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Optoelectronic Device for Monitoring the Linear Density of Cotton Ribbons Based on Emitting Diodes of the Al-106, Al-107 and Al-108 Types

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Abstract: the article is devoted to an optoelectronic device for monitoring the linear density of cotton ribbons based on functional control of the emitter, and also provides a block diagram of the converter with functional sweep and timing diagrams explaining the principle of operation of the device. The operating principle of the device is explained on the basis of a circuit diagram.

Keywords: tape quality, converter range, functional sweep, emitter follower, controlled object, linear density control, generator, radiation flux.

Standards for spinning products and quality standards for sliver, roving and threads always indicate the permissible level of unevenness [1].

Determination of unevenness is carried out by processing the results of measuring the weight of the controlled semi-finished product. Based on the amplitude method of controlling the radiation source, an optoelectronic weight converter was developed, designed for non-destructive testing of cotton sliver at the output of the draw machine during the technological process [2]. When developing the converter, the following were taken into account: a) the tape weight values can range from 0.5 to 4 g/m, that is, it is necessary to cover the operating range of the converter eightfold; b) the speed of movement of the controlled belt is in the range of 90 ÷ 150 m/min; c) the transducer must provide weight measurement in increments along the length of the belt of no more than five millimeters [3]. Thus, the repetition rate of the measurement process is defined as:

$$f_{rep} = \frac{2 \cdot 15000}{0,5 \cdot 60} = 1000\,[Hz] = 1\,[kHz] \qquad (1)$$

The need to ensure eightfold coverage of the measurement range makes it most appropriate to use a primary converter with a functional sweep, which can operate in a frequency range on the order of several kilohertz [4].

Based on considerations of the greatest simplicity of hardware implementation, a functional sweep in the form of a falling exponential was chosen [5].

The block diagram of the converter with functional development is shown in Fig. 1. Timing diagrams explaining the principle of operation of the device are shown in Fig. 2. The block diagram contains: the generator - G, the generator of the exponential pulse - GEF, the emitter repeater - ER, the controlled object - KO, which is moved by the field-detecting diode - LED and the photodetector-FD, the comparator - CM and a time interval meter-TIM.

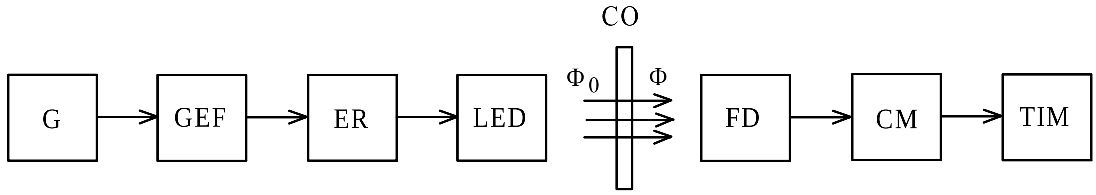

Fig.1. Block diagram of an optoelectronic device for controlling the linear density of cotton ribbons based on functional control of the emitter.

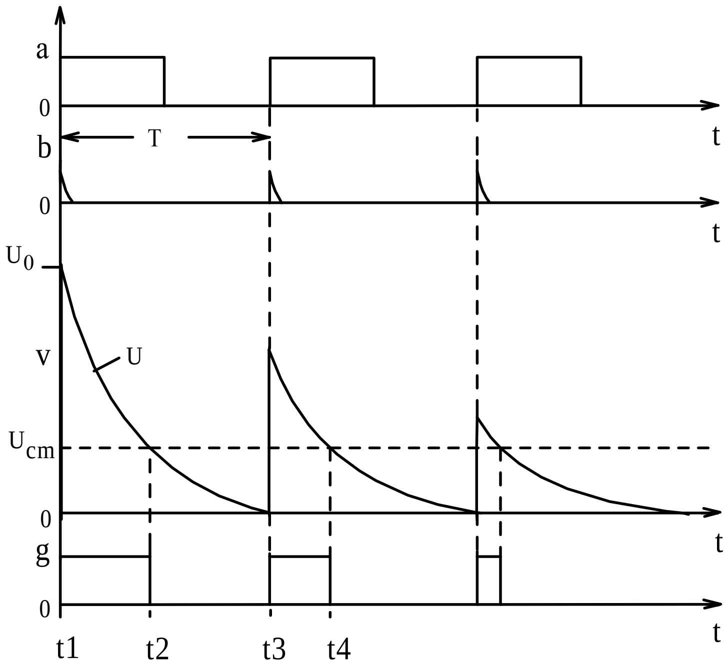

Fig.2. Timing diagrams of the operation of an optoelectronic device for monitoring the linear density of cotton ribbons based on functional control of the emitter.

The generator G produces a sequence of rectangular pulses with a frequency f = 1.0 kHz (see Fig. 2a). These pulses trigger the exponential pulse generator GEF, which serves to generate exponential pulses at the output. Exponential pulses from the output of the exponential pulse generator GEF are amplified in current by the emitter follower ER and fed to the input of the emitting diode LED, and an exponential pulse current flows through the latter.

The radiation flux generated by the LED emitting diode passes through the controlled object CO and enters the FD photodetector.

The output signal of the FP photodetector (see Fig. 2v) is fed to the input of the CP comparator. At the output of the latter, rectangular pulses are formed, the duration of which is proportional to the linear density of the cotton ribbons (see Fig. 2d). The duration of the output pulses of the CP comparator is measured by a time interval meter TIM.

As a radiation source, emitting diodes of the AL-106, AL-107 and AL-108 types, emitting in the near-IR range (λ=0.94 µm), can be used.

The output power of gallium arsenide emitting diodes is almost proportional to the current flowing through it.

The maximum current value of the emitting diode with exponential power pulses is determined as:

$$I_m = I_n \frac{\alpha T}{1 - e^{-\alpha T}} \tag{2}$$

The pulse repetition period is

$$T = \frac{1}{f_{rep}} = \frac{1}{10^3} = 1 \cdot 10^{-3} [\text{sec}] \qquad (3)$$

and the value of coefficient α is calculated by the expression as:

$$\alpha = \frac{K \cdot x_{\max}}{T} = \frac{K \cdot x_{\max}}{1 \cdot b \cdot T} = \frac{20 \cdot 4}{100 \cdot 0,4 \cdot 1} = 2 \left[\frac{1}{m\text{sec}} \right] \qquad (4)$$

Substituting the values of T and α into (2), we obtain:

$$I_m = 100 \frac{2}{1 - e^{-2}} \approx 230 \, [mA] \qquad (5)$$

A schematic diagram of an optoelectronic device for monitoring the linear density of cotton ribbons based on functional control of the emitter is shown in Fig. 3. The master oscillator is made on an NE555 type chip, the generation frequency is 1 kHz. The generator of exponentially falling pulses is made on transistors VT1, VT2 and parallel-connected chains R6 and C3, which is launched through a differentiating chain C2 and R3. The emitting diode is powered by two series-connected emitter followers, the first of which is made on a composite transistor VT3, VT4 and the second on a transistor VT5.

Let's consider the operating principle of an optoelectronic device for controlling the linear density of cotton ribbons based on the functional control of the emitter. The output rectangular pulse of the master oscillator ZG through the differentiating circuits C2, R3 opens transistors VT1 and VT2. As a result, transistor VT2 is saturated and the capacitor is charged to the voltage of the power source. After turning off transistor VT2, capacitor C3 begins to discharge through resistor R6. The discharge current has the form of a decaying exponential and, therefore, the emitting diode, which is connected to the emitter circuit of the transistor VT5, emits a flux Φ_0 proportional to the exponential. The radiation flux of the emitting diode incident on the photodiode Φ is attenuated depending on the linear density of the cotton ribbons (see Fig. 2v). The output signal of the photodiode is fed to the input of a saturating high-speed electronic switch, which is made on transistors VT6, VT7, VT8 and diodes VD1 and VD2. At the output of the electronic key, a rectangular pulse is formed, the duration of which is proportional to the linear density of the cotton ribbons.

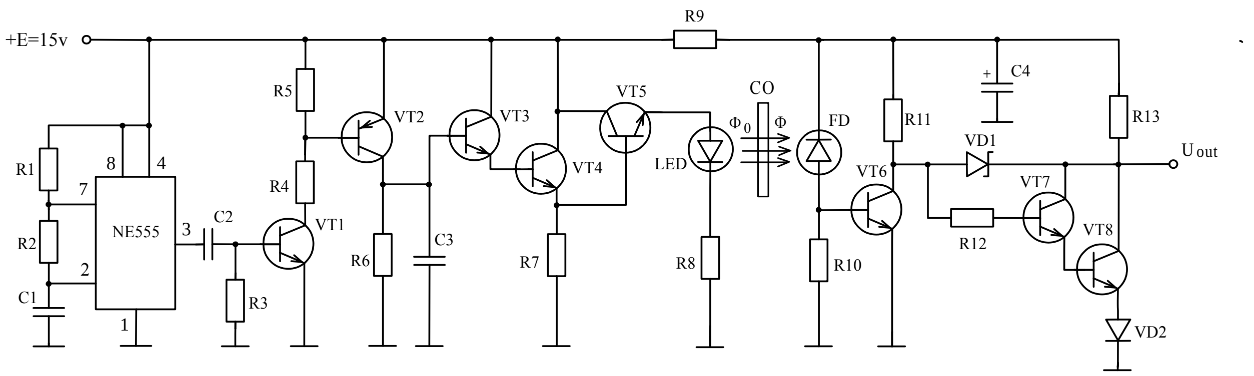

Fig.3. Schematic diagram of an optoelectronic device for monitoring the linear density of cotton ribbons based on functional control of the emitter.

The use of this device makes it possible to obtain a time pulse signal at the output, which is an information signal for automatic control of the linear density of cotton belts in carding machines of the textile industry. The resulting mathematical model made it possible to develop a block diagram, as well as a schematic diagram of an optoelectronic device for monitoring the linear density of cotton ribbons during the technological process.

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