Calibración de transformadores de voltaje

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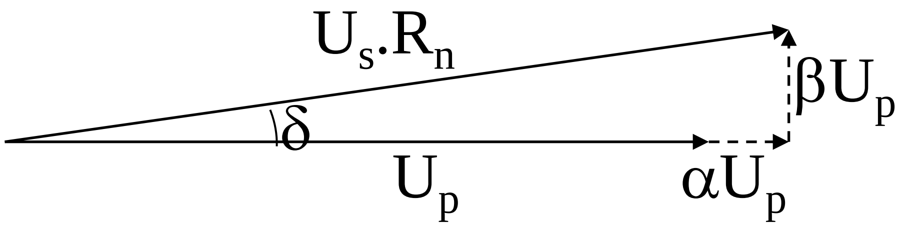
Errores

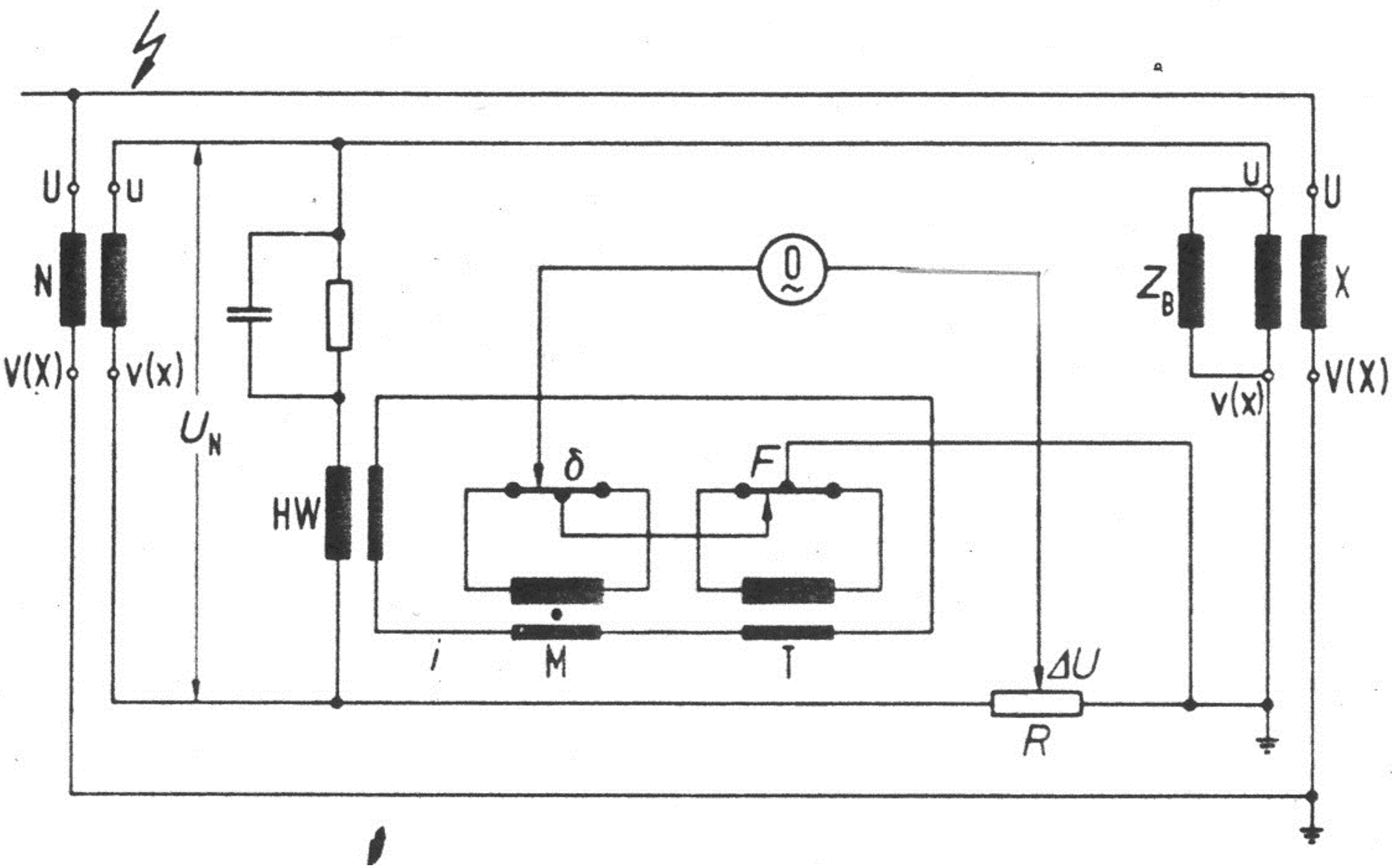


$$U_sR_n=U_p(1+\alpha+j\beta)\approx U_p(1+\alpha)$$

$$\delta \approx Ar\ \mathrm{tg}\,\beta \approx \beta$$

Si $\alpha>0$, la tensión de salida es mayor que la que debería ser.

Puente diferencial



Puente de transformadores diferencial LABUTE

Puente de medida

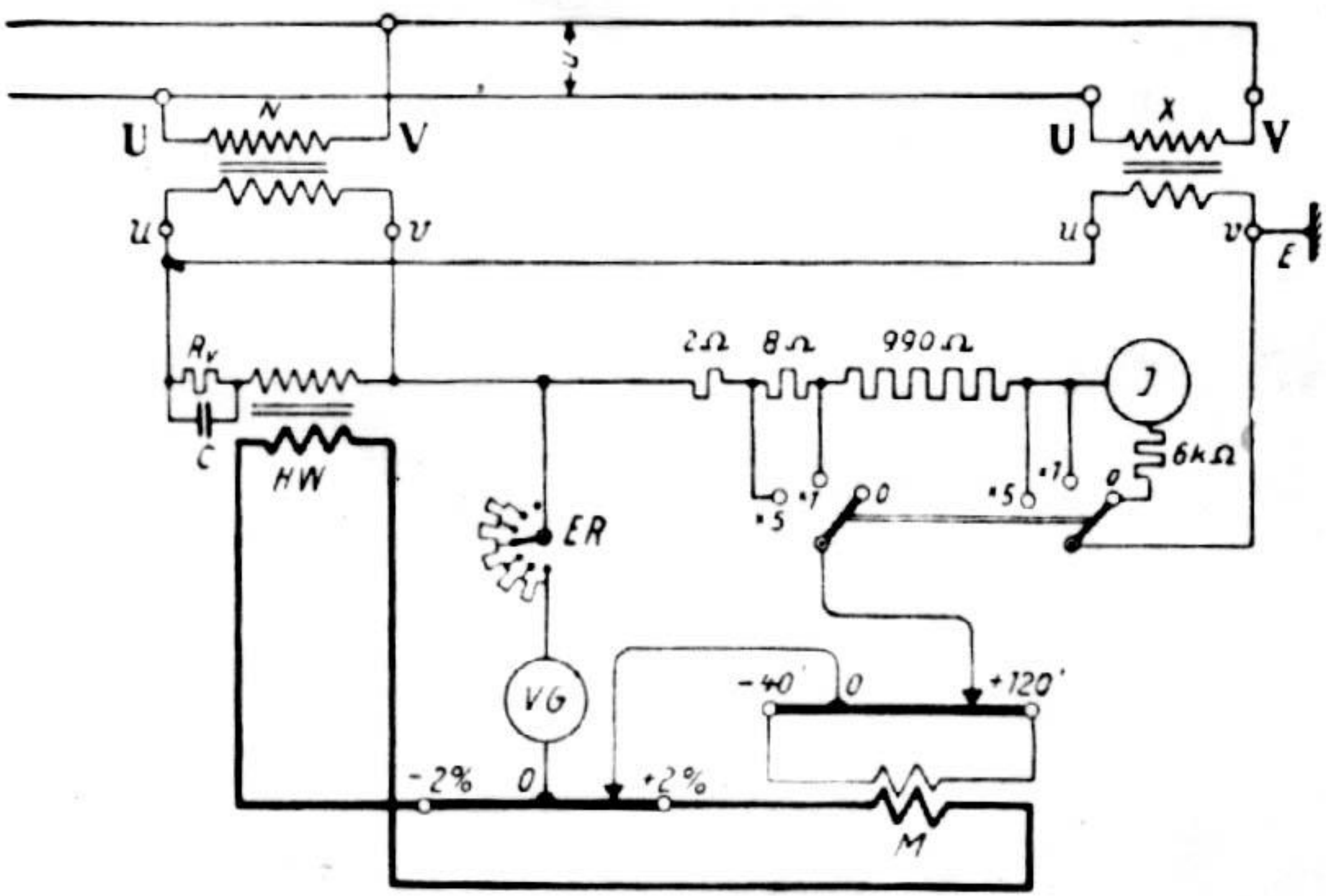


Abb. 2. Schaltbild der Spannungswandler-Prüfeinrichtung nach Dr. Hohle.

Galvanómetro eléctronico

Método diferencial con IVD

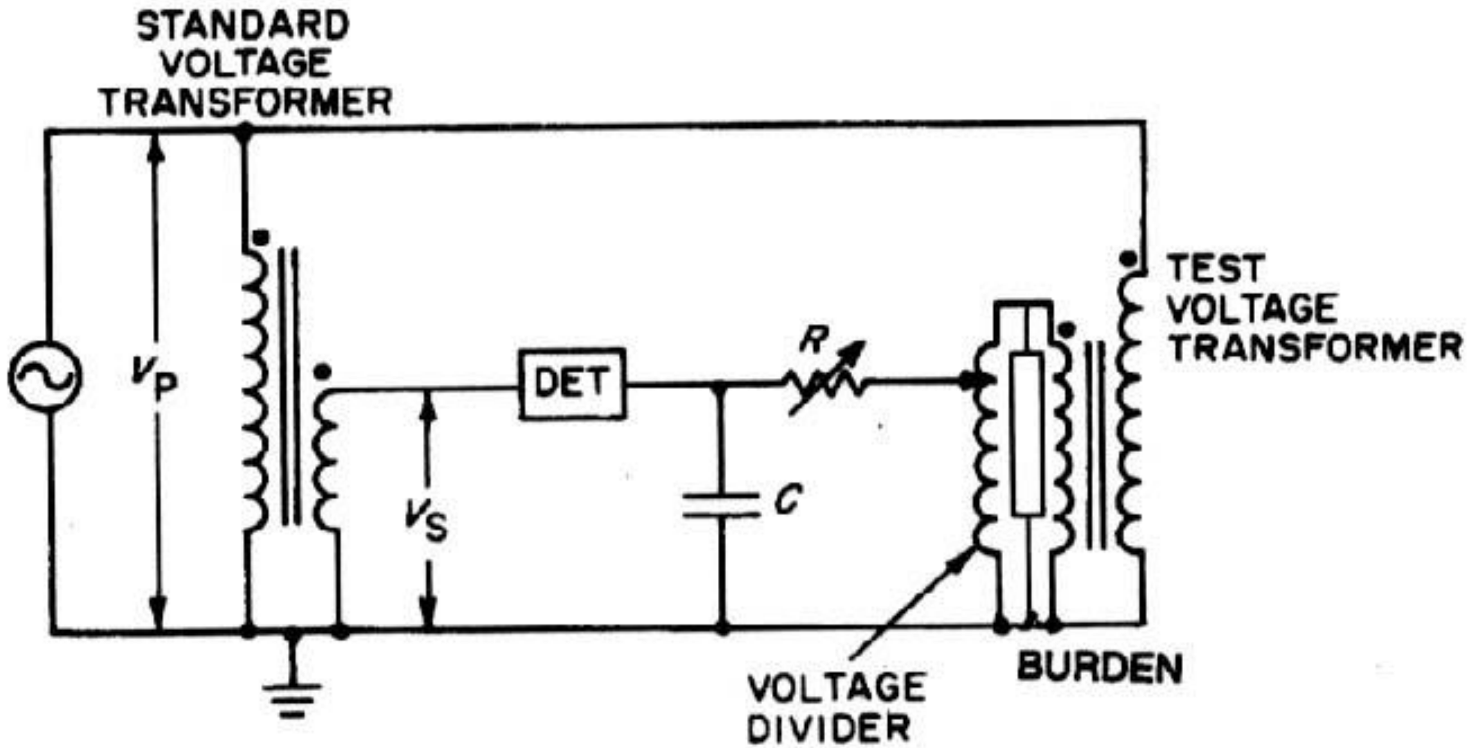
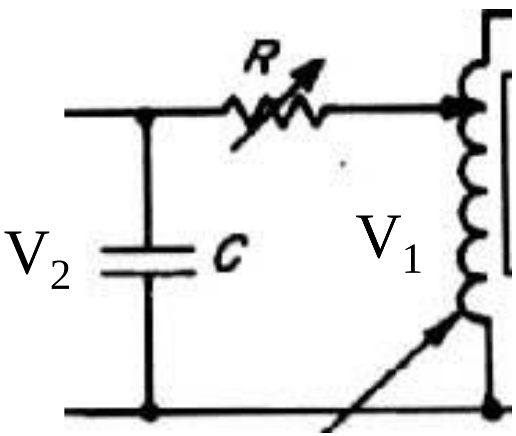


Figure 17 —Voltage transformer accuracy test—Comparative-null method

Desfasador



Sea V_1: tensión de entrada
V_2: tensión de salida

$$\frac{V_2}{V_1} = \frac{1}{1 + j\omega RC}$$

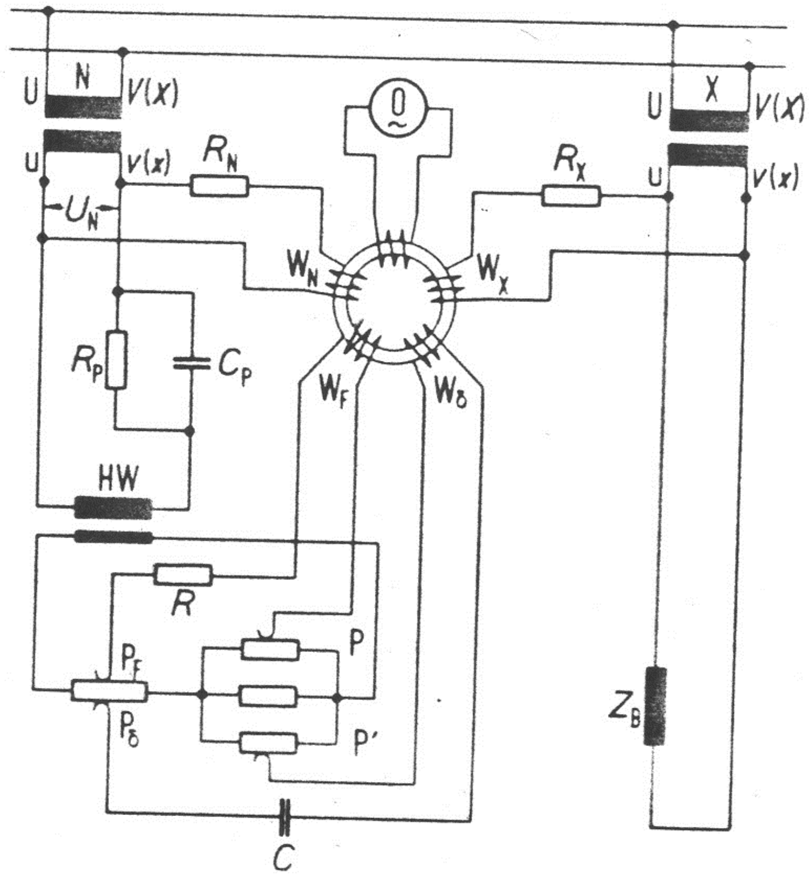
$$Arg\left(\frac{V_2}{V_1}\right) = -\omega RC$$

$$\left|\frac{V_2}{V_1}\right| = \frac{1}{\sqrt{1+(\omega RC)^2}} \approx 1 - \frac{(\omega RC)^2}{2} \approx 1$$

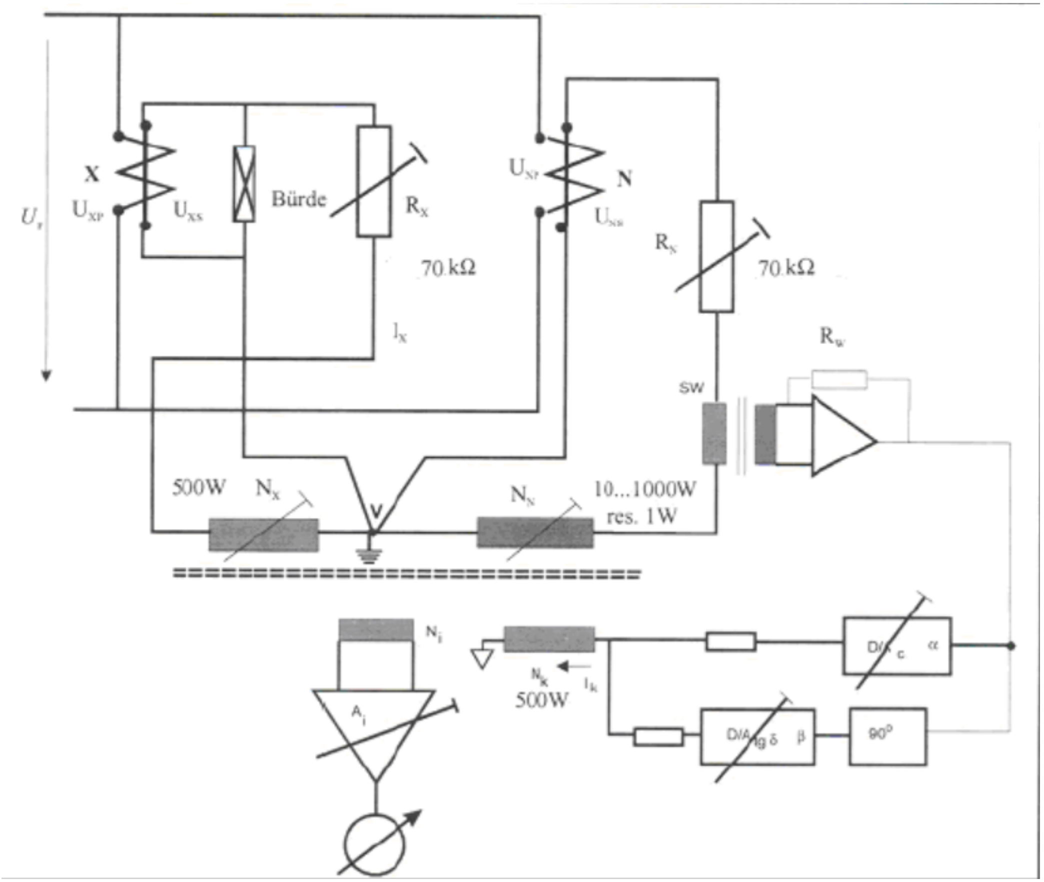
IVD

Precisión: ± 0,0005 %, ± 20 µ rad

Puente basado en comparador de corriente



Puente electrónico automático



Puente electrónico

Puente electrónico

Potential Transformer test part

Nominal voltage of the PT to be tested (X)	30 ... 350 V with factors 1, $^1/_2$, $^1/_3$, $1/\sqrt{3}$
Nominal voltage of the standard PT (N)	30 ... 350 V with factors 1, $^1/_2$, $^1/_3$, $1/\sqrt{3}$
Matching	0.5 ... 1.6
Working range	1 ... 210% of nominal current
Input voltage range N and X	1 V … 350 V
Frequency	50 and 60 Hz
Measuring range ratio error	± 20 %
Resolution ratio error	0.001 %
Measuring range phase angle	± 200 crad
Resolution phase angle	0.001 Min or 10 μrad
Uncertainty of ratio measurement	± 100 ppm ± 1% of reading
Uncertainty of phase measurement	± 100 μrad ± 1 % of reading
Inherent burden of X- and N-Side	30 kΩ … 110 kΩ
Resolution voltage measurement	0.1 % / 0.01 kV
Uncertainty voltage measurement	± 1% reading ± 1% of range

Método con comparador de corriente con capacitores

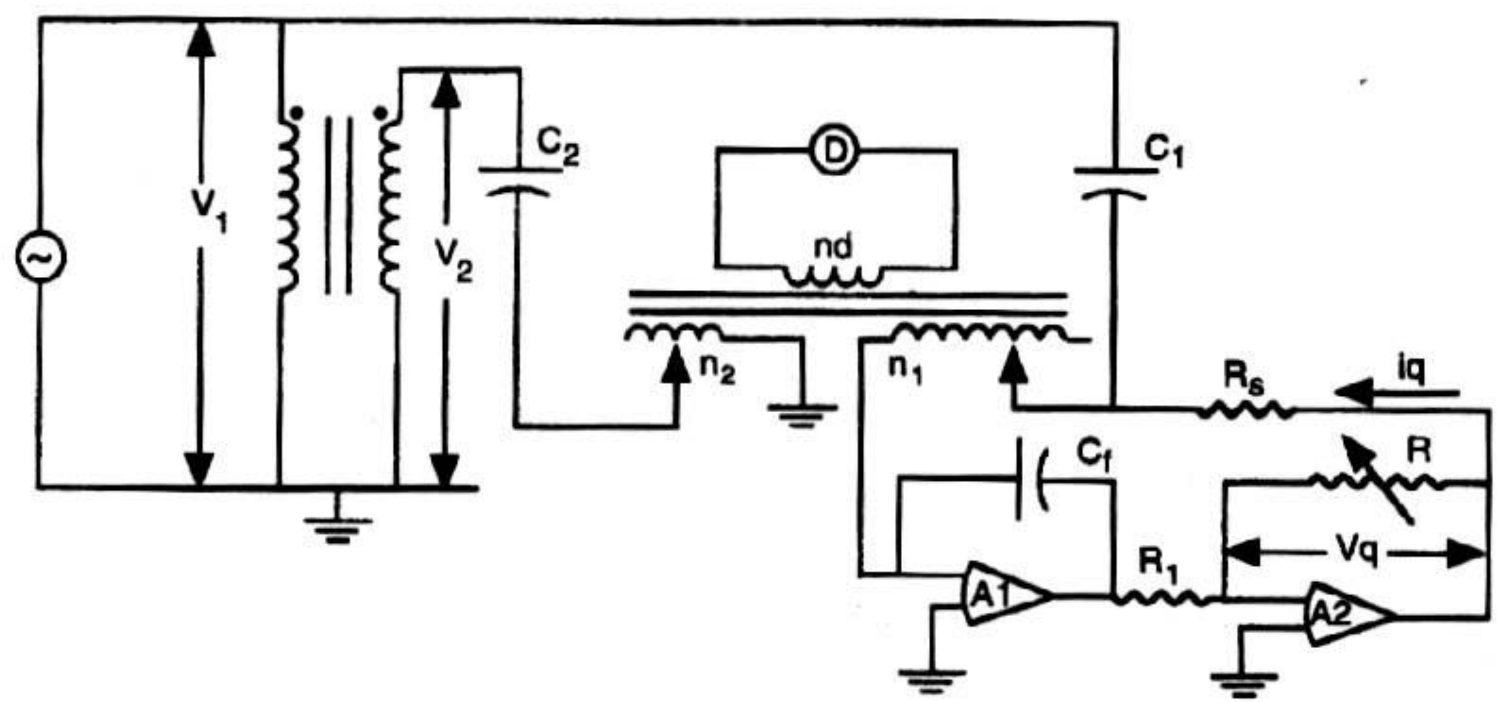


Figure 13 —Voltage transformer accuracy test (direct-null) current comparator— Capacitance ratio method

Método con comparador de corriente con capacitores

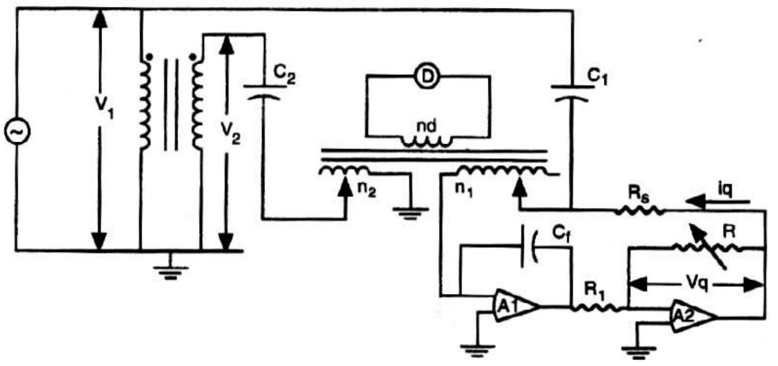


Figure 13 —Voltage transformer accuracy test (direct-null) current comparator—Capacitance ratio method

$$I_{C1} = V_1 j\omega C_1 \qquad I_{C2} = V_2 j\omega C_2$$

$$I_q \approx \frac{1}{R_s}\frac{R}{R_1}\frac{C_1}{C_f}V_1$$

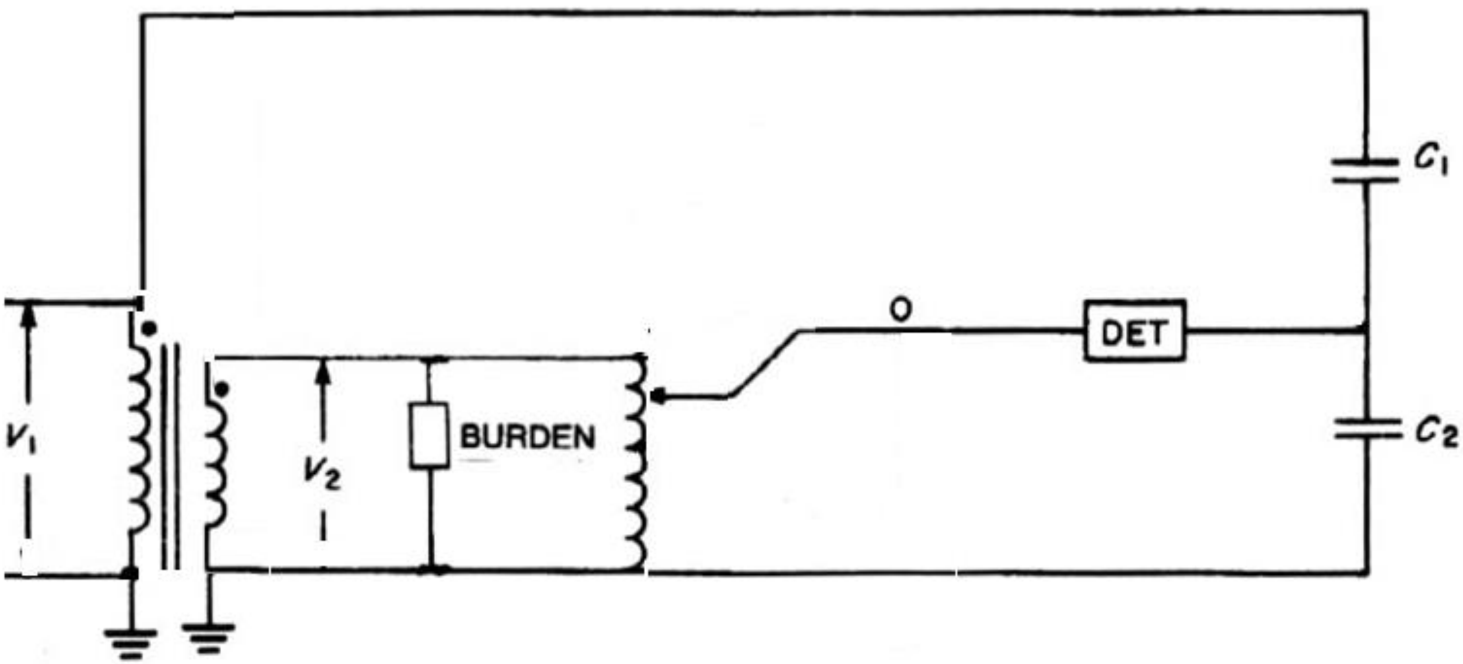
$$n_1 I_{C1} + n_1 I_q - n_2 I_{C2} = 0$$

$$n_1 V_1\left(j\omega C_1 + \frac{1}{R_s}\frac{R}{R_1}\frac{C_1}{C_f}\right) = n_2 V_2 j\omega C_2$$

$$\frac{V_2}{V_1} = \frac{n_1}{n_2}\left(\frac{C_1}{C_2} - j\frac{RC_1}{\omega R_s R_1 C_f C_2}\right)$$

$$Relación \approx \frac{n_1 C_1}{n_2 C_2} \qquad Angulo = -\frac{R}{R_1}\frac{1}{R_s \omega C_f}$$

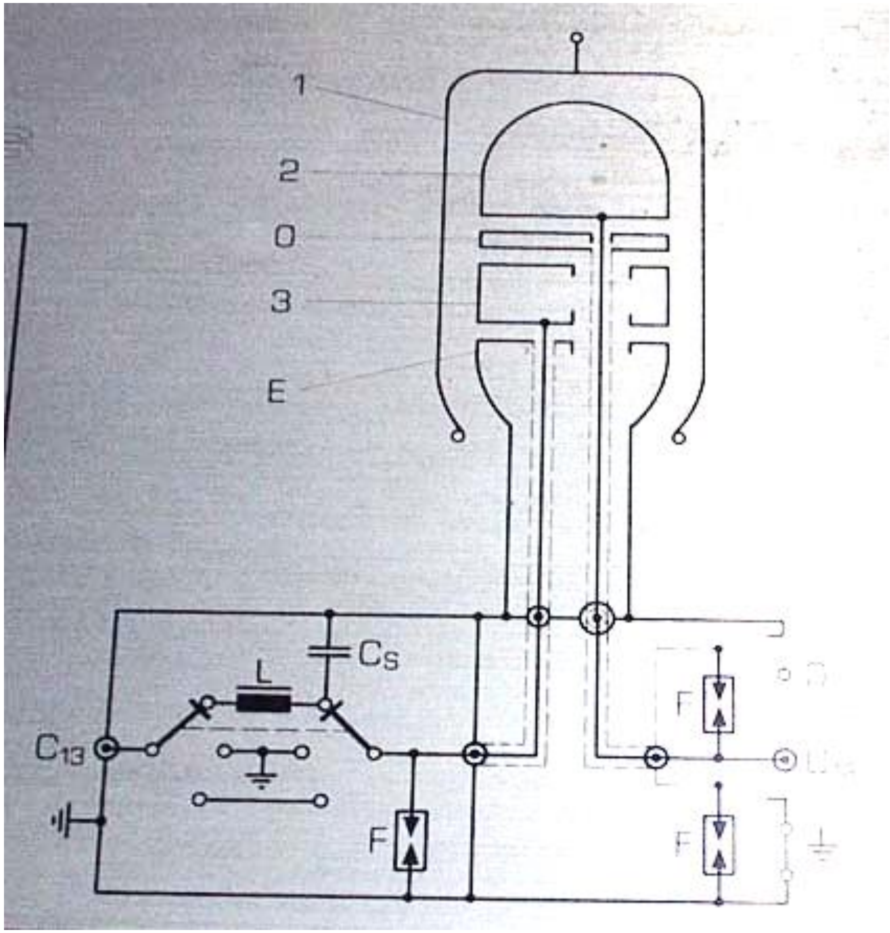
Método con divisor de tensión capacitivo



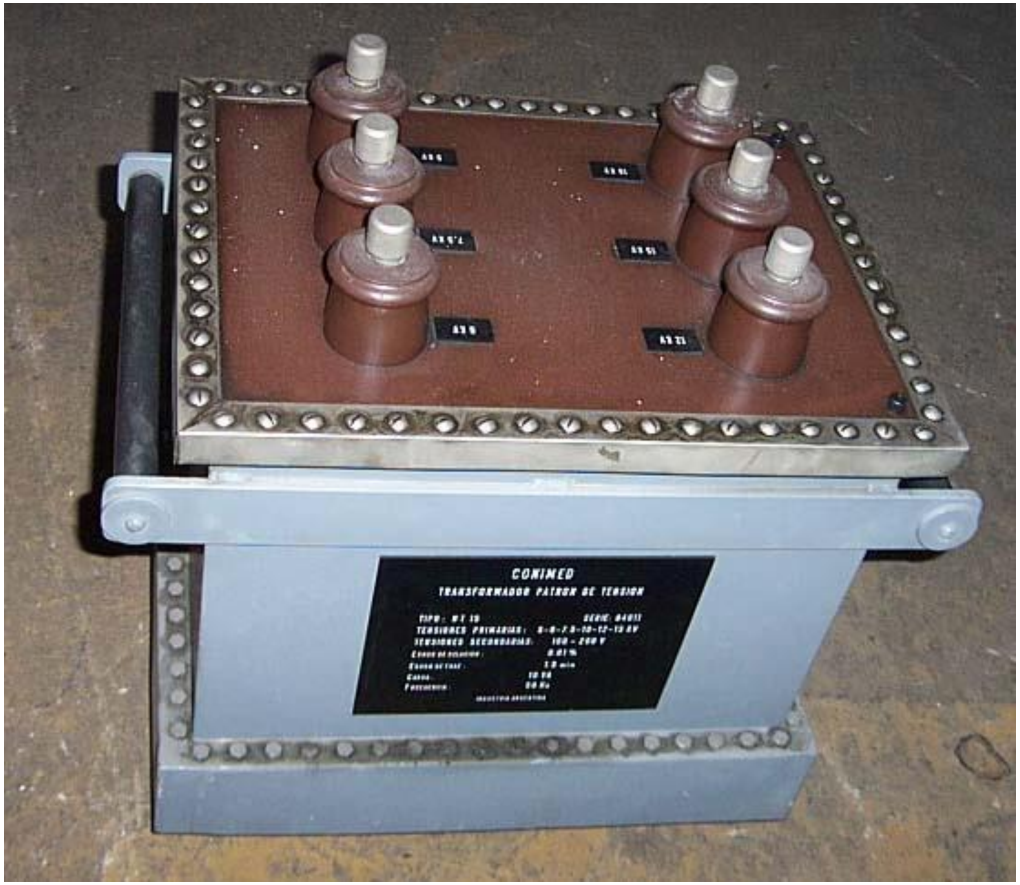
Ajuste de divisor hasta minimizar lectura en DET
Error relación: lectura de divisor, C1, C2
Error desfasaje: lectura DET

Capacitor patrón de gas de 200 kV

Capacitor patrón de AT
Placa de características



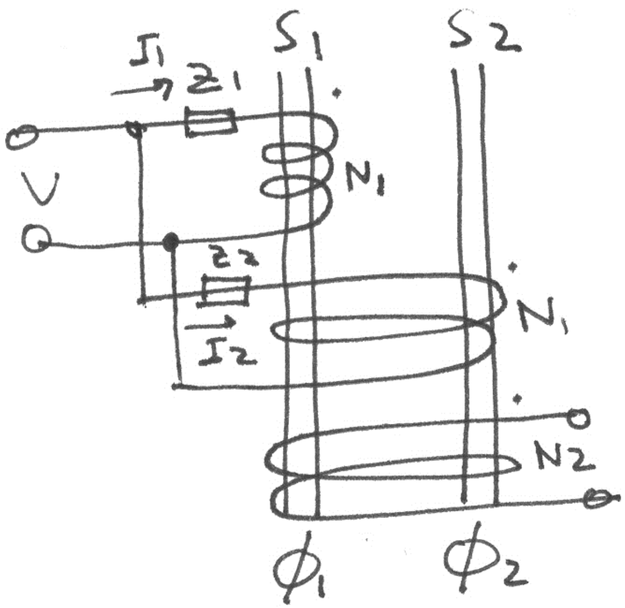
Transformador patrón 15 kV



Transformador patrón 100 kV

Exactitud: ± 0,01 % ± 1' para 0,3< U/Un< 1,2

Transformador patrón, doble etapa



$$E = -jN\emptyset\omega$$

$$NI = Hl = \frac{Bl}{\mu} = \emptyset l/(\mu A)$$

$$V - E = Z.I$$

$$\emptyset 1 = \emptyset(1 - e1)$$

$$E1 = -jN\emptyset 1\omega$$

$$E2 = -jN\emptyset 2\omega$$

$$I2 = \emptyset 2.\, l2/(\mu.\, A2.\, N)$$

$$V - (E1 + E2) = Z2.I2$$

Sustituyendo

$$V.\, e1 = \emptyset 2.\, N.\, \omega\left(\frac{Z2}{jXL_{L2}} + 1\right), \quad X_{L2} = \mu.\, A\mu 2.\, N^2\omega/l$$

$$V.\, e1(1 - e2) = \emptyset 2.\, N.\, \omega$$

Finalmente

$$\emptyset 1 + \emptyset 2 = \frac{jV}{N\omega}(1 - e1.\, e2)$$

Fin