DIGITAL ELECTRONIC MOISTURE METER AND REGULATOR

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Electrophysical methods for determining moisture are now being widely used. Pointer indicators with a low reading precision and speed of operation are being used in many existing moisture meters. Direct feeding of information from a moisture meter to a digital electronic computer requires additional devices which complicate the design.

Digital instruments can be freed from the above deficiencies, and more precise readings can be obtained if compensation methods are used. In this case instead of the voltmeter a null detector should be used [1, 2].

Zero balance is existing instruments is attained manually. It is desirable to develop an automatic moisture meter which can also be used as a regulator.

Let us examine how a measuring element's capacitance $C_s$ depends on the moisture of the tested material. It is known that

$$\delta = \frac{\varepsilon_M - \varepsilon_d}{\varepsilon_{H_2O} - \varepsilon_d},$$

where $\delta$ is the relative moisture of the tested material, $\varepsilon_M$ is the total permittivity of the moist material, $\varepsilon_M$ is the permittivity of the dry material, and $\varepsilon_{H_2O}$ is the permittivity of water.

Let us denote

$$\varepsilon_M = \frac{C_0}{K},$$

where $K$ is the penetrability factor; $C_0$ is the capacitance of the tested element with dry material. Then

$$\delta = \frac{(C_s - C_0)}{K(\varepsilon_{H_2O} - \varepsilon_d)} = \frac{\Delta C}{K(\varepsilon_{H_2O} - \varepsilon_d)};$$

i.e., the variation of capacitance becomes directly proportional to that of moisture content.

Measurement errors due to losses in the measuring capacitance can be reduced considerably by using it as a frequently-determining element in a high-frequency oscillator circuit. The compensating capacitance should then be changed to keep the frequency constant. In order to raise the precision of frequency evaluation it is possible to use the heterodyne method, and for extending the "capture band" to employ a wide-band and a narrow-band discriminators.

The block diagram of one of the possible versions of such a device is shown in Fig. 1. The moisture meter consists of an autocompensator with a digital indication of measurement results. The capacitance of the measuring element $ME$ is compensated automatically by connecting in parallel with it capacitances which are selected by means of a decade-switching device. This device is controlled by a three-position null detector used for determining the direction in which $C_C$ should be changed for attaining compensation.


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Fig. 1. 1) Variable frequency oscillator; 2) fixed frequency oscillator; 3) mixer; 4) wide-band amplifier; 5) narrow-band frequency detector; 6) wide-band frequency detector; 7) adder; 8) null detector; 9) decade-switching device; 10) digital indicator.

It should be noted that the utilization of a fixed frequency oscillator which is of the same type as the variable frequency one serves to reduce the high-stability requirements of the latter, owing to a smaller effect of the ambient medium and the supply voltage on the different frequency.

The schematic of the solid-state moisture meter is shown in Fig. 2.

The variable frequency oscillator is of the Hartley type and it uses the transistors T1 and T2. The provision of the oscillator circuit with a composite transistor reduces the effect of its parameters' variations on frequency and raises the stability of operation when the tested substances have large conductances. The element with the tested substance is connected in parallel to the oscillatory circuit which consists of the inductance L1 and the capacitance of the decade switching device.

The high-frequency oscillator voltage is fed through a small capacitance C3 to the input of the emitter follower which has a dynamic load and uses the transistors T3 and T4. This arrangement considerably reduces the effect of the subsequent stages on the high-frequency oscillator [3].

An important part of the instrument is the wide-band detector, which comprises the T5 emitter follower and two groups of series-tuned circuits consisting of the capacitors C9-C12 and inductors L2-L6 (first group) and C13-C16 and L7-L9 (second group). The resonant frequencies and the width of their "passband" are selected to ensure a high precision in determining the operating frequency f0 for a wide "capture band." The high precision in determining f0 is necessary in order to measure moisture content with a small error, and the wide "capture band" is required for a normal functioning of the moisture meter in transient processes and during sharp variations of the moisture of the tested substance. In order to obtain autocompensation the frequency of the oscillator must under any conditions remain inside the "capture band."

Fig. 2