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BASIC ERRORS OF OPTICAL MOISTURE METERS

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ABSTRACT

To ensure the linearity of the scale in the design of moisture meters, such measurement conditions are chosen under which the dependence of the transmission coefficient on informative and non-informative parameters is linear or close to it. Errors of optical moisture meters are determined at two stages: choosing the optimal measuring scheme and during calibration and verification of moisture meters. The existing variety of measuring circuits brings to the first place the problem of choosing the optimal measuring circuits, their structural and parametric optimization in terms of metrological indicators (random and systematic errors). The vast majority of moisture meters are based on a ratio metric scheme.

KEYWORDS: *Diagrams, Metrological indicators, Parameter, Moisture meter, Scales, Operation, Coefficient.*

INTRODUCTION

Errors of optical moisture meters are determined at two stages: choosing the optimal measuring scheme and during calibration and verification of moisture meters.

The existing variety of measuring circuits brings to the first place the problem of choosing the optimal measuring circuits, their structural and parametric optimization in terms of metrological indicators (random and systematic errors). The vast majority of moisture meters are based on a ratio metric scheme.

In operating conditions, the output signal uvh depends not only on the informative parameter - humidity W and changes in external factors, but also on non-informative parameters of the controlled environment, including the ambient temperature 0, supply voltage Ucc, time t (when evaluating stability), the concentration of uninformative parameters y (density, scattering properties, etc.), the temperature of the controlled environment, sun, nonselective mechanical impurities d). In view of the above, the output signal and, consequently, the transmission coefficient are functions of external factors and uninformative parameters [8, 17]:

Where Uн is the nominal value of the output signal under normal conditions; Ai is the coefficient of influence of external factors on the output signal (Л, is easily determined experimentally).

To ensure the linearity of the scale when designing moisture meters, such measurement conditions are chosen under which the dependence of the transmittance on the informative and non-informative parameters is linear or close to it. This condition is observed when measuring humidity within a small range (10 ... 25%). Then the transmittance can be represented by a linear function [17, 110, 122, 123, 269, and 277]

KP = [1 - I <w (W - W0)] [l - Ku {y - m>)] [1 - Kvs {0c - 0so) b =

= [l-I <w (W-Wmin)] Bi. (10.5.2)

Under normal conditions, y = yo \ sun = bco \ r / = 1; IN 1; then the transmittance

Кр = 1 - Kw {W - Wmin), (10.5.3)

Where I \ w is the coefficient characterizing the relative change in the transmittance of the controlled medium per unit of humidity W ', Ku, K $ s are the values characterizing the relative change in the transmittance per unit of concentration of non-informative components of the medium (density, pollution) y and 1 ° C change in temperature 6C, respectively.

The relative characteristic of the random error σ, reduced to the measurement range (under normal conditions Ai = 1 and Bi = 1) is described by the expression [122]

04 = trwi (Wmax - Wmm) / Sw, (10.5.4)

Where Sw is the sensitivity of the moisture meter to a change in moisture content at the averaged values of the moisture meter parameters (Sw = dUvix / dW), moreover, σ ^ = 72 [[/ out] is the dispersion of the output signal.

The characteristic of the random error for the ratiometric structural diagram is described by the expression

(Ti - <ti - J +

\ 1 ^ mav

7, (10.5.5)

7 ^ 71.1

1 - T ^ shah 61

where qi -is a value that depends on the cross-correlation coefficient 72, signals of the reference U1 and measuring U2 channels and the ratio of the squares of the relative errors 6N and 6c, caused by electrical noise and photoelectric signal, respectively, <71 = 2 (1 - V.) + ёshch / 6ts, and the relative error 6ts is the same for the reference and measuring channels and does not depend on their level:

Where cr \ = D [Ui], st2 = £> [£ / 2] are the variances of the reference and measurement signals, respectively; M [U 1], L7 [7 / g] - mathematical expectations of the reference and measuring signals, respectively; 6SH = <tsh / M [7 / w]; crsh, M [Um] - variance and mathematical expectation due to the noise signal Tssh.

The relative error of the inverse transducer <5kos (logarithmor or device that implements the ratio), equal to the ratio of the variance ckos = t> [L'oc] of the feedback coefficient of the divider and its mathematical expectation M [/ \ oc]:

^ braid = <^ braid / -L £ [^ os] - (10.5.7)

The relative error 6cn due to the dispersion &Uon = D [Uon] - the reference voltage source Uon and its mathematical expectation M [7 / op],

&Uon = &Uon / M [U0n] - (10.5.8)

A parameter characterizing the relative change in the signal of the reference channel U \ within the scale (U ^ t; n, U ^ max),

Zmax = Kw {Wmax ~ Zhpt), (10.5.9)

Where: Kw - coefficient characterizing the relative change in the transmittance of the controlled object per unit of humidity; VFmin, WmBX - minimum and maximum values of humidity, respectively; y - coefficient characterizing the scale of the instrument in dimensionless quantities, and y = (W - Wm \ n) / {WmBX - U ^ m; n); W is the measured value of humidity.

Expressions for determining random errors were obtained on the assumption that random variations of Kos, Uon-u (Ush are stationary, mutually independent, with the exception of U \ and U2, correlated with each other by the correlation coefficient R.

The relative reduced to the measurement range (WmBX, Wm \ n) characteristic of the systematic error A, - depends on changes in external influencing factors and is found by the formula [123]

= M [uvykh - UH] / [Sc (Wmax - Wmm)], (10.5.10)

where M [uykh - {/ „] is the mathematical expectation of the deviation of the current value of the output signal C / out from its nominal value UH under nominal conditions; Sc is the average value of the moisture meter sensitivity to the measured humidity, and

Sc - AU „/ Aw = (t / out check ^ out min

) / (WmBX - (10.5.11)

Where 7 /vyshax UBbixmin - output signals corresponding to the maximum WT „ax and minimum Wmm moisture values.

The additive component is the smaller, the smaller the relative standard deviation of the signals and the greater their cross-correlation coefficient. When R = 1, the additive component is determined by the signal-to-noise ratio of the circuit elements.

Systematic errors depend on the influence of external factors (ambient temperature, supply voltage, operating time) on the signal of both the reference and measuring channel, as well as on the transmission coefficient, measurement range and feedback coefficient of the device that implements the signal ratio.

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It is possible to reduce systematic errors by thermostating or introducing temperature correction into the measuring circuits, increasing the stability of the supply voltage, narrowing the measurement range and stabilizing the feedback coefficient. The latter errors are easily eliminated by using a functional sweep.

Let's consider the main errors of optoelectronic moisture meters with functional sweep. The sources of errors are: inaccuracy of the formation of the radiation flux according to the exponential law; inaccuracy of the exponent reproduction by the photodetector; influence of temperature and time instability of emitting diodes.

(10.5.12)

In the general case, a generator of exponential radiation pulses (IPPE) is a master oscillator, a switch and an RC circuit. If you pre-charge the capacitance from the master oscillator

Pulses of limited duration, then with parallel connection of capacitance C and resistor R we obtain

UR - Um exp {-t / t)

Where um is the pulse amplitude; r - time constant; t is time.

(10.5.13)

Assuming that the emitting diode has linear current-voltage and power characteristics, when passing an exponential current through the emitting diode, we obtain [10]

h = lm exp (-t / t) -, PL = ■ KLImexp (-t / t),

Where II is the emitting diode current; 1t - the initial (maximum) current value; Pi is the radiation power of the emitting diode; Ki is the coefficient of conversion of current into radiation intensity.

Since the initial sections of the current-voltage and power characteristics are nonlinear, exponential distortions arise. To eliminate these distortions, it is necessary to apply an initial bias to the emitting diode, the value of which can be determined from the current-voltage characteristic of the emitting diode.

One of the disadvantages of emitting diodes is their temporal and temperature instability, which are determined by the coefficient of instability of the radiation power [29]. The stabilization of the radiation power of the emitting diodes can be carried out by the following methods: thermostating, introducing thermosensitive elements into the power circuit of the emitting diode, choosing the optimal resistance values in the power circuit, introducing feedback on the thermosensitive parameter and displacing the working area, stabilizing the radiation power, by introducing an optical comparison channel.

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