The Optimal Condition for Velocity Modulation

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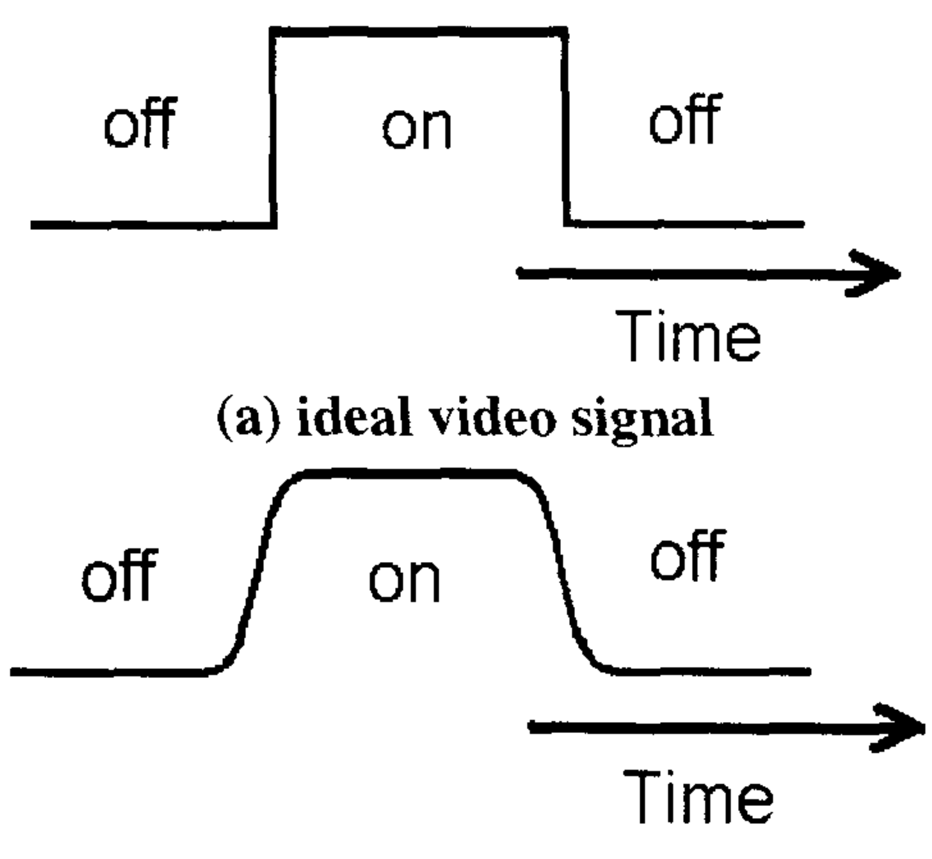
Abstract

The effect of the scan velocity modulation is studied. The effect of the velocity modulation on the picture image is judged from the intensity profile of the image. The intensity profile is obtained as time integral of moving Gaussian beam. To confirm the applicability of this integral formula, the measurement and simulation data is compared. And by calculating the intensity profile for different amounts of velocity modulation, the optimum modulation displacement that gives the best image quality is obtained. This optimum modulation displacement can be used in designing scan velocity modulation system.

1. Introduction

The scan velocity modulation is a widely used technology to improve image sharpness of large CPT. The non-zero rise time of the video signal as shown in figure 1 results in the degradation of picture image sharpness. To compensate the degradation of the sharpness of picture image, the scan velocity is modulated at the on and off edge.

Recently a few studies have been made on velocity modulation. Most of them were electromagnetic field analysis and focused on increasing modulation to current efficiency [1], [2], [3], [4]. No quantitative study has been made on the visual effect of the resulting image sharpness.



(a) ideal video signal

(b) real video signal

Figure 1: Degradation of video signal

In this paper, we will show a method to find optimal condition for velocity modulation in the light of image sharpness. We will introduce a simple integral formula to obtain the spatial profile of the picture image. And with that, we will obtain the optimal modulation displacement.

2. Model

Human eyes sense a light that lasts shorter than 10 to 100ms as the time integral over that period - if the time resolution of the human eyes is higher than that, we will see a moving electron beam instead of full screen images. To put the fact in a formula, the profile of the picture image on screen

$$f(x) = \int g(x,t)dt, \qquad (1)$$

where $g(x,t)$ is the instantaneous intensity profile of the rapidly changing light at time t generally. In case of a cathode ray tube, $g(x,t)$ is the free spot's intensity profile. We will call the instantaneous beam spot on the screen by a moving electron beam "a free spot". We handle it one-dimensionally, because we are interested in the change of the picture image sharpness, which occurs only in horizontal direction.

Let's assume that the free spot has Gaussian profile and we get the intensity profile of the free spot moving in x direction

$$g(x,t) = A(t)\exp\left[-\frac{12(x-p(t))^2}{d^2(t)}\right], \qquad (2)$$

where $A(t)$ is the peak intensity of the free spot, $p(t)$ is the center position, and $d(t)$ is the 5% width of the free spot. The center position can be written as

$$p(t) = p_0(t) + p_m(t), \qquad (3)$$

where $p_0(t) = v_0 t$ is the position of the free spot moving at a fixed scan velocity v_0 without modulation. And $p_m(t)$ is the displacement from the original position caused by velocity modulation. Moreover, the modulation displacement $p_m(t)$ can be written

$$p_m(t) = C_m S_m(t), \tag{4}$$

because it is substantially proportional to the VM current.

And the peak intensity of the free spot A(t) is dependent on the video signal. To simplify the model, we assume the proportionality.

$$A(t) = C_b S_b(t), \tag{5}$$

3. Experiments

With the proposed model, the intensity profile of scan image can be obtained for any type of brightness signal and any type of modulation current.

In this paper, we defined optimal condition of image sharpness as the condition that gives the minimal line width when the video signal of crosshatch pattern is applied.

We applied this model for a 29-inch color picture tube.

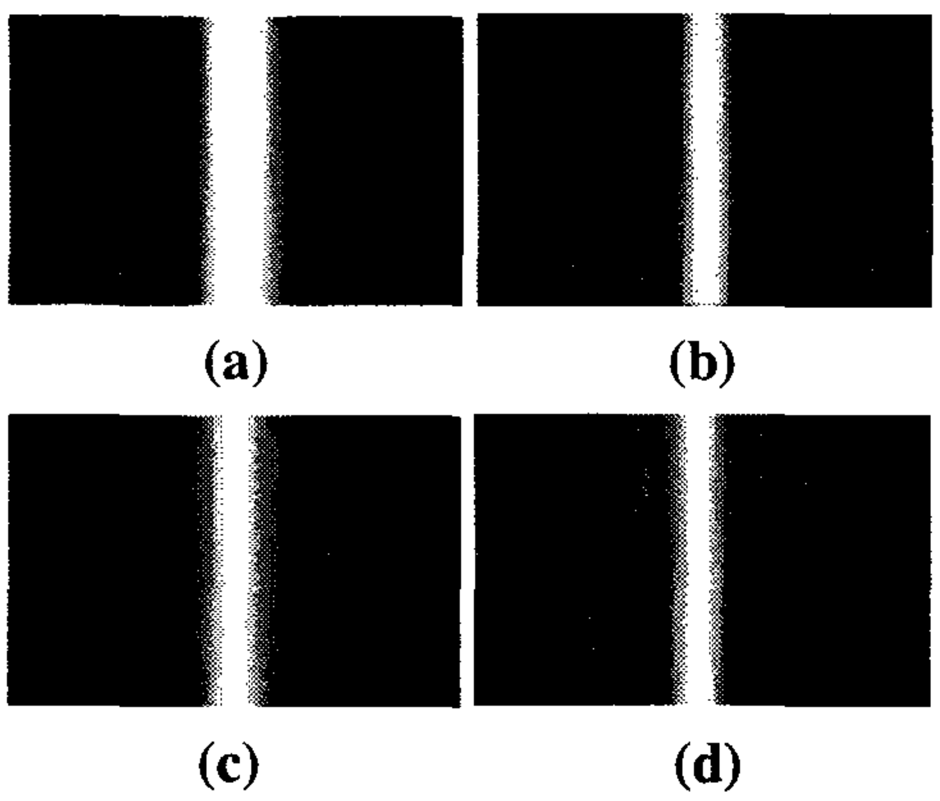


Figure 2: The horizontal profile change of a vertical line with a different modulation displacement ((a)none, (b)1.77㎜, (c)3.09㎜, (d)4.41㎜)

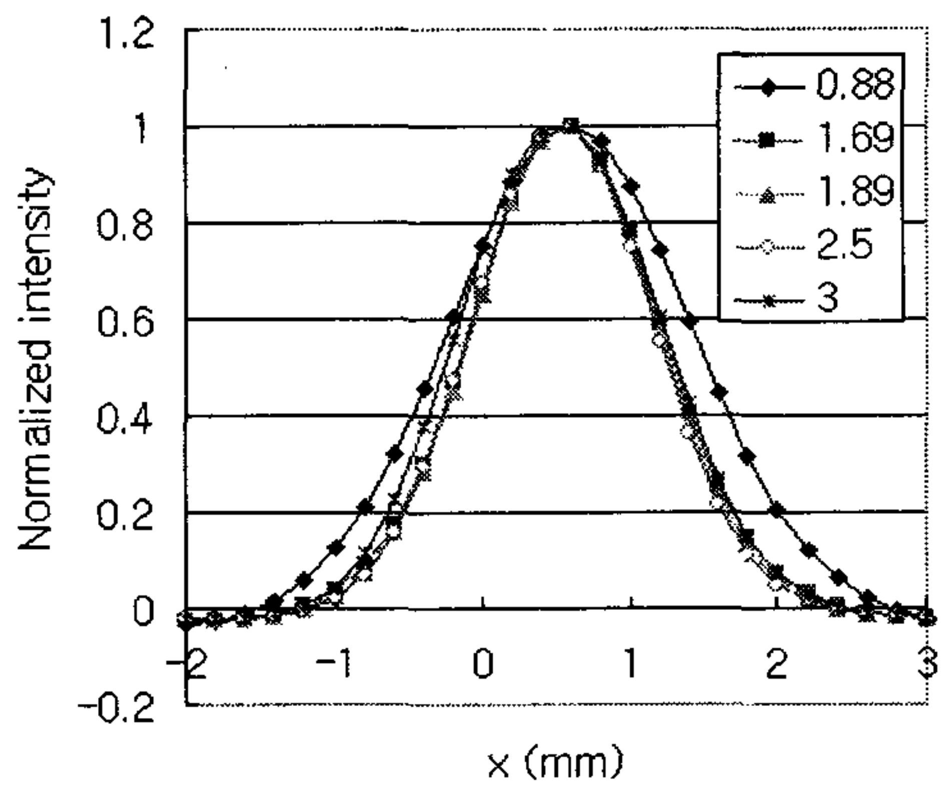


Figure 3: The intensity profile of the screen image for different maximum modulation displacements, 29"CPT 4Turn Coil (0.88mm, 1.69mm, 1.89mm, 2.5mm, and 3.0mm)

3.1 Preliminaries

For virtual modulation displacement and peak intensity, the intensity profile of the scanned image was obtained as in figure 2. We assured that optimal displacement, at which the vertical line width at the screen is minimum, exists.

3.2 Real case

Then we tried to find the optimal modulation displacement in real case. The measured video signal and VM signal is used for Equation (4) and (5). For amplitude of VM modulation displacement, we obtained the profile of the screen image.

3.3 Verification

Also we compared the calculation with the measurement to verify the applicability of the formula. We recorded video signal and VM current while measuring the line width. For different current levels, the measurement and calculation is compared.

4. Results and discussion

Table 1 shows the verification result. The difference

Table 1: Measurement and simulation data

Modulation Displacement (mm)	Pixel Width (mm)	
	Simulation	Measurement
0	4.53	4.53
0.88	3.70	3.72
1.69	3.05	3.09
1.89	2.95	3.01

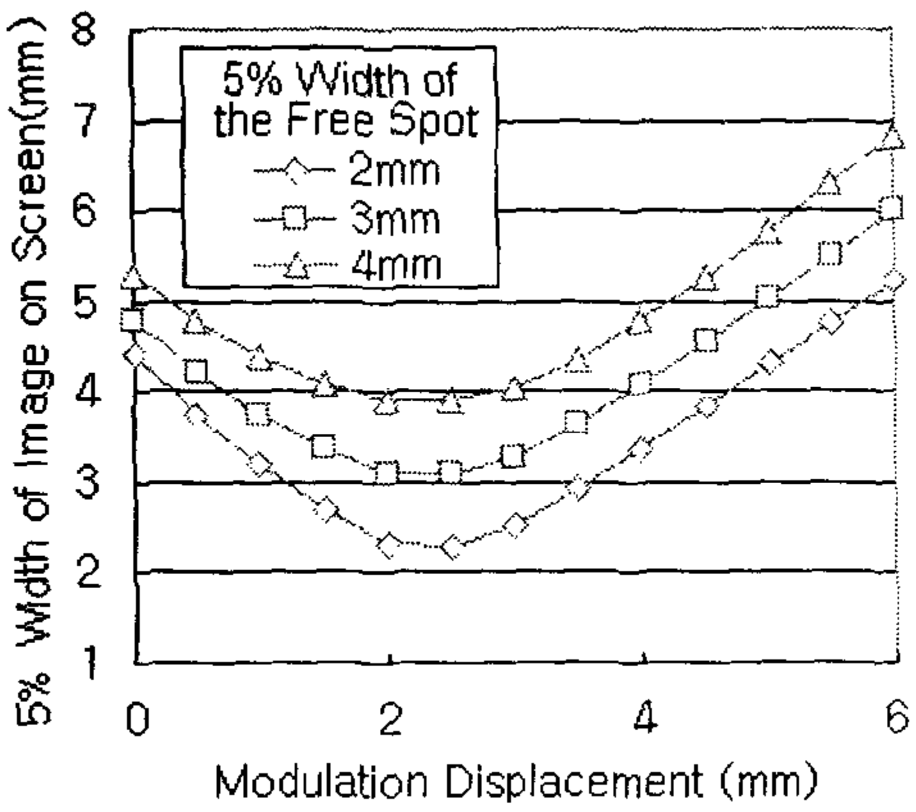


Figure 4: The relation between modulation displacement and the 5% -width of Image on Screen (29" CPT)

between measurement and calculation result was under 3%. The calculated intensity profile is shown in figure 3.

We obtained a graph to see the modulation displacement to 5% width of the image on screen relation for different free spot widths. And we could find out that optimal modulation displacement is about 2.5mm and it doesn't depend on the free spot size.

5. Conclusion

We introduced a simple integral formula to show the effect of velocity modulation on image sharpness quantitatively. And by comparing the calculated result with measurement for 29-inch color picture tube, we verified the applicability. We also obtained the optimal modulation displacement of about 2.5mm. The optimal modulation displacement can be used as a reference in design of velocity modulation system.

6. References

[1] M. J. Dekker, IEEE Transactions on Magnetics 33, 2 (1997).

[2] M. Konda, Y. Taguchi, T. Ishikawa, and K. Shimada, IDW'02, 587 (2002).

[3] K. Hirai, S. Shirai, K. Brown, H. Heiser, and T. Asano, IDW'02, 579 (2002).

[4] C. S. Koh, Kwang-sig Jung and Song-yop Hahn, IEEE Transactions on Magnetics 36, 1800 (2000)