class of accuracy for 110 kV or higher can be built using either a capacitive divider of special
design or a linear high-voltage or nonlinear low-voltage reactor for error compensation. The
error involved in the calculation of CVT parameters using the equivalent circuit of Fig. 2
does not exceed ±15%.

LITERATURE CITED
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TEST SETUP FOR 110 TO 500 kV VOLTAGE TRANSFORMERS

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The design and operating principles are discussed of a test setup for high-voltage trans-
formers (VT). The setup design is based on the voltage doubling principle which makes it
possible to eliminate the error component due to uncontrolled variations of leakage currents
in the switched components of the setup.

Voltage transformer errors are now most frequently measured by comparison with a reference
VT (or voltage divider) with the primary windings of the reference and tested transformers
connected in parallel [1]. One of the advantages of the method is the relative simplicity
of its implementation, the test accuracy depending mainly on the metrological properties
of the reference VT.

Voltage transformer errors can be determined by the voltage doubling method [2]. This
method makes it possible to compare the tested VT with the reference transformer at a voltage
equal to twice the reference transformer voltage.

The voltage doubling method (see Fig. 1) is based on producing with a desired degree
of accuracy the voltage \( U' \) equal to reference transformer voltage \( U \) and on their addition.
In Fig. 1 PS denotes the power supply with a tap providing a voltage equal to one half of
the output voltage, RVS is an auxiliary regulated voltage supply, VT_r is a reference voltage
transformer, VT_a is an auxiliary voltage transformer, VT_x is the tested voltage transformer,
S is a switch, and VC1 and VC2 are voltage comparators. The voltage \( U'' = U + U' = 2U \) is
produced by adjusting by means of the RVS and monitoring with the aid of VC1 the primary
voltage of VT_a. In the circuit shown in Fig. 1 VT_a can be compared with VT_r by placing S
in position 2.

The advantage of method [2] in comparison with method mentioned above [1] is the possi-
bility of extending the scale-conversion factor to higher voltage levels and of reducing
the number of reference VT types necessary to test transformers operating at different voltages.

In general, in method [2] the voltage error of the VT_x is calculated from

\[
f_{VT_x} = \frac{K_{VT_x}}{2 K_{VT_r}} \left( f_{VT_r} + f_{VC2} \right) + \frac{K_{VT_x}}{2 K_{VT_r}} - 1
\]

where \( K_{VT_r} \) and \( VVT_{VT_x} \) are the nominal transformation ratios of VT_r and VT_x, \( f_{VT_r} \) is the refer-
ence transformer error, and \( f_{VC2} \) is the reading of the voltage comparator VC2.

Using the same notation, the angular error \( \delta_{VT_x} \) is given by

\[
\delta_{VT_x} = \delta_{VT_r} + \delta_{VC2}
\]

As a metrological aid to the design, testing, and manufacture of voltage transformers for the 110 to 500 kV range, we have developed and put into operation an original test setup UPTN-500. The setup combines the features of the two test methods mentioned above. Its principal elements are two identical wide-range reference voltage converters (RVC) and a voltage doubler (VD).

The reference converters operate at primary voltages from $63/\sqrt{3}$ to $300/\sqrt{3}$ kV and have a variable conversion factor. This makes it possible to test VTs at primary voltages within the indicated range as described in [1]. The two RVCs are used for mutual comparison within the specified test interval and for extending the functional possibilities of the setup.

One of the VT test setup versions based on the voltage doubling method is shown in Fig. 2, where SUT is a step-up transformer with a center tap in its secondary winding, RVS is a regulated voltage supply, ITp is an insulating power transformer, VT1 and VT2 are step-down voltage transformers, RVC is a reference voltage converter, IT is an insulating transformer, VC1 and VC2 are voltage comparators, VTx is the tested voltage transformer, VR is a voltage regulator, and V is a voltmeter.

The VTx is found in two steps. First (with $S_1$ and $S_2$ in position 1), the primary windings of VT1, VT2, and RVC are connected in parallel to the center tap of the SUT output winding whose voltage is equal to one half of the VTx primary test voltage. The voltage is read from the voltmeter and the difference between the VT1 transformation ratio and that of VT2 and IT connected in series is detected by VC1.

The second step consists in connecting the primary windings of VT1 and VT2 in series so that the high-potential leads of the primary windings of VT2 and VTx are connected to the high-potential lead of the step-up transformer SUT ($S_1$ and $S_2$ in position 2). Using the RVS and ITp and adjusting the circuit input voltage by means of VR the voltages are set to one half of the primary voltage of VTx indicated above. The instant the voltages across VT1 and VT2 become identical occurs when the readings of VC1 and V are the same as in the first step. Using the readings of VC2, the effective error of VTx is obtained from (1) and (2).

It should be noted that in order to preserve the necessary polarity of the VC1 input voltages the phase shift of the VT2 output voltage is rotated through $\pi$ by reversing the output windings of IT.

The transformer components of the VD have the form of gas-filled modules and are constructed as a single block.

The designed setup differs from other similar systems [4, 5] in that the insulating transformer IT windings and the magnetic circuit and the low-potential lead of the primary winding of VT2 are in the course of measurement under one and the same potential so that the capacitive leakage remains unchanged. This made it possible to eliminate the error component due to the variation of the potential of the primary-winding shield of the auxiliary transformer [4, 5] in the course of measurement.

The principal metrological characteristic of the setup is its admissible test error for a confidence coefficient equal to 0.99. The effective test error has been determined for all regular operating modes of the setup over the entire voltage range in accordance with the recommendations of [6]. In the course of verification, the setup as a whole and its components were experimentally analyzed in order to determine the components of the non-excluded systematic error (NSE) components of the setup as well as the nature of the random com-