COMPUTATIONAL PROBLEMS OF ELECTRICAL ENGINEERING

Vol. 4, No. 2, 2014

INTERACTIVE OPERATION OF A SCANNING TELEVISION OPTICAL MICROSCOPE

Volodymyr Shkliarskyi, Yuriy Balaniuk, Volodymyr Vasyliuk, Borys Hudz

Lviv Polytechnic National University, Lviv, Ukraine

shkliarskyi@polynet.lviv.ua

Abstract: The ways of increasing an operation speed of the formation of an illuminating raster in a scanning television optical microscope are analyzed. The raster is formed by a digital-to-analog method using a precise voltage-to-current converter. Vast functioning possibilities of the microscope provided by forming the raster of changeable size and changeable resolution as well as by moving the scanning raster of a reduced size to an arbitrary point on the cathode ray tube screen require that the time of deflection of the illuminating scanning beam to a point with specified coordinates and required accuracy be controlled. We propose a hardware solution for increasing the operation speed, which will significantly reduce the time of forming the scanning raster in discrete mode.

To ensure the high accuracy of conversion of the input voltage into the current of an electronic beam deflector coil, a voltage-to-current converter is realized in the form of dc amplifier with strong negative current feedback. A negative feedback signal is formed on a precision resistor connected in series with an inductive load, that is, the coil of an electronic beam deflector. The accuracy of the iput-voltage-to-load-current transformation is determined by the amplification factor without the negative feedback operation. As a rule, the amplification factor exceeds 1000, and the transformation factor of the voltage-to-current converter is close to unity.

Depending on the amplitude of the input signal, the amplifier stages of the voltage-to-current converter can operate either in a linear mode or in a saturation mode. The latter appears due to the break in the feedback loop caused by the large difference between the input signal amplitude and negative feedback signal amplitude. There are given analytical expressions for determining the settling time of the inductive load current with prescribed accuracy. An interactive mode of the scanning television optical microscope operation is proposed. The essence of the STOM interactive operation mode is that the instant when the code of the next coordinates of the illuminating raster element is delivered to the system is determined by the current settling time (obtained with the prescribed accuracy) and the duration of an illumination pulse.

Two block diagrams have been proposed which, in the interactive operation mode, generate normalized pulses, whose duration is equal to the duratin of transient for the inductive load current settling. A block diagram of the scanning television optical microscope that takes into account the duration of the transient that corresponds to the settling time of the illuminating scanning beam in different STOM operation modes has been developed.

Key words: scanning microscope, cathode ray tube, voltage-to-current converter, operation speed, scanning raster formation accuracy.

1. Introduction

The method of the formation of an illuminating raster in the scanning television optical microscope (STOM) developed by authors enables the increase in raster formation speed. As a light source for illumination of a test object in such a microscope a cathode ray tube (CRT) of high resolution is used [1]. Very short time of afterglow of such CRT allows us to use a flying spot mode. The advantage of such a microscope in comparison with a video television microscope consists in its ability to form a microobject (MO) image that consists of 5000 decomposition elements over each coordinate. Reducing the size of the illuminating raster up to its 10th allows us to create a scaled-up image of a selected image fragment without losing the resolution. In comparison with an electronic microscope, the STOM provides an opportunity to carry out real-time investigations of living MOs. The advantage of the STOM in comparison with a laser microscope consists in much smaller energy of illumination which eliminates the influence of an illumination source on living MOs. Moving of the illuminating scanning raster of a reduced size provides imaging the selected fragment of a tested MO on the monitor screen of a personal computer.

This paper considers the ways for development of an interactive operation mode of the STOM, which takes into account the time of deflection of the scanning beam to a point on the CRT screen with specified coordinates and required accuracy. The essence of the interactive mode is that the next coordinates for the illuminating raster element is generated by a control device as soon as the point with previous coordinates has been hit and illuminated by the scanning beam. Analytical expressions for determining the settling time of an inductive load current that corresponds to the time of displacenment of the scanning beam to a point with specified coordinates are given. Block diagrams of the interactive mode for the STOM and block diagrams of some of its components are presented.

2. Voltage-to-Current Converter

To ensure the high accuracy of conversion of the input voltage into the current of an electronic beam deflector coil, a voltage-to-current converter (VCC) is realized in the form of dc amplifier with strong negative current feedback. A negative feedback signal is formed on a precision resistor connected in series with an inductive load, that is, the coil of an electronic beam deflector. VCC operation speed means the time that elapses from the application of a step input excitation to the time at which the load current enters and remains within a specified error band [2, 3]. A sweep input signal of the scanning beam is formed by a digit-to-analog converter, so we assume that the signal proceeds in discrete steps. The instantaneous value of the signal amplitude corresponds to the deflection of the scanning beam to the next point on the CRT screen. The following assumptions have been made during the analysis of the operation speed: 1) the amplifier is represented by an inertial branch with the transfer function $K/(1+pt_A)$; the amplifier consists of the input stage, intermediate stage, and output stage; 2) the intrinsic capacitance of the inductive load is negligible; 3) the intrinsic resistance of the inductive load is taken into account together with the resistance of the resistor $R3$ that shapes the negative feedback signal; 4) the power supply voltage of the VCC output stage is higher than the inductive load voltage that settles in the issue of the transient. The VCC circuit diagram used for the calculation of settling time of the inductive load current is shown in Fig. 1 and its functional diagram is shown in Fig. 2.

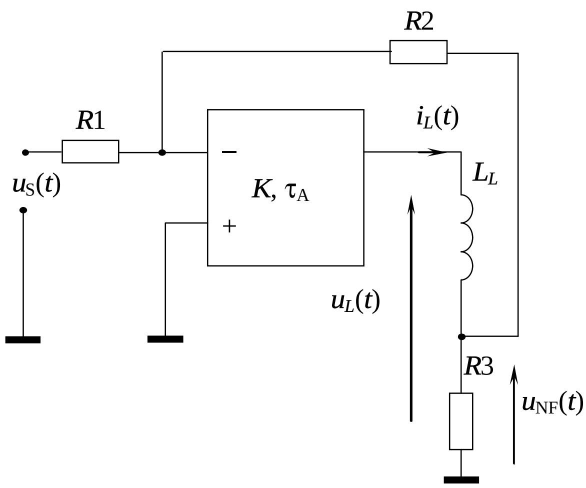


Fig. 1. VCC circuit diagram for settling time calculation.

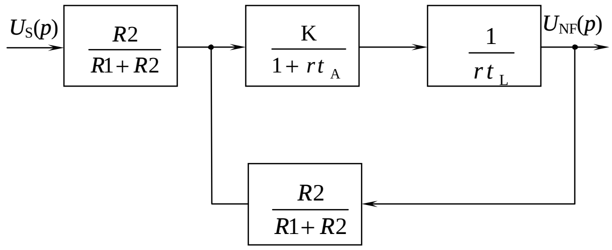


Fig. 2. VCC functional diagram for settling time calculation.

The transfer function of this amplifier can be given by the following formula [1]:

$$W(p)=\frac{nK}{K+(1+n)\cdot(1+pt_A)\cdot(1+pt_L)},$$

where $n=R2/R1$ is the feedback coefficient; $t_L=L_L/R_L$ is the time constant of the load; $R_L=R_{in}+R3$ is the resistance of the inductive load with the consideration of resistor $R3$ that forms the negative feedback signal; R_{in} is the intrinsic resistance of the inductive load; K is amplification factor of the CVV without the negative feedback.

The response of such a system to the input signal U_{S0}/p (a voltage step $u_S(t)=U_{S0}$) can be written as:

$$U_{NF}=\frac{U_{S0}\cdot K\cdot n}{1+K+n}\times$$
$$\times\frac{1}{p\cdot\left[p^2\cdot\frac{(1+n)\cdot t_A\cdot t_L}{1+\hat{E}+n}+p\cdot\frac{(1+n)\cdot(t_A+t_L)}{1+\hat{E}+n}+1\right]}$$

that after inverse Laplace transform gives such an original

$$u_{NF}(t)=\frac{U_{S0}\cdot K\cdot n}{1+K+n}\cdot$$
$$\left[1+\frac{1}{\sqrt{1-x^2}}e^{-xt}\sin\left(w\sqrt{1-x^2}t-c\right)\right], \quad (1)$$

where $x=1+m/2\sqrt{m}$ is the attenuation coefficient; $w=\sqrt{\frac{1+K+n}{(1+n)\cdot t_A\cdot t_L}}$ is the self-resonant angular frequency; $m=t_L/t_A$.

For such circuit an equivalent time constant is:

$$t_E=1/x\cdot w=2t_L\cdot t_A/(t_L+t_A). \quad (2)$$

The analysis of the expressions (1) and (2) shows that the rate of voltage rise across the feedback resistor $R3$ or its corresponding current does not depend on the amplification factor and the feedback coefficient, while the VCC amplifier is operating at the linear mode (these parameters determine the frequency of system oscillations and the attenuation coefficient) and is determined only by the time constant of the amplifier and the time constant of the inductive load with the consideration of resistor $R3$ that forms the negative feedback signal. However, in most practical cases it is necessary to compute the VCC response to signals linearly increasing from zero up to the amplitude U_{S0} reached at the instant t_0, i.e. $u_S(t) = U_{S0}t/t_0$. The analysis for such case was conducted in [2]. According to [1], the Laplace transform for such signal is: $U_S(p) = U_{S0}/(p^2 t_0)$. The response of the closed system to this signal can be written down as follows:

$$U_{NF}(p) = \frac{U_{S0}\cdot K\cdot n}{t(1+K+n)}\cdot\frac{1}{\left(p^2+pa+d\right)} \tag{3}$$

where $a = \frac{t_A + t_L}{t_A \cdot t_L}$; $w = \sqrt{d - \frac{a^2}{4}}$; d is constant term of the characteristic equation, its formula was given in [1].

The inverse Laplace transform gives such an original in the case of $d < a^2/4$

$$u_{NF}(t) = \frac{U_{S0}\cdot K\cdot n}{t(1+K+n)}(t - \frac{1}{2b}(e^{(b-\frac{a}{2})\cdot t} - e^{-(b+\frac{a}{2})\cdot t}) - \frac{a}{d}\cdot$$
$$(1 - \frac{1}{4b}((2b+a)\cdot e^{(b-\frac{a}{2})\cdot t} + (2b-a)\cdot e^{-(b+\frac{a}{2})\cdot t}))) \tag{4}$$

where $b = \sqrt{\frac{a^2}{4} - d}$; and in the case of $d > a^2/4$:

$$u_{NF}(t) = \frac{U_{S0}\cdot K\cdot n}{t(1+K+n)}(t - \frac{1}{w}\, e^{-\frac{a}{2}\cdot t}\cdot\sin wt -$$
$$-\frac{2}{a}(1 - e^{-\frac{a}{2}\cdot t}\cdot\cos wt + \frac{a}{2w}\cdot\sin wt))\,. \tag{5}$$

After analyzing the expressions (4) and (5) we can determine the delay time of the amplifier. In real devices K >> 1, $t_L/t_A >> 1$. After simplifying, the delay time is calculated as:

$$t_{DLY} = (1+n)\cdot t_{KO}/K\,. \tag{6}$$

Let us determine the response of the closed system to a pulse signal shown in Fig. 3; according to [6], the Laplace transform for such signal can be written as follows:

$$U_S(p) = U_{SO}\cdot(1 - e^{-pt_0})/(p^2 t_0)\,.$$

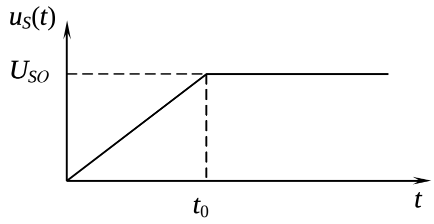


Fig. 3. The shape of the input pulse for settling time calculation.

We can see that the signal in Fig. 3 is represented by two similar linear signals (whose Laplace transform is given by (3)) that have opposite signs and the negative one starts with the time delay of t_0. The response to this pulse can be derived from (4) and (4). The inverse Laplace transform gives such an original in the case of $d < a^2/4$

$$u_{NF}(t) = \frac{U_{SO}\cdot K\cdot n}{t_0(1+K+n)}\cdot(t_0 - \frac{1}{2b}(e^{(b-\frac{a}{2})\cdot t}\cdot$$
$$(1 - e^{-(b-\frac{a}{2})\cdot t_0}) - e^{-(b+\frac{a}{2})t}\cdot(1 - e^{(b+\frac{a}{2})\cdot t})) +$$
$$+\frac{a}{4bd}((2b+a)\cdot e^{-(b+\frac{a}{2})t}\cdot(1 - e^{-(b-\frac{a}{2})t_0}) +$$
$$+(2b-a)\cdot e^{-(b+\frac{a}{2})t}\cdot(1 - e^{-(b-\frac{a}{2})t_0}))), \tag{7}$$

and in the case of $d > a^2/4$:

$$u_{NF}(t) = \frac{U_{SO}\cdot K\cdot n}{t_0(1+K+n)}(t_0 - \frac{1}{w}\cdot e^{-\frac{a}{2}\cdot t}\cdot$$
$$(\sin wt - e^{-\frac{a}{2}\cdot t_0}\cdot\sin w(t-t_0)) - \frac{a}{d}\cdot(e^{-\frac{a}{2}\cdot t}\cdot$$
$$(e^{\frac{a}{2}\cdot t_0}\cdot(\cos w(t-t_0) + \frac{a}{2w}\cdot\sin w(t-t_0)) -$$
$$-(\cos wt + \frac{a}{w}\cdot\sin wt))) \tag{8}$$

The expressions (7) and (8) allow us to determine the settling time of the inductive load current with the required accuracy. For example, if we use the CVV amplifier with amplification factor K = 1000, upper frequency limit F_t = 5 MHz, inductance load L = 100 μH, the resistance of the feedback resistor of 1 Ω (that is, $t_L = 1\times10^{-4}$; $t_L/t_A = 500$). Then after generating an input pulse with amplitude U_{SO} = 10 mV and rising edge time t_0 = 1 μs, the coil current settles after the time period of t = 1 μs with accuracy of 5 %, and after the time period t = 10 μs with accuracy of 0.1 %.

Depending on the amplitude of the input signal, the VCC amplifier stages can operate either in a linear mode or in a saturation mode due to the break in the feedback loop caused by the large difference between the input signal amplitude and negative feedback signal amplitude. A timing diagram explaining the VCC operation is shown in Fig.4. In the first case, the amplitude of the input signal at the timepoint t_1 (Fig. 4a) is so small, that a voltage surge on the inductive load (Fig. 4b) does not exceed the supply voltage and the amplifier operates in the linear mode. In this case current settling consists of two phases. The first phase lasts from the timepoint t_1 (when the input signal is applied) until the timepoint t_3 (when the maximum value of the inductive load voltage is reached and the feedback begins to operate), that is, $t_I = t_3 - t_1$. It should be noted that, according to [1], the inductive load current starts to increase at the timepoint t_2, which is determined by the delay time t_{DLY}.

During the second phase (its duration is $t_{III} = t_4 - t_3$) the inductive load voltage is reduced (due to the feedback effect) to the value required for maintaining a prescribed load current magnitude with a prescribed accuracy Δ. The inductive load current settling time in this case is calculated as:

$$t_{SET} = t_I + t_{III} . \tag{9}$$

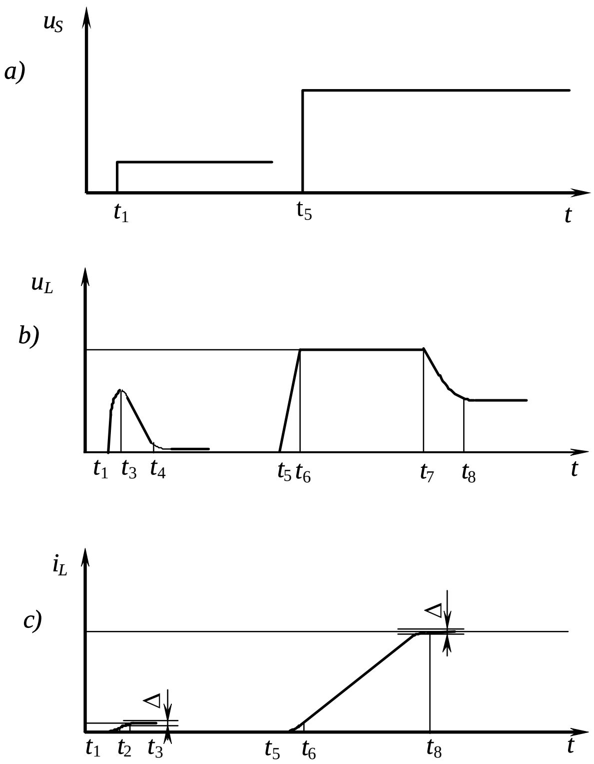


Fig. 4. Timing diagrams for VCC operation.

If the power supply voltage at the input of the amplifier's output stage is confined to its ideal value E_{PWR} then the circuit response to a rectangular input signal of a large amplitude can be divided into three phases. The first phase lasts from the timepoint t_5 (when the input signal is applied) to the timepoint t_6 of inductive load voltage settling; the settled voltage is virtually equal to the supply voltage. In this case, the inductive load current starts to increase at the timepoint t_6. During the second phase (τ_{II}) the load voltage remains practically constant, and the current changes in accordance with the expression:

$$u_L(t) = L \cdot di_L / dt + i_L R_L , \tag{10}$$

For a rough approximation, we can assume that $Ldi_L / dt >> i_L R_L$, and, therefore, $u_L(t) \approx L \cdot di_L / dt$, i.e. the load current changes almost linearly. If the condition

$$u_S(t) - u_L(t) \cdot R2 / R1 \leq E_{PWR} / K \tag{11}$$

is satisfied at the timepoint t_7, the feedback comes into action, the load voltage begins to drop and the circuit enters the third phase, which lasts from the timepoint t_7 to the timepoint t_8, i.e. the timepoint when the load current settles with the prescribed accuracy. Total time of the current settling is calculated as:

$$t_{SET} = t_I + t_{II} + t_{III} . \tag{12}$$

The duration of the first phase τ_I is determined by the equivalent time constant of the system according to (2); the duration of the second phase equals to $t_{II} = LI/U$ (where I is the current value necessary for the beam's deflection from the CRT center to its edge; U is the real power supply voltage at the input of the amplifier's output stage); the duration of the third phase τ_{III} depends on the kind of required dynamic accuracy and is calculated by the expressions (7) or (8) in case of applying the pulse voltage (shown in Fig. 3) to the VCC input or by the expression (1) in case of applying the step voltage.

The analysis of requirements regarding VCC operation shows that the requirements for operation speed may vary depending on the method of forming the illuminating raster. For example, while forming a full-frame illuminating raster with maximum resolution, the attention should be given to the phase with the settling time τ_{III}. This phase is determined by the constants τ_A and τ_L. When generating the raster with low resolution, we should focus on the phases with the settling times τ_{II} and τ_{III}. When the scanning microscope operates in a passive mode, the time that is necessary for the beam's deflection to the next position of the scanning element on the screen (i.e. the inductive load settling time) is calculated by a software in accordance with the distance which the beam covers moving. Calculation time (about 10 μs) is significantly greater than the time required for moving the scanning element to the next point with specified accuracy, even taking into account the time of illumination (1 - 2 μs).

3. Passive and interactive operation modes of STOM

The essence of the STOM passive operation mode is that the time between receiving two consecutive coordinate codes of the illuminating raster element exceeds the sum of the load current settling time for the current's maximum magnitude and the duration of the illumination pulse. The maximum settling time is determined in accordance with (12). The essence of the STOM interactive operation mode is that, as soon as the scanning element is illuminated, a VCC readiness signal is generated and the code of the next coordinates of the illuminating raster element is received by the system; the time between receiving two consecutive coordinate codes of the illuminating raster element is roughly equal to the time determined according to (9) or (12) and is obtained not by its direct calculation but owing to an appropriate hardware solution set forth below.

Two block diagrams of VCC have been proposed which, in the interactive operation mode of the STOM, generate normalized pulses, whose duration is equal to the duratin of transient for the inductive load current settling. Fig. 5 shows the block diagram of the shaper of transient process pulses which consists of two comparators (C1 and C2), two sources of reference voltage (VREF1 and VREF2) and a logic circuit component OR. The first input gates of both comparators are connected in parallel to the VCC output which is connected to the inductive load. The sources of reference voltage VREF1 and VREF2 generate their output voltage whose value exceeds the sum of voltages on the feedback resistor and intrinsic resistance of the inductive load in the regime of maximum load current. Thus, the OR output gate generates the transient process pulse regardless of the polarity of the load current.

Fig. 6 shows the block diagram of the transient process pulse shaper, which consists of two comparators (C1 and C2) and a logic circuit component OR. The peculiaity of this circuit is that the two comparator input gates are connected directly to the inductive load. During the transient the difference between the signals on the comparator inputs is equal to the sum of the voltage across the ideal inductance and the voltage across its intrinsic resistance; in steady-state the voltage on the ideal inductance vanishes to zero. That is why the threshold of these comparators exceeds the voltage drop on the intrinsic resistance of the inductive load in the regime of maximum load current.

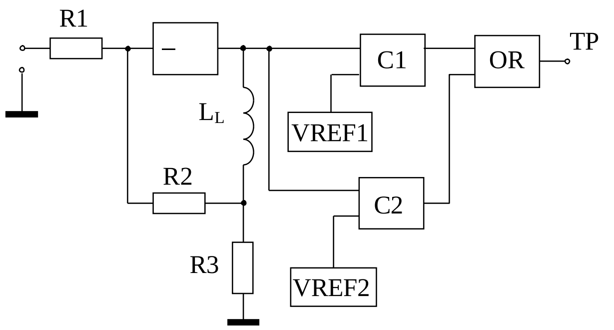


Fig. 5. Block diagram of the transient process pulse shaper with comparators connected to VCC output.

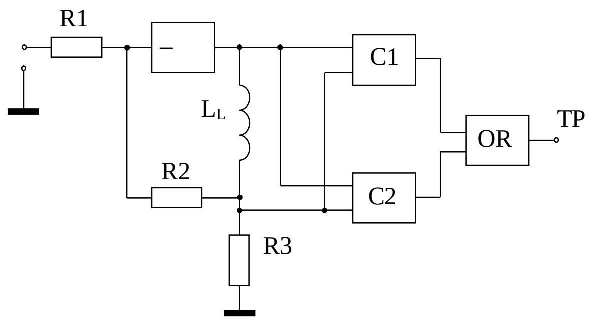


Fig. 6. Block diagram of the transient process pulse shaper with comparators connected to the inductive load.

The threshold of the comparators in the second diagram needs to be much lower than those in the first diagram, as the voltage drop on the intrinsic resistance of the inductive load (1–2 V) is much less than the maximum signal of the negative feedback and intrinsic resistance of the inductive load (5–10 V). According to (7), the load current settling time, while moving the scanning element to the neighboring point, is of 3 μs. In the first case (Fig. 5), the transient pulse duration is of 1 μs, and in the second case (Fig. 6) it is of 2.5 μs, which practically coincides with the actual current settling time with high accuracy. Using the first circuit variant, it is necessary to provide some additional circuit details for stretching the transient pulse.

4. Functional diagram of STOM with thorough consideration of settling time in interactive operation mode

The block diagram of the STOM is shown in Fig. 7. The block diagram includes the digital-to-analog converter for generating the signal for scanning element moving with respect to X coordinate (DACX) in accordance with the deflection code (CODX), the digital-to-analog converter for generating the signal for scanning element moving with respect to Y coordinate (DACY) in accordance with the deflection code (CODY), two voltage-to-current converters (VCC), which convert the deflection voltage signal into the deflection current with high accuracy, each VCC is loaded with corresponding deflection coil (DCX and DCY) and transient process pulse shaper (TPPSX and TPPSY), three OR gates - OR1, OR2, OR3, AND gate, clock shaper (CLK), counter (CNT), video signal shaper (VSS), digital-to-analog converter (DAC), nonlinear converter (NLC), voltage-to-time converter (VTC), and pulse stretcher (PE). STOM input base OCP is a receiver for a code delivery pulse (OCP); and its output base OCEP provides a pulse permitting the next code delivery (OCEP).

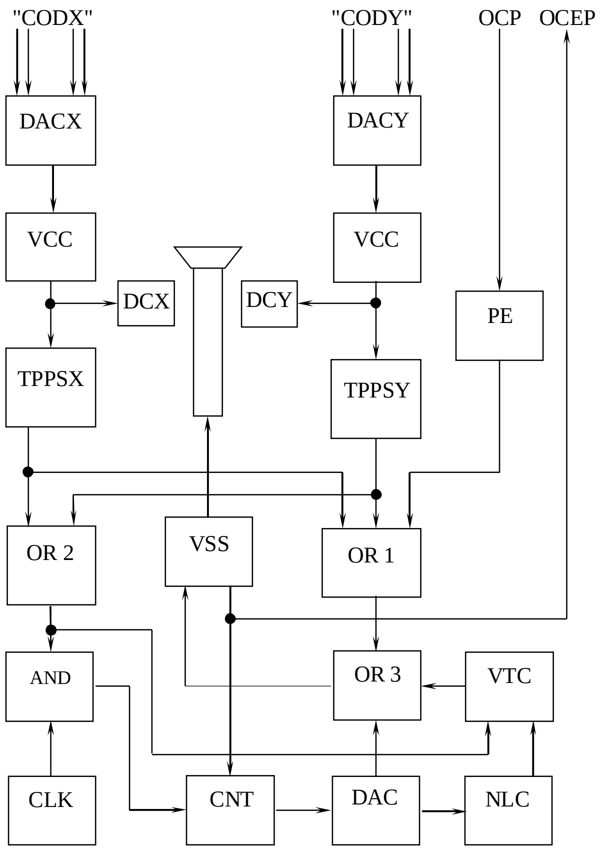


Fig. 7. Block diagram of STOM in interactive operation mode.

The principle of operation of this microscope is as follows. In the initial state the input signals on the buses CODX and CODY and the delivery pulse code (OCP) are absent. At the outputs of transient pulse shapers (TPPSX and TPPSX), pulses stretcher (PE), first OR1 gate, second OR2 gate, third OR3 gate, and AND gate the corresponding signals are also absent. In this case, the cathode ray tube (CRT) is modulator-closed. The code at the output of the counter corresnonds to the code of current scanning element; at the STOM output bus (OCEP), such a potential is set that permits the delivery of next code, i.e. the code identifying the next element of the illuminating raster.

The microscope starts working when the input buses CODX and CODY receive the codes identifying the coordinates of the next scanning element of the illuminating raster and transfer them to the inputs of DACX and DACY; the input bus OCP receives the code delivery pulse. At the outputs DACX and DACY the voltages are formed which correspond to the delivered codes of coordinates; these voltages are applied to appropriate inputs of the VCC-s. During the transients in the the inductive loads (responsible for X-deflection and Y-deflection) the voltages at the outputs of the VCC-s depend on the corresponding currents in the DCX or DCY and their change. The settling times of the VCC output voltages are the very variables that are necessary for proper operation of the microscope in interactive mode. Thus, on the outputs of the transient process pulse shapers TPPSX and TPPSY, normalized pulses are formed, whose duration corresponds to the duration of the transient processes in the inductive load, i.e. their current/voltage settling times. The pulses (identifying the corresponding settling times for X-deflection and Y-deflection) are transmitted to OR1 and OR2 gates. Additionally, from the pulse extender (PE) the third input of the gate OR1 receives a pulse, whose duration exceeds the time of a transient in the inductive load which corresponds to such deflection of the scanning element on the raster screen that does not trigger TPPSX and TPPSX due to their thresholds. The thresholds of TPPSX and TPPSX are selected equal to the sum of voltages across the intrinsic resistance of the inductive load and the feedback resistor when maximum current flows through them in steady state. If current increments in the inductive loads are relatively small, they do not trigger TPPSX and TPPSX. In this case, at the output of OR2 gate the pulse is absent, and at the output of OR1 gate a signal is formed whose duration is equal to the duration of the PE pulse described above. This signal is fed to the input of video signal shaper (VSS) through the OR3 gate. At the first output of VSS the illumination pulse normalized in amplitude and duration is formed, whose start point matches the end of the output pulse of OR3 gate. At the second output of VSS the amplitude-normalized pulse permitting the next code delivery is formed; its startpoint matches the startpoint of the output pulse of OR3 gate, and its end matches the end of the illumination pulse.

The signal from the output of OR2 gate is fed to the control input of the voltage-to-time converter, switching it to the operation mode. In this case, within the duration of the output pulse of OR2 gate, pulses are generated on the output of the AND gate with clock generator (CLK) frequency, which pass to the counter (CNT) whose output code corresponds to the number of the pulses. At the output of DAC a voltage proportional to the duration of the output pulse of OR2 gate is formed. At the output of nonlinear converter (NC) and, therefore, at the output of voltage-to-time converter (VTC) a pulse is generated whose duration is equal to the settling time of magnetic flux which sets the scanning element with the prescribed accuracy. Since the settling time of magnetic flux is bigger than the duration of the transient of the current in the inductive load, then at the output of the OR3 gate a pulse is formed whose duration is equal to the magnetic flux settling time with the prescribed accuracy. The accuracy of forming the VTC output pulse is determined by the digit capacity of the DAC and CNT and by the frequency of CLK.

5. Conclusion

On the one hand, the STOM interactive mode allows considerable simplification of the software, since it eliminates the calculation of deflection time, i.e. the time necessary for moving the scanning element to the next position with prescribed accuracy, and, on the other hand, it can significantly increase operation speed, since the coordinates of the next position of the scanning element are generated without delay.

6. References

[1] V. Shkliarskyi, *Television scanning optical microscopy: theory and practice. A monograph.* Lviv, Ukraine: Publishing House of Lviv Polytechnic, 2010. (Ukrainian)

[2] V. Vasyliuk and V. Shkliarskyi, "Voltage-to-current converter as a mean of current setting in a complex load", *Electronics and Telecommunications*, no. 738 , pp. 48–56, 2012. (Ukrainian)

[3] Y. Balaniuk, Y. Matiyeshyn, A. Pedan, and V. Shkliarskyi, "Scanning Television Optical Microscope with Illumination of Microobject in a Ultra-Violet Range", in *Proc. XI Intern. conf. TCSET'2012 Modern Problem of Radio Engineering, Telecommunications and Computer Science,* p. 113, Lviv-Slavske, Ukraine, 2012.

[4] V. Vasyliuk, V. Goy, and V. Shkliarskyi, "Raster Forming Block in ScanningTelevision Microscope", in *Proc. X Intern. conf. TCSET'2010 Modern Problem of Radio Engineering, Telecommunications and Computer Science,* p. 67, Lviv-Slavske, Ukraine, 2010.

ДІАЛОГОВИЙ РЕЖИМ РОБОТИ СКАНУВАЛЬНОГО ТЕЛЕВІЗІЙНОГО ОПТИЧНОГО МІКРОСКОПА

Володимир Шклярський, Юрій Баланюк, Володимир Василюк, Борис Гудзь

Проаналізовано шляхи підвищення швидкодії формування освітлювального растра в сканувальному телевізійному оптичному мікроскопі. Растр формується цифро-аналоговим методом з використанням прецизійного перетворювача напруга-струм. Широкі функціональні можливості мікроскопа за рахунок формування растра змінних розмірів, змінної роздільної здатності та зміщення зменшеного растра в довільну точку екрана електронно-променевої трубки вимагають контролювати час виведення світного сканувального променя в точку зі заданими координатами та зі заданою точністю. Пропонується апаратний варіант збільшення швидкодії, який дасть змогу значно скоротити час формування сканувального растра в дискретному режимі.

Для забезпечення високої точності перетворення вхідної напруги на струм котушок відхилювальної системи перетворювач напруга-струм виконано за схемою підсилювача постійного струму з глибоким від'ємним зворотним зв'язком за струмом. Сигнал від'ємного зворотного зв'язку формується на прецизійному резисторі, ввімкненому послідовно з індуктивним навантаженням. Індуктивним навантаженням є навої індуктивності відхилювальної системи. Точність перетворення вхідної напруги в струм навантаження визначається загальним коефіцієнтом підсилення без урахування дії від'ємного зворотного зв'язку. Як правило, коефіцієнт підсилення перевищує 1000, а коефіцієнт передачі перетворювача напруга-струм близький до одиниці.

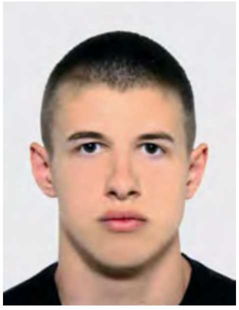
Залежно від амплітуди вхідного сигналу підсилювальні каскади перетворювача напруга-струм можуть працювати як в лінійному режимі, так і в режимі насичення. Останній режим виникає внаслідок розриву петлі зворотного зв'язку через велику різницю амплітуд вхідного сигналу і сигналу від'ємного зворотного зв'язку. Наведено аналітичні вирази, які дають змогу визначити час встановлення струму в індуктивному навантаженні зі заданою точністю. Запропоновано активний режим роботи сканувального телевізійного оптичного мікроскопа. Суть активного режиму роботи полягає в тому, що код наступної координати світного сканувального променя видається через час, який визначається часом перехідного процесу встановлення струму в індуктивному навантаженні зі заданою точністю та тривалістю імпульсу підсвічування. Запропоновано дві структурні, які в активному режимі роботи формують імпульси нормованої величини, тривалість яких дорівнює тривалості перехідного процесу встановлення струму в індуктивному навантаженні. Розроблено структурну схему сканувального телевізійного оптичного мікроскопа, яка враховує тривалість перехідного процесу встановлення світного сканувального променя за різних режимів роботи мікроскопа.

Volodymyr Shkliarskyi – PhD, professor of the Department of Radioelectronic Appliances and Systems, Institute of Telecommunications, Radioelectronics and Electronic Engineering, Lviv Polytechnic National University, Ukraine.

Basic direction of his scientific research is television scanning systems.

Yuriy Balaniuk – Asistant of the Department of Radioelectronic Appliances and Systems, Institute of Telecommunications, Radioelectronics and Electronic Engineering, Lviv Polytechnic National University, Ukraine.

Research interests: television measuring systems



Volodymyr Vasyliuk – Junior researth fellow of the Department of Radioelectronic Appliances and Systems, Institute of Telecommunications, Radioelectronics and Electronic Engineering, Lviv Polytechnic National University, Ukraine.

Research interests: television measuring systems.

Borys Hudz – Junior researth fellow of the Department of Department of Radioelectronic Appliances and Systems, Institute of Telecommunications, Radioelectronics and Electronic Engineering. Lviv Polytechnic National University, Ukraine.

Research interests: television measuring systems.