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The Analysis of the Video Signal from TV Scanistor Using Spatial-Structural Parameters

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The issues of the dimensions and coordinates measurement of the light zones on the TV scanistor have been considered. For this purpose we propose to use spatial-structural parameters of the trapezoidal video signal from the scanistor. It is shown that using spatial-structural parameters makes it possible to increase accuracy of the narrow light zones measurement on the scanistor's photosensitive surface.

Keywords: TV scanistor, information-measuring system, video signal, light zone, accuracy, spatial-structural parameters.

INTRODUCTION

The most reasonable way to measure linear and angular movements of the objects in real-time scale is to use the information-measuring system (IMS) based on the TV scanistor structures (continuous scanistor, discrete multiscan) in time-pulse mode which have high sensitivity and coordinate resolution, small dimensions, high reliability and long service life, relatively low cost. Also it make it possible to measure many non-electrical quantities characterizing the production processes and different phenomena in physics, chemistry (dimensions, coordinates, motions, torque, forces, pressures, concentrations, densities, expenses, temperatures etc.) without mechanical contact with the object [1–5]. Therefore, the problem of increasing accuracy of the scanistor IMS is urgent.

INFORMATION-MEASURING SYSTEM FOR MEASURING OF DIMENSIONS AND MOTIONS OF THE LIGHT ZONES ON THE SCANISTOR

In the scanistor IMS the registration of the light relief (in the form of controlled light zones along a photosensitive surface) is carried out continuously by increasing the amplitude

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of the unfolding sawtooth voltage and the corresponding linear movement of the equipotential zero potential line along the scanistor. To extract a video signal (VS) from the continuous scanistor the most rational way is to use interrogation circuit using sawtooth-voltage generator (SAW) and peak detector (PD) where the bias voltage of the scanistor (SC) bleeder bar is found by rectifying interrogation sawtooth-voltage (Figure 1).

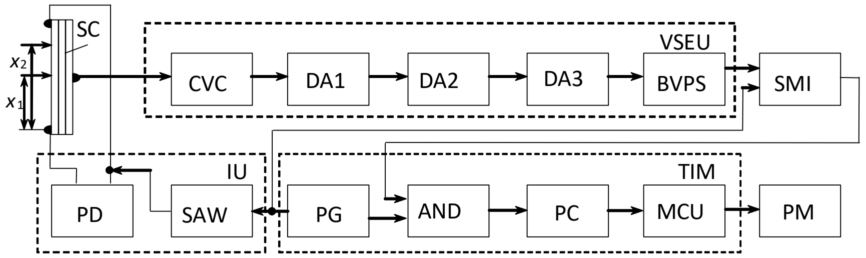

Figure 1. Block diagram of scanistor IMS for measuring dimensions and movements of light zones of the scanistor: IU – interrogation unit TS; VSEU – video signal extraction unit

The automatic ensuring of the equality of the bias voltage and amplitude of the sawtooth-voltage leads to improving stability of the scanistor coordinate characteristic. The collector of the scanistor SC across the current-voltage converter (CVC) is connected to the differentiating divider (DA1), at the output of which a video signal $V(t)$ is generated. Further the signal from the output of DA1 is put across the differentiating amplifiers DA2, DA3 to the block BVPS of the video-pulses shaper, which shapes pulses by beginning, end and maximum of the video signal for the SMI shaper of measuring time intervals. The duration of the formed intervals is measured by TIM, which includes pulse generator (PG), AND circuit, pulse counter (PC), microprocessor control unit (MCU). Herewith the duration of the formed information intervals is proportional to the light zone (LZ) and distance of its middle from beginning of the scanistor SC.

It can be shown that in a sequential interrogation of the elementary photodiode cells of the scanistor SC the video signal is formed, which can be described by the dependence [1]:

$$V(t)=\frac{L\cdot b\cdot l}{T}\cdot 2j_s\left[\frac{1}{\exp\alpha\left(E_e-E_k\right)+1}\right]_0^L+\frac{L\cdot b\cdot l}{T}\cdot 2j_{feb}\left(1+K_{н}\right)\cdot\left[\frac{1}{\exp\alpha\left(E_e-E_k\right)+1}\right]_{x_1}^{x_2}, \quad (1)$$

where L – coefficient depending on differentiation method; b, l – width and length of the scanistor, respectively; $\alpha=\left(A\frac{KT^\circ}{q}\right)^{-1}$; K – Boltzmann's constant; q – electronic charge; A – coefficient reflecting the degree of imperfection $p-n$ junction of the scanistor structure; T° – temperature in Kelvin degrees; $E_e=E_0\cdot\frac{x_0}{l}$ – emitter potential at the interrogation point x_0; E_0 – emitter constant bias voltage; $E_c=E_0\cdot\frac{t_0}{T}$ – value of the sawtooth voltage at the moment of interrogation t_0; T – sawtooth-voltage time; j_s, K_s – dark saturation current and unbalance factor of the current-voltage characteristic of the photodiode cell, respectively; j_{feb} – increment of the saturation current of the photodiode cell under illumination; x_1, x_2 – coordinates of the beginning and the end on the scanistor of the light zone.

THE RESULTS OF THE MODELING AND THEIR DISCUSSIONS

In Figure 2 there are dependences of the light components of the video signal *V*(*t*), calculated by formula (1), on its first and second derivatives for LZ with different width and equal illumination.

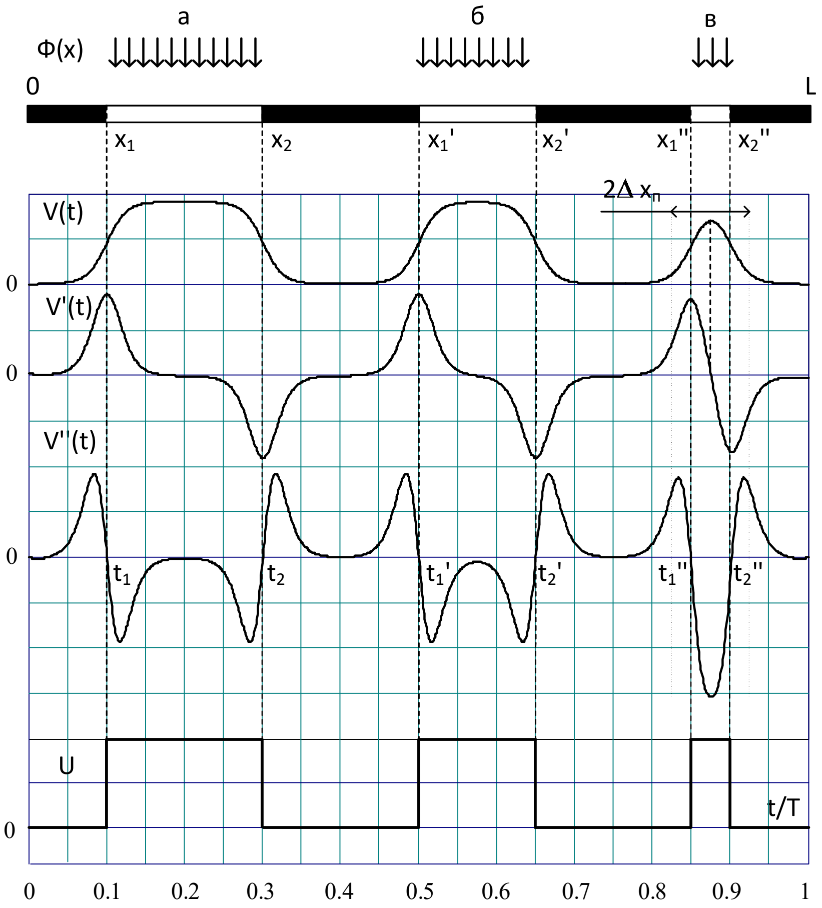

Figure 2. Shapes of the video signal curves and its first and second derivatives for the light zones with different width

The analysis of these dependences has revealed the following aspects:

– At the constant width of the LZ of the amplitude VS from the scanistor and first and second derivatives are directly proportional to the illumination.

– When expanding from the minimum LZ the amplitudes of the VS and its first and second derivatives first increase nonlinearly, and then become constant and independent of the width of the LZ (if the width $x_2 - x_1$ LZ exceeds the doubled value of the switching zone of the scanistor structure $2 \cdot \Delta x_\Pi$).

– Time coordinate of the midpoint of the LZ ($x_2 - x_1 < 2 \cdot \Delta x_\Pi$) is uniquely determined by the moment of the first derivative of the BC passing through zero.

– Time coordinate of the middle of the wide LZ ($x_2 - x_1 < 2 \cdot \Delta x_\Pi$) can be determined by the half-sum of moments of time $t_c = (t_1 + t_2 / 2)$ of the second derivative of the VS passing through zero.

It should be noted that coordinates and dimensions determination of the digital picture is an urgent and complicated task [6, 7], especially in case of small-dimensions objects [8] on conditions of the image blur [9]. Herewith, to extract and manipulate the video signal from the scanistor it is effectual to use schematic diagram shown in Figure 3.

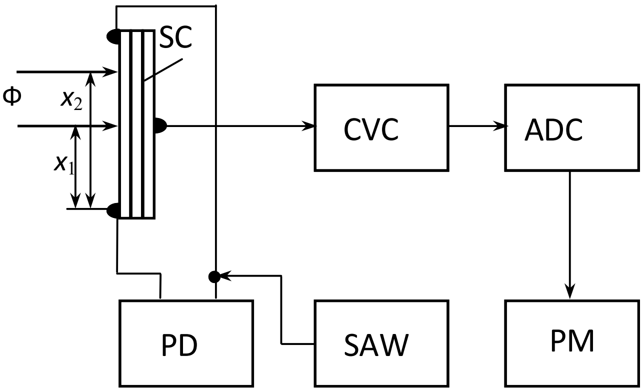

Figure 3. Schematic diagram of the scanistor IMS for measuring dimensions and movements of the light zones

In this paper, we propose to use spatial-structural parameters (SSP) to solve the problems of determining the dimensions and coordinates of the trapezoidal video signal (TS) from the scanistor (Figure 2b). It is shown in the works [10, 13] that the SSP make it possible to estimate the width of the signal (TS), localize it in space and also determine the amplitude. SSP is calculated from the one-dimensional function of the trapezoidal video signal.

In the work [8] five SSP video signals are estimated: mass (*M*), centroid (*C*), dissipation (*D*), extent (*E*) and luminance (*Y*). SSP is found using one-dimensional moments W_0, W_1, W_2 from the following formulas:

$$M = W_0, \tag{2}$$

$$C = W_1/M, \tag{3}$$

$$D = (W_2/M) - C^2, \tag{4}$$

$$E = 2\sqrt{3D}, \tag{5}$$

$$Y = M/E. \tag{6}$$

The physical meaning of the SSP, applying to the video signal, is as follows [11]:

– *«mass»* describes total mass of the video signal;

– *«centroid»* is a coordinate of its centre of gravity;

– *«dissipation»* describes the degree of localization of the mass of the video signal around its centre of gravity;

– *«extent»* is numerically equal to the width of the video signal;

– *«luminance»* describes the amplitude of the video signal.

The work [14] shows that short pulse duration TS is calculated with a smaller margin of error by the SSP than by the derivatives.

In Table 1 there are results of the measurements of the width of three LZ by the video signals shown in Figure 2b. The measurements were taken by two methods. Firstly, by the second derivative signal passing through zero. Secondly, the width of the LZ was estimated by the SSP, i.e. by the value of the extent of the corresponding video signal. From the Table 1 it is clear that for LZ 0.2 width and 0.15 both of the methods give a high accuracy in measuring the width values. However, for the narrow LZ the value, obtained from the zero-passing of the 2nd derivative signal, has a significantly overestimated value. Nevertheless, SSP allow obtaining a rather high accuracy when estimating the width of the narrow LZ.

Table 1. The results of the measurements of the LZ width

LZ Width	**Measured LZ width**	
	By 2nd derivative	**By SSP**
0.2	0.200	0.2
0.15	0.150	0.15
0.05	0.065	0.05

CONCLUSIONS

This paper considers possibility of using spatial-structural parameters of the unidimensional trapezoidal signal of the small-dimension structural elements of the digital pictures to estimate the parameters of the video signal from the scanistor. The analysis in Table 1 shows that using SSP makes it possible to increase the accuracy of measuring the dimensions of the narrow LZ on the scanistor's photosensitive surface.

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