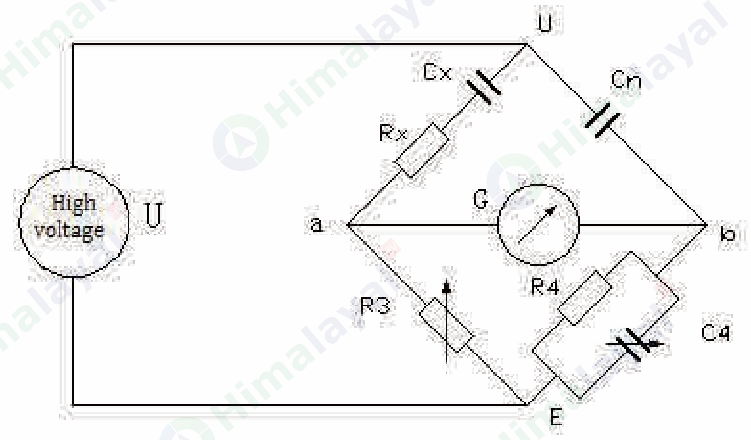
Basic Operation Principles for High Voltage Capacitance Tan Delta Bridge

(1) Schering Bridge



Adjust R3, C4 to balance tan delta bridge, during which voltage at a and b pole is equal, which means same voltage at R3 and R4 end.

Capacitance impedance in AC circuit is $\frac{1}{j\omega C}$. Parallel impedance of R4, C4 in the circuit equals reciprocal of sum of R4 reciprocal and C4 reciprocal.

$$\frac{1}{\frac{1}{R4}+\frac{1}{\frac{1}{j\omega C4}}}=\frac{1}{\frac{1}{R4}+j\omega C4}=\frac{R4}{1+j\omega R4C4}$$

On basis of principle of impedor partial pressure, it's easy to acquire:

$$Ua=\frac{R3}{\frac{1}{j\omega Cx}+Rx+R3}U=Ub=\frac{\frac{R4}{1+j\omega R4C4}}{\frac{R4}{1+j\omega R4C4}+\frac{1}{j\omega Cn}}U$$

Take reciprocal of both sides of the equation, we get:

$$\frac{1}{j\omega R3Cx}+\frac{Rx}{R3}=\frac{1+j\omega R4C4}{j\omega R4Cn}=\frac{1}{j\omega R4Cn}+\frac{C4}{Cn}$$

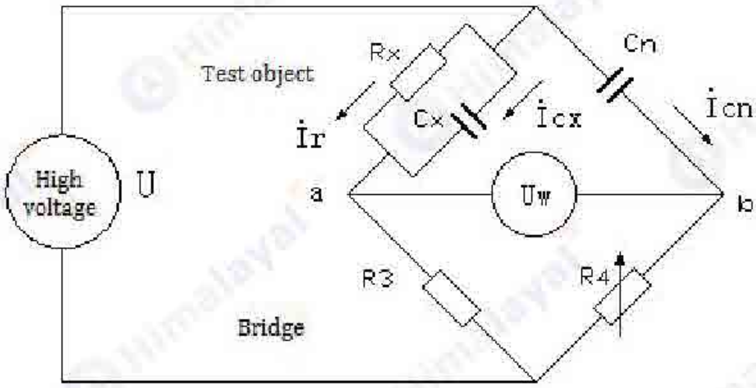
According to stipulation of equal complex number and real, imag equals respectively, we get:

$$Rx=\frac{C4}{Cn}R3 \qquad Cx=\frac{R4}{R3}Cn$$

Define $tg\delta = \omega RxCx = \omega R4C4$ based on parallel model dielectric loss, on account of fixed R4, dielectric loss can be read from C4 dial, Cx can be calculated with R3, R4, Cn.

Instruments apply this principle include on-site QS1, laboratorial 2801, etc.

(2) M-type tan delta bridge



Change test object to parallel model. Please note that Ir forms a 90 angle with Icx, Icn:

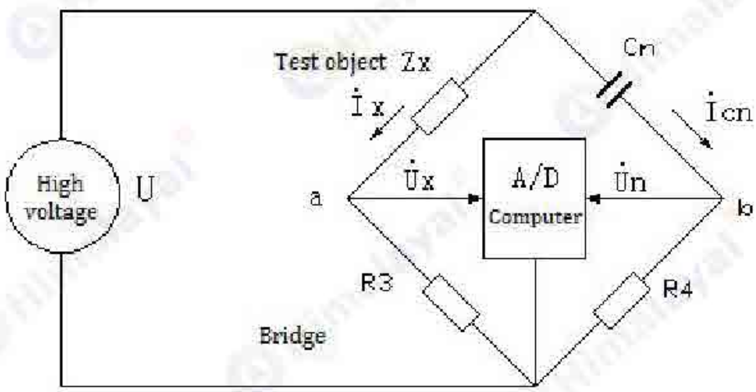
$$Uw = \sqrt{(IcnR_4 - IcxR_3)^2 + (IrR_3)^2}$$

Adjust R4 to minimize Uw. During which IcnR4=Icx R3, Uw-IrR3, thus:

$$tg\delta = \frac{Ir}{Icx} = \frac{Uw}{IcnR_4}$$

By reason that voltage between a and b isn't completely offset, therefore M-type tan delta bridge is also referred to as imbalance tan delta bridge. Uw measures absolute value, voltage is low under small dielectric loss, test precision can't be guaranteed.

(3) Digital tan delta bridge



Test circuit for digital tan delta bridge is still a bridge. Voltage at R3 and R4 end is sampled and transferred to computer through A/D, acquire $\dot{U}x$、$\dot{U}n$:

$$\dot{I}cn = \frac{\dot{U}n}{R4}, \quad \dot{I}cx = \frac{\dot{U}x}{R3}, \quad \dot{U} = \dot{I}cn \times \text{Standard capacitor impedance} = \frac{\dot{I}cn}{j\omega Cn}$$

$$\text{Test object impedance } Zx = \frac{\dot{U}}{\dot{I}cx} = \frac{R3}{R4} \times \frac{\dot{U}n}{\dot{U}x} \times \frac{1}{j\omega Cn}$$

Acquire test object dielectric loss and capacitance through further calculation.

The biggest advantage of digital tan delta bridge lies in: automatic measurement, makes up for all theoretical error, no complicated mechanical adjustment component, software-oriented measurement, stable performance.