target. However, since the high-speed target

Fig. 3. Transfer storage.



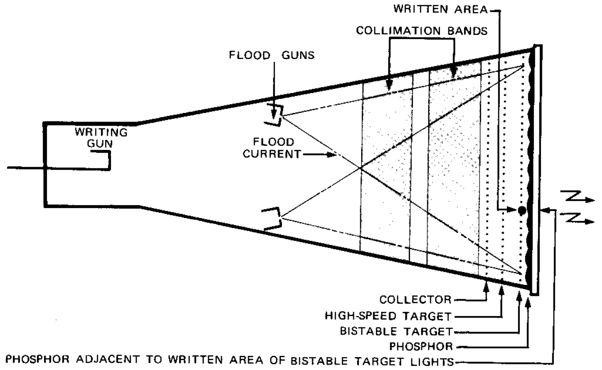
A.

Writing beam dislodges secondary electrons from high-speed target. The written area charges positive while the surrounding area of high-speed target remains negative.



B.

Flood gun electrons pass through written area of high-speed target and strike bistable target dislodging secondary electrons. Remainder of high-speed target blocks flood electrons.



C.

High-speed target is raised positive to allow all flood electrons to pass. Written areas of bistable target pass more electrons than unwritten areas, producing a trace on the phosphor.

passes flood electrons only where the trace has been written, this is the only area that stores on the bistable target. The high-level transfer pulse insures that all written areas of the high-speed target, even those with a very slight positive charge, result in a transferred trace on the bistable target.

The final step in transfer storage is to lower the potential on the bistable target to a normal viewing level while increasing the potential on the high-speed target. The high-speed target now allows all of the flood electrons to pass. However, the written areas of the bistable target allow more flood electrons to pass than the unwritten areas, producing a trace on the phosphor (Fig. 3C). Note that bistable storage takes place on a mesh and that a transmission process is used to display the stored trace on the phosphor. Therefore the action taking place is bistable transmission storage.

Since the final image is stored on a bistable storage target, it can be viewed for as long as desired without deterioration in image quality. A 7 kV accelerating potential between the bistable target and the aluminized phosphor results in a bright display.

The intensity of the stored image can be varied with the front panel STORED INTEN control. When the trace is no longer desired, it can be erased. Erase sequence for the high-speed target is essentially the same as for the halftone transmission tube, while the bistable target is erased in a manner similar to the direct-view bistable tube.

Storage Display Modes

The 7623 offers several storage display modes to accommodate a wide range of storage measurements. The fast storage mode always operates in a single sweep manner where a trace is stored on the high-speed target, transferred to the bistable target, and then viewed as long as desired before manual or automatic erase. During view time, the time-base unit is locked out so further traces cannot be stored; it is "armed" so it can produce another trace after the erase cycle is complete.

Normally, pressing the ERASE button erases both the fast and bistable storage targets. Pressing the MULTI FAST button changes the erase cycle so only the high speed target is erased each time the ERASE button is pressed. After a trace is stored on the high-speed target and transfer is complete, further traces can be stored by pressing the ERASE button; the bistable target is not erased. This permits multiple traces to be stored on the bistable target and displayed on the phosphor screen.

Another change in the operating cycle is effected by pressing the INTEGRATE button. This action turns off the flood guns and interrupts the transfer pulse, allowing several traces to build up the charge on the high-speed target before being transferred to the bistable target. Integrate time is limited to only a few seconds in the fast mode.

In addition to the fast storage modes the 7623 provides bistable and halftone storage. In these modes the high-speed storage target is held at about the same potential as the collector and has essentially no effect on operation. The operating potentials on the second storage target determine whether the tube operates in a bistable or halftone storage mode.

SUMMARY

Each type of storage has application areas for which it is best suited. Direct-view bistable storage offers low-cost, long viewing time and split-screen operation. Halftone storage offers bright, high-contrast displays with variable persistence and the ability to store changes in intensity levels. Transfer storage provides both bistable and halftone storage, plus fast storage to store and display traces as fast as 200 cm/μs for as long as desired. With these three types of storage, in six new 7000 Series instruments, Tektronix, Inc. offers you the best in storage, no matter what your application.

ACKNOWLEDGEMENTS

Three concurrent design projects such as the 7313, 7613, and 7623 involve a lot of people. Although we cannot list all of the people involved in these projects, we would like to give credit to the following:

The new CRT for the 7623 was developed by Gary Siewell, Chris Curtin, and Wes Hayward. Wes also contributed much of the technical information for this article. Larry Virgin designed the 7613 CRT. Electrical and mechanical design of the 7623 and 7613 was as follows: Project Engineer was Bill DeVey under the direction of Oliver Dalton. John Durecka did the electrical design. Doug Giesbers, Ed Wolf, and Chuck Davis provided the mechanical design. Aiding the overall design effort were Dave McCullough and Dick Anderson.

John McCormick served as Project Engineer for the 7313. Tim Boege did the electrical design while Cathy Weinstein worked on the mechanical design. Paul Jordan also assisted in this project.

TEKTRONIX LOOKS at LIGHT

by JON FESSLER *and*
PETE KELLER

Almost since time began, man has been trying to identify and characterize the world around him. Among the first phenomena which drew his interest, and yet one which even today we do not fully understand, was light. At first, light could only be characterized as too bright or too dim, but as scientific knowledge increased, methods of measuring and specifying the quantity of light were developed. This study of light, when it deals with electromagnetic radiation which is visible to the human eye, is called photometry. If the study is broadened to also include the infrared and ultraviolet portions of the spectrum, it is called radiometry.

The study of photometry and radiometry is not confined to the laboratory. In fact, many uses require that the measuring instruments be taken to the light source. In addition, the instruments should be easily adaptable to a wide variety of applications while providing accurate measurements.

It is into this field that Tektronix, Inc., a leader in the manufacture of precision oscilloscopes and related products, enters with the J16 Digital Photometer/Radiometer. The J16 offers small size and light weight with rechargeable battery operation for maximum portability. Measurement results are displayed on a bright 2½-digit LED (light-emitting diode) display to facilitate measurements under low-light conditions and to reduce the errors associated with meter-type displays.

Interchangeable light-sensor probes allow the J16 to be adapted to the measurement requirement. Four calibrated probes are available for precise measurement of illuminance, irradiance, luminance, and LED light output. Since each probe is independently calibrated, the J16 does not need to be recalibrated when the probe is changed. A fifth probe is available to provide uncalibrated measurements where the only interest is the relative light output of the devices under test. The interchangeable probe concept also allows for future expansion of the system. An optional probe-extension cable allows the probe to be positioned independently of the J16.

A Simple Design

The circuitry used in the J16 is relatively simple as represented by the block diagram of Fig. 1. A silicon photo-diode is used as the light sensor in each probe. The different spectral response obtained from each probe is the result of a computer-designed, multilayer glass filter mounted in front of the sensor (except in the uncorrected J6504 Probe). A calibration adjustment in each probe allows the probe output to be normalized for easy interchangeability of probes without system recalibration or loss of measurement accuracy. Each probe also contains coding circuitry to light the correct units of measurement indicator on the front panel.

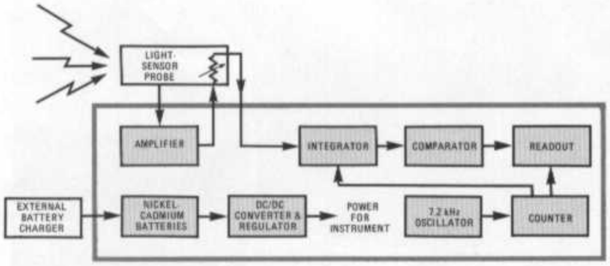


Fig. 1. *Block diagram of the J16 Digital Photometer/ Radiometer.*

The silicon photo-diode used in the probes provide long-term stability, good linearity, and are rugged enough to stand up to typical portable usage. In addition, they cannot be damaged by extreme light levels, even when pointed directly at the sun. All probes include a READOUT HOLD switch which allows the user to store the display for as long as desired. This is particularly convenient when making measurements in situations which make immediate reading of the display difficult.

The photo-diode generates a current proportional to the intensity of the applied light. This current is amplified and converted to a voltage output by the amplifier. Also included in this circuit is the range-selection circuitry which determines the sensitivity of the unit. The output of the amplifier is connected to the integrator through the calibration potentiometer in the probe. This adjustment allows precalibration of the probes.

The remaining circuitry of the J16 comprises a digital voltmeter (DVM). The integrator produces a ramp signal which varies in amplitude in response to the voltage output of the amplifier. This ramp is applied to the comparator where it is compared against a fixed reference level. The output pulse from the comparator triggers the readout.

The 7.2-kHz oscillator free-runs continuously to provide a clock signal for the DVM. This signal is counted to provide a binary-coded-decimal drive signal to the readout. It also provides control signals for other circuits in the instrument.

BASICS OF PHOTOMETRY AND RADIOMETRY

Photometry refers to the measurement of visible light, usually with a sensor having a spectral sensitivity curve similar to the average human eye. Photometry is used to describe lighting conditions where the eye is the primary sensor such as illumination of work surfaces, television screens, etc.

The spectral sensitivity curve of the average human eye at typical light levels is called the CIE Photopic Curve. As can be seen from Fig. 3, the eye responds differently to light of different colors and has maximum sensitivity to yellow and green. In order to make accurate photometric measurements of light of various colors or from differing types of light sources, a photometer's spectral sensitivity must match the CIE Photopic Curve very closely.

The following are the most commonly used photometric units (see the drawing below for their relationship).

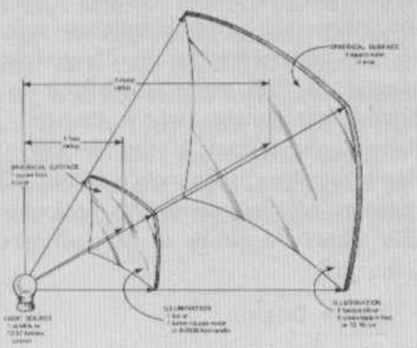
Illuminance is the amount of luminous flux received by a unit of surface area. Usually measured in foot candles (lumens/ft^2).

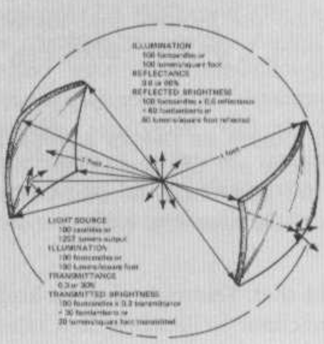
Luminance is the amount of light emitted or scattered by a surface and is usually measured in foot Lamberts. One foot candle falling upon a perfectly diffusing white surface with no loss would produce one foot Lambert.

Luminous Intensity is the luminous flux through a unit of solid angle and is usually measured in candelas (lumens/steradian).

Radiometry generally refers to the measurement of radiation in the infrared, visible, and ultraviolet portion of the spectrum. Devices used to make radiometric measurements should have equal response to light of various wavelengths in order to be versatile and easy to use without the need to correct data. This is similar to the necessity of having an oscilloscope vertical amplifier that has constant sensitivity from DC to the specified bandwidth.

Irradiance is the amount of radiant flux received by a unit of surface area and is usually measured in watts/cm^2. Other units of irradiance such as microwatts/cm^2 and watts/M^2 are also used extensively and are easily converted by shifting decimal places.)





When the readout is triggered by the comparator, it transfers the present count at its input to the LED display. The display is updated in this manner approximately every 80 milliseconds unless the READOUT switch on the probe has been set to HOLD. Under the latter condition, the readout retains the display present when the HOLD command was received.

Several convenience feaures are provided by the readout to facilitate accurate measurements. If the light intensity being measured is too great for the measurement range that has been selected, the display blinks at a 6-Hz rate to call the operator's attention. Another feature is the built-in battery check. When the BATT CHK button on the front panel is pressed, the battery potential is measured by the DVM and displayed on the readout.

Rechargeable nickel-cadmium batteries provide power for the instrument. A DC-DC converter with an electronic regulator provides stable voltages for accurate operation. Protection circuitry is included to interrupt instrument operation and prevent battery damage due to over-discharge. The batteries can be recharged in about 16 hours with the external battery charger. If desired, spare battery packs can be purchased so the J16 can be operated from one set while the spare is being recharged.

Packaging Performance

The mechanical design of the J16 results in a compact, self-contained instrument with mechanical performance to complement its electrical capabilities. The small size (2.4 x 4.6 x 8.0 inches) and low weight (3.25 pounds) result in a highly portable, easy-to-use instrument. The J16 can be hand-held while making measurements or the probe can be detached and used with the optional extender cable. Under the latter condition, the J16 can be placed in a fixed position or carried around the neck with the shoulder strap while the probe can be moved about freely to obtain the desired measurement. Also, both the J16 and the probes have ¼-20 mounts so they can be mounted on optical benches or used with standard photographic tripods or similar equipment.

Servicing Simplified

The J16 is a completely self-contained unit; discrete components are used throughout the instrument rather than sealed, non-repairable modules. The instrument is built on circuit boards for easy accessability to the components (see Fig. 2). As a result, the instrument is easy to service should repairs be necessary. In addition, the TEKTRONIX reputation for reliability and our world-wide service organization is available to back you up.

The J16 is totally solid-state, using a dependable integrated-circuit design. This results in a very reliable, stable instrument which requires recalibration only about once a year under normal operating conditions. Recalibration to insure accurate measurements requires only three adjustments. 1) Calibrate the DVM section against an accurate voltage source. 2) Set the front-panel ZERO adjust for a zero readout with no light striking the probe sensor (in dark room or with a photographic dark cloth covering the instrument). 3) The GAIN adjustment, located on the probe, should be made only under controlled conditions with an accurate light source. Tektronix, Inc. maintains complete recalibration facilities where the probes are adjusted with light sources traceable to the National Bureau of Standards. Since both the J16 and the sensor probe are precalibrated for normalized gain, only the probe needs to be returned to Tektronix, Inc. for recalibration.

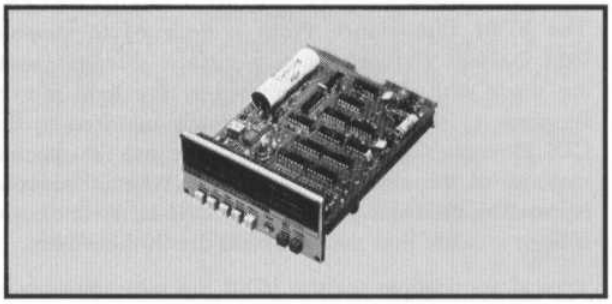


Fig. 2. *Simple construction of the J16 makes servicing easy.*

A Variety of Probes

The measurement flexibility of the J16 is greatly increased by the variety of plug-on light-sensor probes available. Measurement capabilities can be changed in a matter of minutes by simply changing probe units. A few of the typical application areas for the J16 system are:

- **Outdoor lighting of highways, streets, airport runways, signs . . .**
- **Indoor lighting of offices, work areas, homes, movie and TV studios, hospital operating rooms . . .**
- **Manufacturing checks of lamps, light fixtures, auto headlamps, displays, photography equipment, light-dependent processes, light filters, industrial photo processing . . .**
- **Checks of TV picture tube brightness and uniformity, lasers, storage CRT brightness, readouts such as LED's and electroluminescent panels . . .**
- **And many, many more!**

Following is a summary of the probes currently available along with some typical applications. Fig. 3 shows the spectral response of each probe.

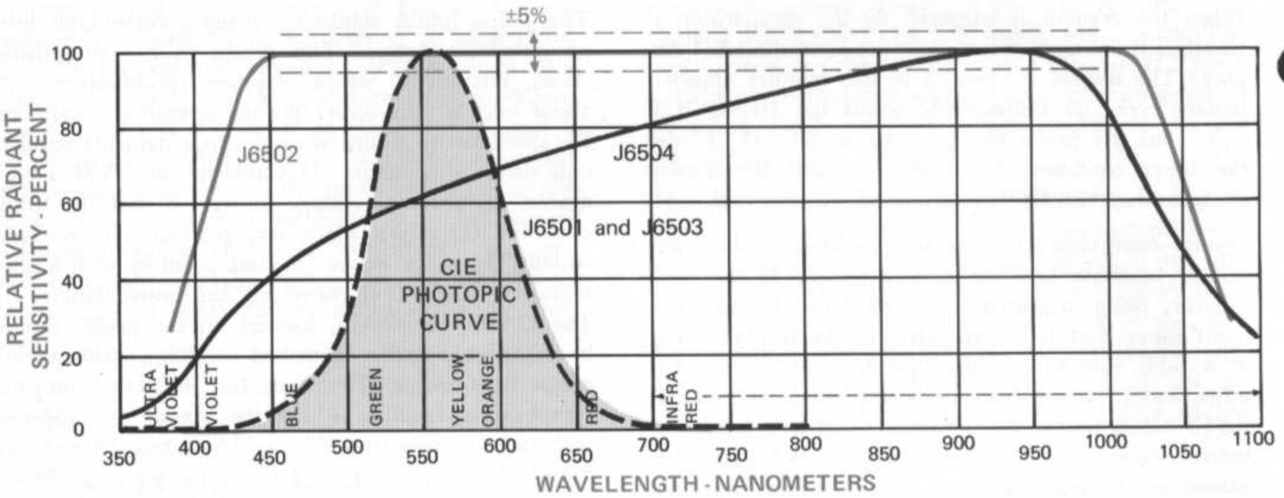


Fig. 3. *Spectral response of probes for J16.*

The J6501 Illuminance Probe is designed to measure light incident (falling) upon a surface. Measurements are made with the J6501 pointed at the light source. Response of this probe is very closely matched to the CIE Photopic Curve (see Fig. 3) to equal the spectral response of the average human eye. When this probe is installed, the front-panel FOOT CANDLES indicator is lit to indicate that measurements are in these units.

Typical applications for the J6501 are measurements of street lighting (see back cover), building lighting, television and movie scene illumination, and light levels falling on working surfaces.

The J6502 Irradiance Probe is corrected to provide a flat spectral response within 5% over the spectral range of 450 to 1000 nanometers (visible and near infrared). Measurements are made with the J6502 pointed at the light source. The front-panel μWATTS/SQ CM indicator is on when this probe is used.

Typical applications include measurement of radiant efficiencies and laser research experiments (see Fig. 4). For measurements of lasers exceeding about two milliwatts output, use neutral density filters to reduce the light intensity to the probe sensor.

The J6503 Luminance Probe measures light scattered, reflected, or emitted by a surface. Measurements are made with the J6503 pointed at the surface. Response of the probe is closely matched to the CIE Photopic Curve. Measurements with the J6503 are in FOOT LAMBERTS as shown by the front-panel indicator.

The J6503 can be used for typical applications such as measurement of television picture tube luminance and uniformity (see Fig. 5), storage CRT brightness, light reflected from work surfaces, and light output of electroluminescent devices.

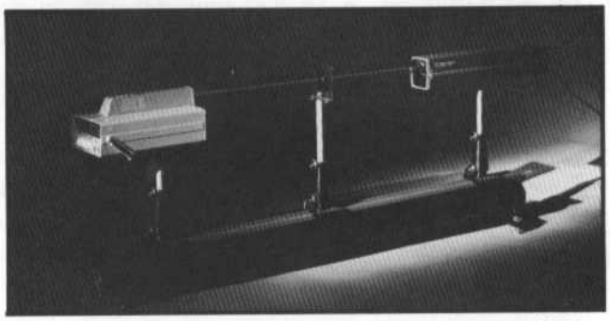


Fig. 4. *Measuring laser output power with the J6502 Irradiance Probe.*

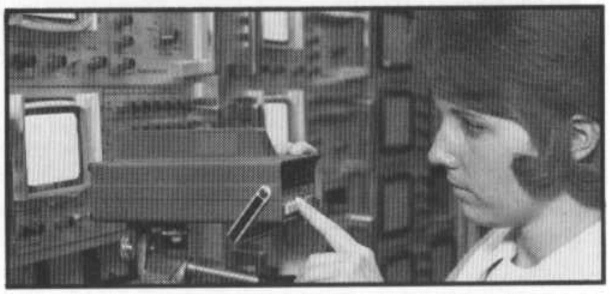


Fig. 5. *Tek employee Marilyn Bonin monitors the new 7623 Transfer Storage Tube with the J6503 Luminance Probe.*

Fig. 6. *The J6505 LED Test Probe being used for incoming inspection of light-emitting diodes by Brenda Bryant.*

The J6504 Uncorrected Probe can be used where only the relative light level needs to be measured. No correction filters are used so the response is that of the silicon light sensor. However, an optional filter holder is available so you can add standard one-inch diameter filters in front of the sensor to match the response to your measurement requirements. Since measurements are relative, no units are indicated on the front panel when this probe is installed.

Typical uses of the J6504 are for standardizing light sources of photoresist and photoprocessing equipment or for matching light sources without regard to absolute units.

The J6505 LED Test Probe is designed to measure illuminance of light sources such as light-emitting diodes with spectral outputs in the range of 620 to 730 nanometers (red light). Measurements are made with the J6505 pointed at the light source. The front-panel FOOT CANDLES indicator is on when this probe is used. Measurements can be made in millicandelas by maintaining a predetermined probe-to-LED spacing.

The principal application of the J6505 is measurement of light-emitting diode output (see Fig. 6). However, it can also be used to measure any light source whose output falls in the 620 to 730 nanometer range.

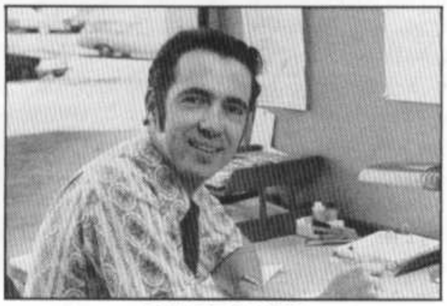
Summary

The TEKTRONIX J16 Digital Photometer/Radiometer can bring new capabilities and flexibility to your light-measurement applications. Just as interchangeable voltage and current probes greatly expanded oscilloscope measurements, the interchangeable light-sensor probe concept of the J16 will greatly expand your light measurement capabilities. Perhaps your job does not have requirements for an instrument such as the J16, but you know someone who could use it. If so, we would appreciate your passing this article on to them.

ACKNOWLEDGEMENTS

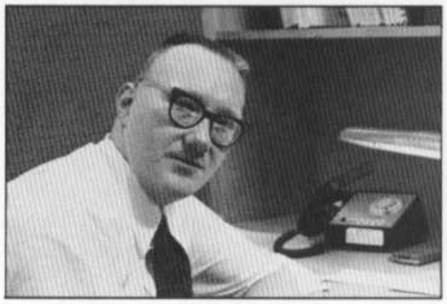
The J16 is the result of a joint effort by many people. Russ Anderson assisted Jon in the electrical design. The J16 was based on circuit concepts developed by Wendell Damm. Mechanical design was by John Benson and Larry Pearson and optical design by Pete Keller. Ron Phillips provided evaluation support while Millie Cantrall built the prototype units.

About our authors—



JON FESSLER

Jon started at Tek in 1965 as a Component Application Engineer and later worked as manager of the Prototype Engineering Group where he assisted in getting many new TEKTRONIX instruments into production. His present duties as Engineering Project Manager in the Optical Products group led to involvement on the J16. During his off-duty hours, Jon shares his hobbies of ghost-town exploring, rockhounding and photography with his wife Judy.



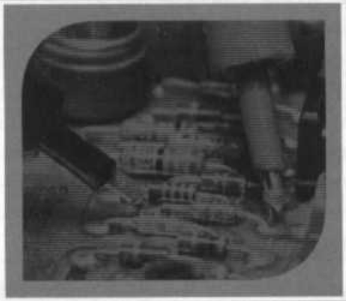
PETE KELLER

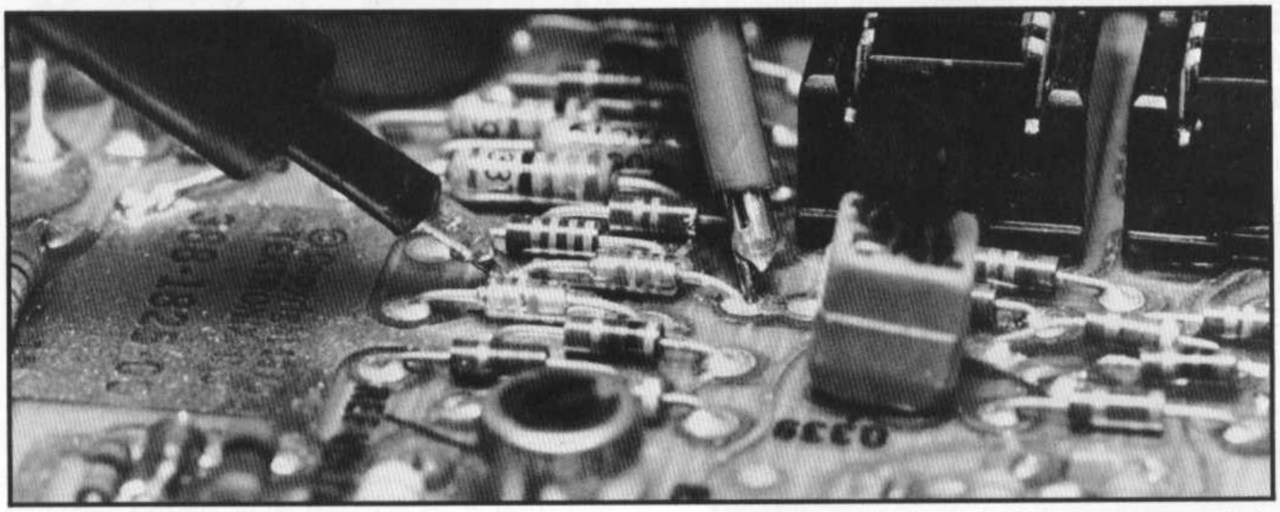
Pete has worked at Tek for 8½ years. Prior to his present duties as Marketing Staff Engineer for the Optical Products group, he worked in the CRT Development area. Pete has been involved with electro-optical measurements for many years and worked at Kitt Peak National Observatory before coming to Tek. Pete spends his spare time with his wife and four children, and enjoys pastimes of astronomy, classical music, and radio.

TEKNIQUE

TUNNEL DIODES:

In-Circuit Testing Using the 7D13 Digital Multimeter Plug-In.





A common practice in troubleshooting electronic circuitry is substitution of components as a quick analysis of the circuit malfunction. Often, however, a replacement is not readily available, especially if the part is expensive; and some components, such as semi-conductors, are extremely sensitive to heat and easily damaged during installation or removal.

Tunnel diodes frequently qualify in both of these categories. As such, it is best to test them in-circuit if possible. In past issues of Tekscope we have discussed various methods of checking tunnel diodes. One method described the use of the sawtooth output from your test scope as a current source for the TD with the resulting characteristic curve displayed on the test scope. Another method discussed using the TEKTRONIX 576 Curve Tracer for in-circuit testing of tunnel diodes.

For some applications a simpler, quicker test can be made using the ohmmeter section of the TEKTRONIX 7D13 Digital Multimeter plug-in. You may legitimately ask, "What's new about using an ohmmeter to check semiconductors? We've been doing that for years." The answer is that instead of getting just a high-low resistance indication you can take a resistance measurement accurate to within 0.5 percent ±1 count. Here is how this can be of importance to you in checking tunnel diodes and other devices.

When using the 7D13 on the 200-ohm scale, precisely 10 mA is caused to flow through the resistance being measured. The resultant voltage is then measured by the voltmeter circuits and read out as resistance, in digital form, on the CRT screen. In checking tunnel diodes, this 10 mA current switches the TD to its high state and a resistance reading is taken in the tunnel direction. The leads are then reversed and a reading is taken in the low resistance direction. We can thus establish a set of resistance "standards" for the device since precisely 10 mA is flowing through the device during each measurement. Readings for a given type of device are typically within one or two percent from one unit to another.

For tunnel diodes requiring more than 10 mA to switch, a 0.001-μf capacitor is placed across the 7D13 input terminals. This supplies the additional current needed for switching and the resistance reading is then taken with a constant 10 mA flowing through the device.

A note of caution is in order here. Some tunnel diodes, such as those with low-picosecond switching times, are easily damaged and should not be checked using this procedure. Typical of this class of device are the output tunnel diodes used in the TEKTRONIX 284 and S-50 pulse generators with switching times of less than 70 ps and 25 ps respectively.

The capability of making precise resistance measurements is particularly useful in production testing where several instruments of the same type are being processed. For example, a chart can be prepared showing the expected readings for each type of device to be checked. The chart need not be limited to tunnel diodes, of course. It may include signal diodes, Micro-T transistors and other devices easily damaged during installation.

When a reading is taken that does not correspond to the value shown in the chart it usually indicates a marginal or defective device, or as sometimes happens in production, a wrong component is installed.

The sample chart below shows typical readings for some of the tunnel diodes used in TEKTRONIX products. Several units of each part number were measured and the average reading listed. As we mentioned before, the readings for a given type were all within one or two percent of each other.

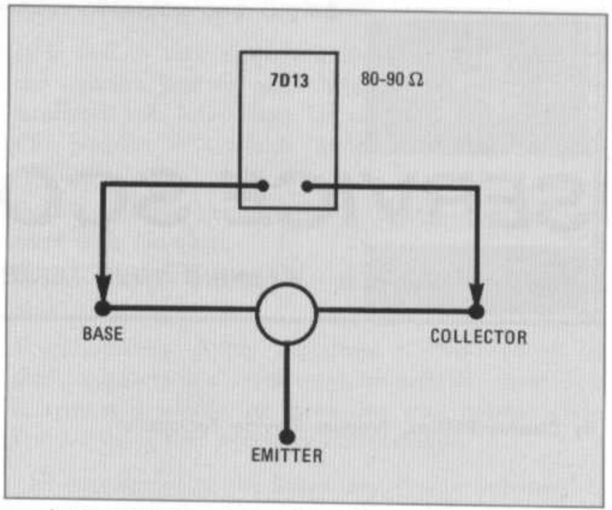
Tunnel Diode Resistance Readings Taken with the 7D13

Type No.	Part No.	Switching Current	Resistance Low-High
1N3712	152-0169-00	1.0 mA	10 - 60 Ω
1N3715	152-0330-00	2.2 mA	6 - 55 Ω
1N3713	152-0125-00	4.7 mA	5 - 55 Ω
1N3717	152-0381-00	5.0 mA	5 - 50 Ω
1N3718	152-0386-00	10.0 mA	3 - 53 Ω
TD253	152-0154-00	10.0 mA	5 - 60 Ω
TD253B	152-0177-00	10.0 mA	6 - 60 Ω
TD254	152-0380-00	20.0 mA*	3 - 53 Ω
TD274A	152-0387-00	20.0 mA*	3 - 53 Ω

**Install .001-µf cap across 7D13 Terminals*

Checking Micro-T Transistors

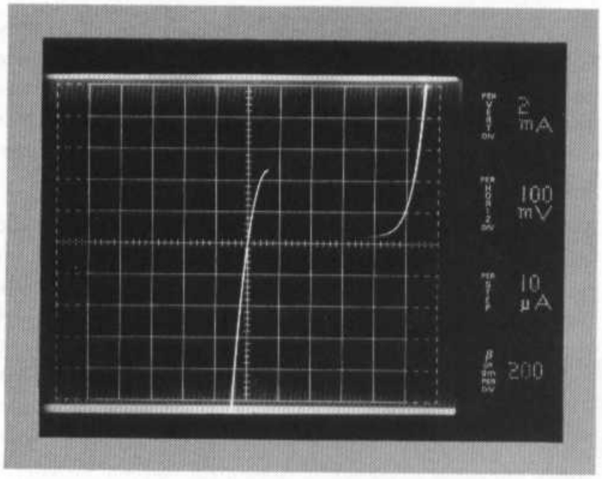
The Micro-T transistor is another device that is almost impossible to remove from the circuit for testing, without damage. This small, high-frequency package is usually soldered right onto the printed circuit board. The diagram shows the lead arrangement for the device. The layout is ideal for passing a signal through the device while maintaining a constant impedance environment in the printed circuit board layout. A resistance reading is usually taken across the base-to-collector junction and should typically read 80-90 ohms. Values outside of this range indicate a marginal or defective device.



Lead arrangement for Micro-T transistor. Resistance reading is taken across BASE/COLLECTOR junction.

Summary

Using the 7D13 Digital Multimeter plug-in for making accurate in-circuit measurements can substantially reduce the time spent in identifying marginal components that are causing trouble, or represent potential trouble spots. This technique is especially applicable to production testing where many units of the same type are being tested.



Pictured above is the characteristic curve for a 4.7-mA tunnel diode displayed on a TEKTRONIX 576 Curve Tracer. The device is being driven by the Collector AC supply. Zero current and zero voltage is at center screen. With 10 mA flowing in the forward direction there is 555 mV across the device. Forward resistance is thus 55.5 ohms. With 10 mA flowing in the reverse direction there is 45 mV across the device for a reverse resistance of 4.5 ohms.
The 576 is a convenient means of verifying what the forward and reverse resistance readings should be for a given type of device. The 7D13 provides a fast and accurate method of making these same readings for an "in-circuit" production test application.

SERVICE SCOPE

WASHING YOUR TEKTRONIX INSTRUMENT

By Charles Phillips, Product Service Technician

Have you ever noticed how much better your car seems to run when it has just been washed or polished? This is a psychological reaction of course, but the improved appearance does cause us to value our car more highly and take better care of it until the next rain storm messes it up again.

Test equipment gets dirty, too. Not as rapidly as our car, perhaps, but with a more detrimental effect on its operation. Thorough cleaning of a dirty instrument not only improves its appearance, but improves its performance and reliability as well.

Many of you are aware that Tektronix has, for many years, been washing instruments sent to our service centers for repair and calibration. Some customers with large numbers of instruments have installed their own wash facilities as an aid in keeping their instruments in top shape.

With the advent of printed circuit boards and solid state devices in instruments comes the question, "Is it still necessary to wash instruments and, if so, what precautions do I need to observe?" While it is true that solid state instruments do not usually get dirty as quickly as their vacuum tube counterparts, they too, can benefit from a periodic cleaning. We find they are easy to wash and no particular precautions, other than those applying to vacuum tube type instruments, need be observed.

Equipment Needed

Chuck Phillips is pictured at right washing a 7000-Series instrument in the wash booth of our factory service center. The booth includes an exhaust system to remove the dust and mist generated during cleaning and is typical of the wash booths used in our other centers.

There are several items you will need to do an effective job. They are as follows:

(a) Liquid silver cleaner used to remove tarnish from connectors.
(b) Brushes used to clean knobs and connectors.
(c) Paint brush used for dry method of cleaning, etc.
(d) Sponge for applying cleaner to remove marks on aluminum.
(e) Non-sterile cotton-tip applicators used for miscellaneous cleaning chores.
(f) Piece of plastic light filter or graticule used to remove labels and adhesive after soaking them with solvent.
(g) No-noise applied sparingly to pots and switches as needed.
(h) Kimwipes or equivalent for wiping off front panel, etc.
(i) WD-40 used for several applications.
(j) Spray paint used to touch up cabinets and side panels.
(k) Flux remover or any solvent that will soften adhesive used with calibration stickers and other labels.
(l) Ajax cleaner or equivalent used for removing marks on aluminum chassis, etc.
(m) Screwdriver for removing slotted screws.
(n) Screwdriver for removing Phillips screws.

The other items needed in the wash area are:

A source of compressed air with aproximately ten feet of hose.

A spray gun with eight feet of hose (Devilbiss Type GDV Series 510 or equivalent).

A rubber siphon hose three to four feet in length.

Hot and cold water.

Detergent (Kelite or equivalent, mixed approximately 1 part detergent to 20 parts water).

The drying oven is pictured at right. There are a number of commercially available ovens suitable for this purpose. The primary considerations in selecting one are size and the capability of providing circulating air at a temperature of 125°F to 150°F.

Steps Prior to Washing

Some early TEKTRONIX instruments used water soluble ink for chassis markings. The chassis have a shiny appearance as compared to those with permanent markings. If you suspect you are washing such an instrument use very little detergent and cold water.

Paper covers on electrolytic capacitor should be replaced with plastic covers or sprayed with a water repellent such as WD-40.

Leather handles should be sprayed with WD-40 or other type water repellent to prevent cracking.

Capacitors leaking oil should be tagged for replacement.

Labels and adhesive should be removed unless specified otherwise.

We no longer consider it necessary to remove the CRT, shields, vacuum tubes, etc. to do a thorough cleaning job. Experience has shown that warm water and detergent under pressure penetrates these areas adequately without completely exposing them.

The cabinet sides and bottom are removed and washed separately. They can be put back on the instrument before placing the instrument in the oven for drying, if desired. The 7000-Series plug-ins are washed with the side panels in place. This saves time and prevents a mix-up in panels.

Washing Procedure

After preparation, place the instrument in the wash booth and spray lightly with detergent and warm water. (Do not spray detergent directly on power transformers or paper items.)

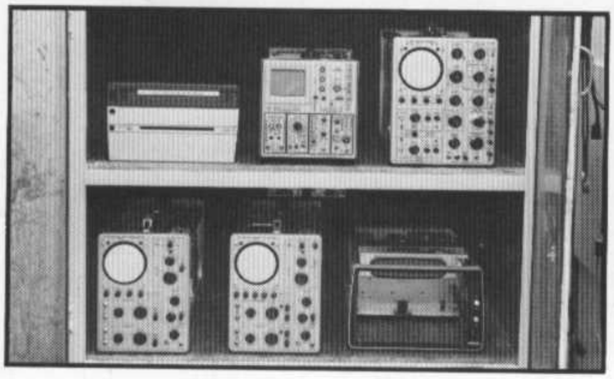
Clean connectors and knobs using appropriate brushes.

Rinse thoroughly with warm water.

Remove excess water from the instrument (especially the front panel) with air.

Place the instrument (with washed plug-ins installed) in the oven and dry for at least 24 hours.

The graticule and light filter are cleaned at the work bench using a glass or plastic cleaner.



After Washing and Drying

It is well to take a few minutes to apply lubricant to the switches, motors, etc., particularly on the older instruments. A lubrication kit designed specifically for this purpose is available under Tektronix Part No. 003-0342-01.

Switches—Lube detents with a light grease and contacts with No-noise.

Motors—Apply 1-2 drops of thin oil. (WD-40 is suitable).

Potentiometers—Apply 1-2 drops of No-noise to the shaft, contacts and open spots around the cover. Use a hypo and needle, or spray can with nozzle. Cover removal is neither necessary nor desirable.

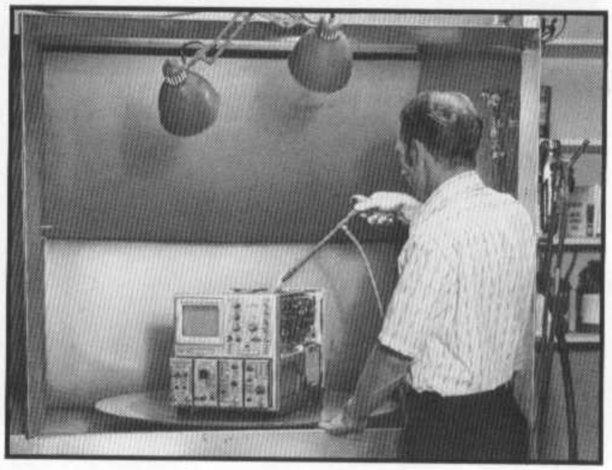
The appearance of the instrument can be enhanced by applying WD-40 or furniture polish to the front panel. The polish should be sprayed on an absorbent towel, not directly on the instrument panel. A small amount sprayed on the one-inch paint brush is handy to get around the knobs.

Summary

You will find that the time spent in properly cleaning an instrument will result in fewer calibration problems, a longer period between calibrations and greater operator satisfaction with both the instrument and the service center.

About our author

Charles Phillips—Chuck has just completed 10 years with TEK. His career at TEK has been devoted entirely to service center activities. After serving six years in field service centers he transferred to Factory Service where he has contributed much to improving servicing techniques and solving new instrument problems. Chuck's "off-work" hours are filled with Laymen for Christ activities, managing his own TV sales and service business, and his family.



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