An effective means for reducing both random and systematic errors consists of using functional discrete methods of measurement [1]. The field distribution is then reproduced in the form of sequential readings taken along the line at equal intervals. The measured quantity is calculated by taking into consideration all the obtained readings.

Various discrete methods differ by the processing of readings. Readings obtained in measuring the standing wave ratio (SWR) deviate on both sides of the relative theoretical distribution of the field. These deviations may be due to errors in indication and an inconstant coupling between the probe and the line. Owing to compensation by the sign of deviations contributed by each reading, the error due to the above factors becomes considerably smaller than in measuring the SWR by the "maximum—minimum" or "bracket" methods.

The Novosibirsk State Institute of Measures and Measuring Instruments (NGIMIP) has developed for certifying the SWR of reference coaxial loads the following method for measuring the modulus of the reflection factor. The discrete distribution of the field at equidistant points (see figure) is evaluated in a measuring line to which the load under certification is connected. In order to simplify the computation formulas for the modulus of the reflection coefficient ρ, the distances between the points are selected to equal (λ/8)q, where q is an arbitrary integer in mm.

For calculating ρ1 it is necessary to select three readings y1(i), y2(i), and y3(i) made at measuring line points spaced by λ/8 (i is the index of the three selected readings). It is assumed that these readings are made with square-law detection. Number 1 denotes the reading at the nearest point to the load. The second and third points are displaced toward the generator by λ/8 and λ/4. The modulus of reflection factor ρ1 is calculated from the formula

\[ ρ_1 = \sqrt{a_i - b_i \frac{y_{2(i)}^2}{y_{1(i)}^2} - 1} \]

where \( a_i \) and \( b_i \) are constants for each point.

where
\[ a_i = \frac{y_3^{(i)}}{y_1^{(i)}} - 2 \frac{y_2^{(i)}}{y_1^{(i)}} + 1; \quad b_i = \frac{y_3^{(i)}}{y_1^{(i)}} - 1. \]

By picking out from all the readings groups of three readings and calculating \( \rho_i \) each time, we obtain a series of different values. The measurement result is taken to be equal to the mean arithmetic value of the series
\[ \rho = \frac{1}{N} \sum_{i=1}^{N} \rho_i, \]
where \( N \) is the number of values thus obtained, which amounts to a third of the number of all the readings.

Formula (1) is obtained from the expression for the readings of a square-law indicator in the measuring line. This expression, without accounting for the line parameters, can be written in the form
\[ y = k \left| 1 + \rho \exp j(\varphi - 2\beta x) \right|^2, \]
where \( \varphi \) is the phase of the load reflection factor, \( x \) is the probe coordinate.

It follows from the above that the readings at points \( y_1^{(1)}, y_2^{(1)}, \) and \( y_3^{(1)} \) spaced by \( \lambda / 8 \) are related by the expression [2]:
\[ F_0(\rho, \varphi, i, y) = \frac{1 + 2p_i \sin \varphi + \rho_i^2}{1 + 2p_i \cos \varphi + \rho_i^2} - \frac{y_1^{(i)}}{y_1^{(i)}} = 0, \quad \Phi_0(\rho, \varphi, i, y) = \frac{1 - 2p_i \cos \varphi - \rho_i^2}{1 - 2p_i \sin \varphi + \rho_i^2} - \frac{y_3^{(i)}}{y_3^{(i)}} = 0. \] (2)

Here, \( \varphi_1 = \varphi - 2\beta x_4^{(1)} \) is the phase of the load-reflection factor referred to the section at which the first reading \( y_1^{(1)} \) was taken.

The solution of Eq. (2) with respect to \( \rho_1 \) leads to expression (1). Any three readings at points spaced by \( \lambda / 8 \) provide in calculations according to (1) the same value of \( \rho_1 \), but different values of \( \varphi_1 \). Subscript 1 of \( \rho \) in (1) indicates from which of the three readings and at what phase \( \varphi_1 \) the value of \( \rho_1 \) was calculated. The line section at which the calculations are made is selected in such a manner that the phases lie in the range of 0-2 \( \pi \), as shown in the figure.

Let us determine the values of particular errors for a single reproduction of a discrete distribution of the field. Variations in the readings \( y_k^{(1)} \) due to errors of indication and inconstant coupling will be considered together. For a single reproduction of the discrete-field distribution these variations are inseparable and lead to a dispersion of the resulting values of \( \rho_1 \). Since the measurement result is taken as the mean value of \( \rho \), the error is determined for this value:
\[ \sigma_\rho = \sqrt{\frac{\sum (\rho_i - \rho)^2}{N(N-1)}}. \]

Thus, the value of \( \sigma_\rho \) characterizes the effect of the indication and coupling-inconstancy errors on the measurement results. The value of \( \sigma_\rho \) does not exceed 0.002 in measuring type R1-5 and R1-6 lines at 30 reading points (\( N = 10 \)).

Let us evaluate the error due to the shunting effect of the probe and calculate corresponding correction. By taking the effect of the probe into consideration, the curve of readings \( y \) can be written in the form
\[ y = k \left| 1 + p \exp j(\varphi - 2\beta x) \right|^2 \approx k \left[ 1 + 2p \cos (\varphi - 2\beta x) + \rho_p^2 \right] \left[ 1 + 2p \cos (\varphi + \varphi_p - 2\beta x) \right], \]
where \( \rho_p \) is the reflection factor of the probe.

The value of \( \rho_p^2 \), which is of the order of \( 10^{-4} \), has been neglected in the last expression.

The relationships among readings \( y_k^{(1)} \) at three points spaced by \( \lambda / 8 \), with the effect of the probe taken into consideration, can be written as
\[ F(\rho, \varphi, \rho_p, \varphi_p y) = \frac{(1 + 2p \sin \varphi + \rho_p^2)[1 + 2p \rho \exp j(\varphi + \varphi_p)]}{(1 + 2p \cos (\varphi + \varphi_p))^2} - \frac{y_2^{(i)}}{y_1^{(i)}} = 0. \]