whence,
\[ \tan \beta = \omega \frac{\Delta R \Delta C'}{(1 + \frac{\Delta R'}{\Delta R}) \left(1 + \frac{\Delta C''}{\Delta C'}\right) \left(1 - \frac{\Delta R'}{\Delta R} \cdot \frac{\Delta C''}{\Delta C'}\right)} \]  

(17)

Thus (similarly to the substitution method) the error in determining the value of \( R_0 \) and \( C_0 \) is eliminated making the measurement independent of the initial capacitance of the capacitor and the resistance of the connecting leads. This method assumes, of course, the constancy of the stray currents (due to resistive and capacitive leakages, and currents through the capacitances shunting the resistance-box components \( R_0 \)) during the measurement.

A complete stability of stray currents is theoretically impossible due to their inconstant nature and also due to the variation of the voltage across the circuit when it is changed by the values of \( \Delta R \) and \( \Delta C \). If the duration of measurements is small and the deviations \( \Delta R \) and \( \Delta C \) are small compared with the values of \( R_0 \) and \( C_0 \) it is possible to consider the stray current as almost constant. The sensitivity of the circuit must be sufficient to allow small variations \( \Delta R \) and \( \Delta C \) of the circuit.

If the operating frequency is raised the reactance of the resistance \( R_0 \) and inductance of capacitor \( C_0 \) must be taken into account in the basic formula \( \tan \delta = \omega R_0 C_0 \).

LITERATURE CITED


EFFECT OF THE COIL INDUCTANCE ON THE FREQUENCY ERROR OF RECTIFYING INSTRUMENTS

E. N. Kurilov and M. N. Drogomyzhskaya
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The frequency error of rectifying instruments was analyzed in a number of papers (for instance [1, 2, 3])

The majority of the analyses are based, due to the complexity of phenomena, on certain approximations. Thus in [2] the inductance of the measuring coil is not taken into account, in [3] the analysis is made on the basis of equivalent circuits without considering the switching process due to the inductance of the coil.

In this article one of the components of the frequency error is analyzed for full and half-wave rectifiers, a component due only to the inductance of the coil.

Let us start the analysis of this error in a half-wave rectifier (Fig. 1) when it is working into an inductive impedance.

In order to find the dc component of the current \( I_L \) in the inductance let us use the expression given in [4]:

\[ I_L = \frac{U_m}{\pi} \sin \frac{\psi}{2} \left[ (\kappa g'' - \kappa' g') \sin \left( \frac{\psi}{2} + \varphi \right) + \kappa' g'' m' (\kappa' g' m') \cos \left( \frac{\psi}{2} + \varphi \right) \right]. \]  

(1)
where $\theta$ is the angle which determines the duration of the rectifier's operating condition; $\varphi$ is the angle which determines the instant rectification begins; $k'$ and $k''$ are transfer constants of the quadripole (Fig. 1b) in an unloaded state with the rectifier in the nonoperating and operating condition; $g'$ and $g''$ are the output conductances of the quadripole $M$ with a shorted input and corresponding to the same conditions on the rectifier.

The values of $m'$ and $m''$ are determined from the equality

$$m' = \omega g'L,$$
$$m'' = \omega g''L$$

In deriving (1) a piecewise linear approximation of the voltampere characteristic of the rectifier was used, as shown in Fig. 2a.

For the circuit under consideration

$$\gamma' = \gamma'' = 1,$$
$$g' = \frac{1}{r' + r}, \quad g'' = \frac{1}{r + r'}$$

Substituting in (1) the equalities (2) we have

$$I_L = \frac{U_m}{\pi} (g'' - g') \sin \frac{\psi}{2} \sin \left( \frac{\psi}{2} + \varphi \right).$$

At a very low frequency ($\omega \to 0$) when it can be considered that the inductance does not affect the instant rectification begins, and $\psi = \pi$, and $\varphi = 0$ (for $u = U_m \sin \omega t$), the mean value of $I_{LO}$ is determined by equation

$$I_{LO} = \frac{U_m}{\pi} (g'' - g').$$

By definition the relative frequency error can be represented as

$$\Delta_f = \frac{I_L - I_{Ln}}{I_{LO}},$$

or, taking into consideration (2), (3) and (4), as:

$$\Delta_f = \sin \frac{\psi}{2} \sin \left( \frac{\psi}{2} + \varphi \right) - 1.$$

The value of angle $\psi$ with respect to $m''$ for various values of $m'/m''$ is given in [5].

It is easy to see that for a half-wave rectifier the frequency error is negative. In fact

$$\frac{m'}{m''} = \frac{r_f + r}{r'w + r}.$$

Here the denominator is considerably larger than the numerator. Hence it is not necessary to calculate the frequency error for various values of $m'/m''$, and it is possible to assume that $m'/m'' = 0$ or that $m' = 0$. Moreover the formula for calculating the frequency error can be reduced to the following form: