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Research Article

THREE-WAVE MOISTURE METER

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Kipchakova Gavharay Mirzasharifovna
Assistant, Fergana Polytechnic Institute, Fergana, Uzbekistan

ABSTRACT

Synchronous detectors are controlled by pulses from the corresponding power generator and, therefore, a signal is allocated that is proportional to the reflected radiation flux at the corresponding wavelength, which is then fed to the input of the information processing unit.

KEYWORDS

Photodetector, tissue, generator, photoresistor, detector, pulse, power supply.

INTRODUCTION

In addition to fluctuations in the radiation power of the illuminator, the sensitivity of the photodetector and the quality of the tissue surface, the reflection coefficient of the reference wave can be affected by the physicochemical properties of the fibers, changes in which can thus introduce an additional error in the moisture measurement results.

MATERIALS AND METHODS

In this regard, at the Department of Industrial Electronics and Automation of MTI, the possibility of increasing the accuracy of measuring humidity by using radiation at three wavelengths was investigated. As radiation sources, LEDs based on gallium antimonide for a wave of 1.93 μm, ternary solid solutions of gallium antimonide and aluminum for a wave of 1.79 μm, and ternary solid solutions of gallium and indium for a wave of 2.1 μm were used. In this case, the reflected radiation flux with a wavelength of 1.79 μm was used to compensate for the effect of tissue thickness, temperature, and fluctuations of the tissue surface relative to the measuring transducer, and the reflected radiation flux with a wavelength of 2.1 μm was used to compensate for the effect of the type of fiber, i.e. its physical and chemical properties.

As a photodetector, a photoresistor of the FSV-16-AN brand was used, which made it possible to obtain an agreement of IR-LED-photodetector pairs of about 0.97 in the range of 1.7 ... 2.1 μm.

Since the above-mentioned LEDs, when powered by direct current, give off power no more than 0.5 ... 1 mW, they were used in a pulsed mode, which made it possible, when powered by current pulses of 5 μs duration with a repetition rate of 1 kHz, to increase the power of the radiation emitted by them by 20-30 once. The inertia of the used photoresistor allows a pulse modulation frequency of up to 3-5 kHz.

Three rectangular pulse generators fed three LEDs with pulses with different repetition rates. The radiation fluxes of all three LEDs were fed to the controlled tissue using molybdenum glass LEDs, the attenuation coefficient of which is 0.04 per centimeter of length, and then, after reflection from it, to the photoresistor. The output signal of the photoresistor was amplified and fed to the inputs of three synchronous detectors. Each of these synchronous detectors is controlled by pulses from the corresponding power generator and, therefore, a signal is allocated that is proportional to the reflected radiation flux at the corresponding wavelength, which is then fed to the input of the information processing unit.

RESULTS

The Fergana Polytechnic Institute has developed a three-wave moisture meter with a functional sweep of the emitter, which works for translucence of a controlled object. The moisture meter consists of an exponential voltage generator, three LEDs (radiating at the reference, measuring wavelengths and at a wavelength lying on the absorption band of non-informative parameters), a controlled object, a photodetector and a photoelectric signal processing unit. The use of a functional sweep in this case improves the accuracy and simplifies the device circuit.

The moisture meter works as follows. Controlled material or product of the irradiator with three light fluxes from LEDs at the measuring length λ_1=1.93 μm and at two reference wavelengths - respectively λ_2=1.83 μm and λ_3=2.1 μm. The flows passing through the controlled object are defined as:

$$\Phi_{\lambda 1} = \Phi_{0\lambda 1}\, e^{-k_1 m_1} e^{-k_2 m_2};$$

$$\Phi_{\lambda 2} = \Phi_{0\lambda 2}\, e^{-k_1 m_1} e^{-k_{01} m_1};$$

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$$\Phi_{\lambda 3} = \Phi_{0\lambda 3}\, e^{-k_1 m_1} e^{-k_{02} m_1};$$

The following designations are adopted in the formulas: k_1-coefficient of scattering of the material without moisture; k_2 - moisture absorption coefficient; k_{01}, k_{02}- the absorption coefficients of the material without moisture on the lengths of the waves λ_2, λ_3, due to the uninformative parameter (for example, the grade of raw materials and then others); m_1- mass of material without moisture; m_1 –mass of moisture. Light flows at the supporting wavelengths change according to the exponential law in time.

$$\Phi_{0\lambda 2} = \Phi^*_{0\lambda 2} e^{-t/\tau};$$

$$\Phi_{0\lambda_3} = \Phi^*_{0\lambda 3} e^{-t/\tau};$$

($\Phi^*_{\lambda_{02}}, \Phi^*_{\lambda_{03}}$ - Initial light flows at the wavelengths λ_2, λ_3).

Then the light flows entering the reflector are defined as

$$\Phi_{\lambda_2} + \Phi_{\lambda_3} = \Phi^*_{\lambda_{02}} e^{-et/\tau} e^{-\kappa_1 m_1} + \Phi_{0\lambda_3} e^{-et/\tau} e^{-\kappa_1 m_1} e^{-\kappa_{02} m_1};$$

$$\Phi_{\lambda_1} = \Phi_{0\lambda_1} e^{-\kappa_1 m_1} e^{-\kappa_2 m_2}.$$

If you level the initial light flows, $\Phi^*_{0\lambda_2} = \Phi^*_{0\lambda_3}$, we will get:

$$\Phi_{\lambda_2} = \Phi^*_{\lambda_{02}} e^{-et/\tau} e^{-\kappa_1 m_1}(e^{-\kappa_{01} m_1} + e^{-\kappa_{02} m_1}),$$

where $\Phi_{\lambda_{03}} = \Phi_{\lambda_2} + \Phi_{\lambda_3}$.

The wavelength of the supporting light flows λ_2, and λ_3 is selected in such a way that the amount $e^{-\kappa_{01} m_1} + e^{-\kappa_{02} m_1}$ remains constant when the non-informative parameters are changed.

With the equality of light flows

$$\Phi_{\lambda_1} + \Phi_{\lambda_3}$$

Get

$$\Phi_{0\lambda_2} e^{-\kappa_1 m_1} e^{-\kappa_2 m_2} = \Phi^*_{\lambda_{02}} e^{-\kappa_1 m_1} e^{-t_{cp}/\tau} C_1$$

or

$$K_2 m_2 = t_{cp}/\tau + In\,[\Phi_{\lambda_1}/(\Phi^*_{0\lambda_2} C_1)]$$

Where is the mass of moisture from where

$$m_2 = t_{cp}/(k_2 \tau) + C.$$

These formulas indicate: τ – constant time exhibits; t_{cp} – time corresponding to the moment of comparison

$$C = In[\Phi_{0\lambda_1}/(\Phi^*_{\lambda_{02}} C)]/\kappa_2.$$

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