A COLOR WRITE-THRU DVST

By

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ABSTRACT

A phosphor-Storage Direct-View Storage Tube (DVST) has been developed which enhances the viewability of the display. The enhancement, called Color Write-Thru, presents refreshed information in a different color from the stored data.

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DVST OPERATION

A DVST operates on well known principles that are reviewed here briefly.[1] Figure 1 shows a simplified DVST structure. A DVST consists of a writing gun that operates at a negative potential with respect to the target. The phosphor target resides over a transparent electrical conductor. A dot array of conductive collectors is arranged in a uniform fashion across the surface of the conductor. Near the back of the funnel wall of the CRT is an array of flood guns in which the cathode is grounded and the anode is at a positive potential.

When the DVST is in normal use for displaying stored information, the writing gun is used to scan the target. As the writing gun beam scans the target, a charge is left on the phosphor dielectric.

Because the charge image areas are at a positive potential relative to the flood gun cathode, the flood electrons strike the target in the written areas and cause the phosphor to luminesce. All other areas that were not written are maintained at an average potential much lower than the written areas. The areas written up are called fully-written (FW), and the unwritten areas are known as ready-to-write (RTW). Figure 1 shows a magnified view of the target structure.

To erase the target and prepare it for new information, a pulse is applied to the STB which capacitively couples to the phosphor. This pulse coupled with the flood gun electrons uniformly fully writes the phosphor and eliminates the ability to resolve between former RTW and FW areas. The balance of the erase pulse (see Figure 2) restores the entire target to a RTW state.

This simple description shows how a DVST is used for displaying data in the stored mode. Once the target is stored, no further refreshing or rewriting of the information is necessary.

WRITE-THRU, HOW IT WORKS

Because of its basic nature, the DVST must be erased every time a new page of information is to be displayed. Although the erasure time is not long (about 1 to 1.5 seconds), if the information is to be changed only slightly, rewriting a complete page of data can take several seconds depending on the baud rate of the system.

The need for interactivity and faster response for DVST's was recognized, and a technique called write-thru was devised.[2] Write-thru displays information on the phosphor target at a current density lower than that required to charge or write the phosphor target. If the repetition rate is adjusted properly along with beam current, the refreshed image will luminesce but not store.[3] This feature is already available in many DVST displays.[4] Options allow the displays to refresh a number of vectors (about 1000) at an average vector length of 1 cm. One drawback to this technique is that the refreshed information appears at approximately the same brightness as the stored information and also the same color. As a result, write-thru can sometimes confuse the observer if the refreshed information overlaps the stored information, as in the case of multilayer circuit board design or facilities design

COLOR WRITE-THRU OPERATION

One way to overcome this problem is to present the refreshed data in a different color. The display is then much more viewable, and information is more discernible. The color write-thru DVST described here utilizes a color of greenish-yellow as denoted on the 1976 CIE-UCS chromaticity diagram (see Figure 3, point A).

Obtaining the greenish-yellow color was fairly straightforward. A simple mixture of red phosphor with the green produced a write-thru color as denoted above. The color obtained is dependent on the proportions of each phosphor. As shown in Figure 3, the line represents this operating area from the green to the red phosphor. The two reds used most frequently are yttrium oxysulfide and yttrium oxide, which have excellent high voltage efficiency characteristics.

COLOR WRITE-THRU OPERATION (continued)

Determining how much red phosphor to add was the subject of another separate study. Color shift is defined as the linear distance, the write-thru information is shifted from the stored information along the line shown in Figure 3. The minimum discernible color shift for high viewer comprehension level required that the red phosphor be 40% to 60% of the target by volume. This phosphor mixture reduced green stored luminance to about 4 foot lamberts. Because of this decrease in performance, a new tube envelope and flood gun design was used which helped to increase the flood gun current density to the target and thereby increased stored luminance. In addition to the use of a new funnel, the phosphor materials were processed in such a way as to increase the nominal operating point used, resulting in additional luminance output. Similar concepts were used in the design of a 25" DVST reported at SID in 1978.[5]

Another by-product of phosphor processing also enhances viewability. Normally, a mixture of phosphor used as a storage target would also present the stored information in the resultant mixed color. However, the processing forms a dead layer on the surface of the red phosphor which does not luminesce until about 400 volts. Because the operating point of the target is usually less than 300 volts, there is a 100 volt margin before the red phosphor begins to luminesce. This shallow dead layer minimizes the loss in luminance when the writing gun strikes the phosphor, and maximum write-thru brightness is achieved with the greatest overall color shift.

These improvements resulted in a new DVST that retains and improves upon the viewability of previous DVST's. Stored luminance was increased by 60% as a result of the greater flood gun current density and operating point. The predominant feature is the improvement in write-thru viewability by using the addition of a red phosphor.

ADDITIONAL FEATURES

"OVER-WRITE"

A feature that was not available in the older single-color display is called "over-write" rather than write-thru. By design, the actual color shift obtained

ADDITIONAL FEATURES (continued)

ØVER-WRITE (cont'd)

with the mix of red and green phosphor is about twice that required for a discernible color shift.[6] If some data is stored, and then the same image is refreshed on top of the stored data, another viewable color is seen halfway between green and normal write-thru. This color is shown as point B on Figure 4. Therefore, the feature is called over-write With this feature, one can obtain two levels of color shift that are discernible from each other. This feature can easily be used to highlight information, whether graphic or alphanumeric.

With proper software, the color write-thru and over-write features expand the usefulness of the DVST display. While still retaining its inherent low cost, high resolution, and flicker-free performance, the display can be much more interactive with the added dynamics capability.

Life

New improved phosphor materials were used in the development of this DVST. One of these phosphors has been reported on in a previous paper.[7] The resultant mixture of this phosphor (called MP-1 for modified P-1) and the red phosphors improved usable life of the display by greater than 50% over the present monochrome DVST.

It has been shown by our research that the life of a given phosphor target is directly related to the total charge delivered to that phosphor. This is further related to flood gun current density. In the color write-thru DVST the flood gun current density is twice that of the monochrome version. This increase in life then represents a three-fold improvement in materials life when normalized to current density

Hard Copy

As previously mentioned, a new funnel and flood gun design were developed for the color write-thru DVST. Extensive experimental data was gathered concerning the relationship between flood gun electron optics and hard copy performance. As a result of these characterization studies, the flood gun system design was optimized to significantly improve the hard copy ability of the device. A quantitative measure of this improvement has shown hard copy range to have increased by a factor of two over the previous display.

SUMMARY

This paper describes a display which embodies several new features that are improvements over the previous 19" DVST. These features are:

1.) Improved viewability in the write-thru mode by refreshing information in a color different than stored information.

2.) An over-write feature, as well as write-thru, which yields three separate viewable colors available on the DVST.

3.) Increase in stored luminance by 60%.

4.) Improved life by the use of newer, more advanced phosphor materials.

5.) Improved hard copy performance.

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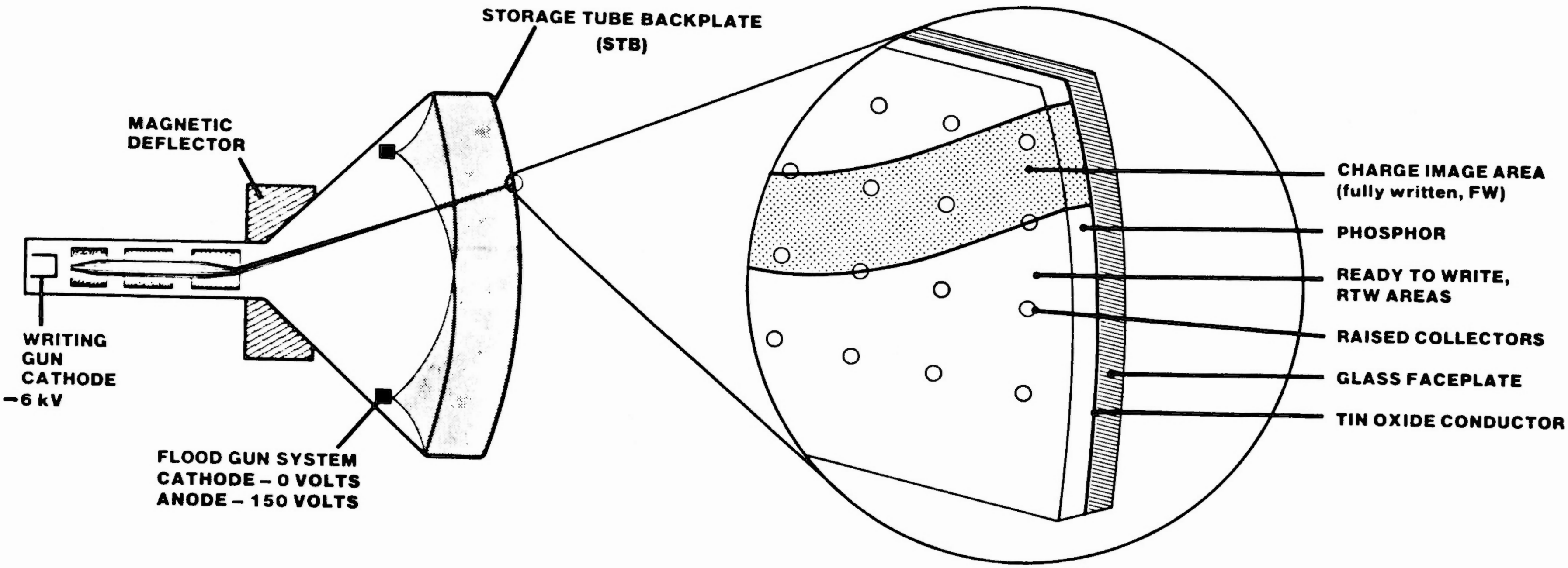


FIGURE 1 - Operation of the direct view storage tube. Flood electrons continuously bombard the phosphor. In the absence of writing-gun electrons, flood electrons maintain the phosphor at the flood-gun cathode potential of 0 volts. When writing-gun electrons strike the phosphor, the phosphor is charged past a threshold to maintain a stored charge image.

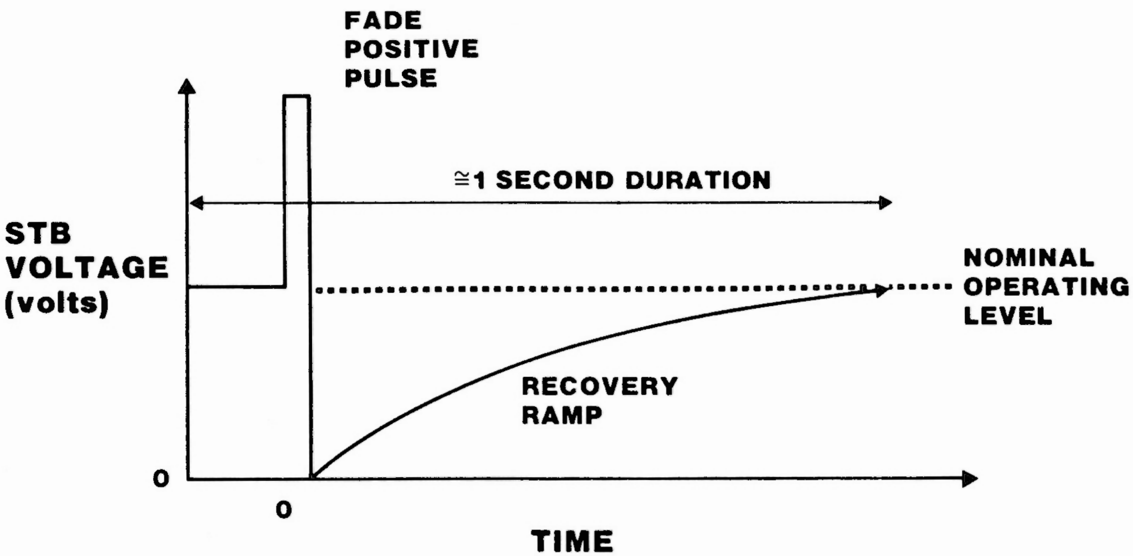
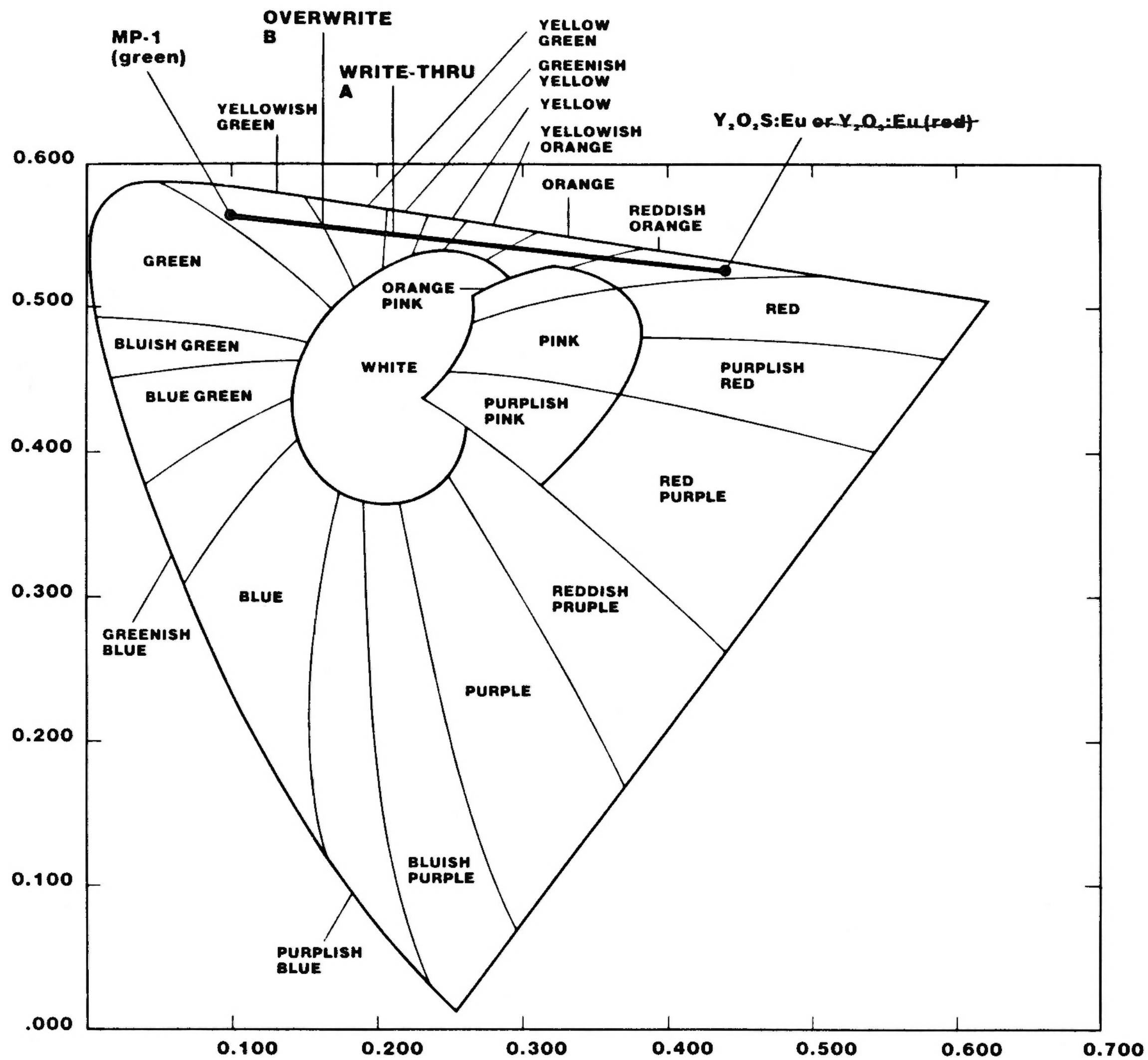


FIGURE 2 - Erase Waveform   The target is fully written by the fade positive pulse and then returned to ground. The target is then slowly ramped back to it's operating level. Action of the flood gun electrons holds the target in a ready to write state.



1976 CIE-UCS CHROMATICITY DIAGRAM

COLOR BOUNDARIES TRANSLATED FROM 1931 CIE CHROMATICITY DIAGRAM

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FIGURE 3