Capacitance and Dissipation Factor Measurement

The capacitance and dissipation factor measurement is a popular and proven test to determine the losses in a rotating machine insulation system.

An ideal insulation with negligible losses can be modelled as a capacitor that draws a current which is 90° leading with respect to the applied voltage. However, in a real insulation there will be dielectric losses due to polarization, conduction, surface currents, etc. The insulation of a rotating electrical machine can hence be modelled by a loss-free capacitance with a parallel ohmic resistance representing the losses in the insulation system (Figure 1).

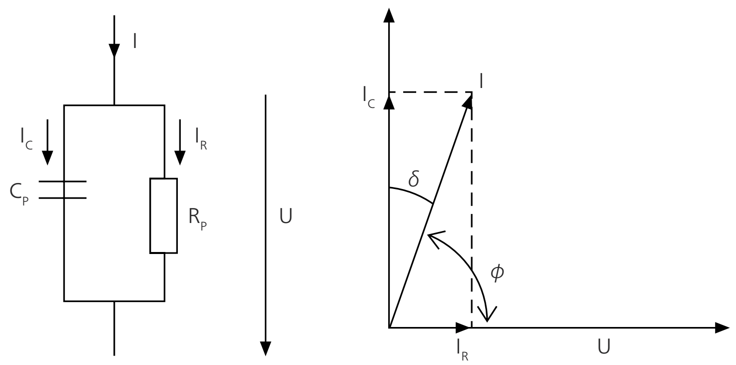

Figure 1: Basic modelling of a rotating machine insulation system with the parallel equivalent circuit diagram and vector diagram.

Simply speaking, the higher the resistive current, the bigger the dielectric losses, which will further increase the deviation of phase angle between resultant current and applied voltage from 90°. Thus tan(δ), the ratio between resistive current and capacitive current, can be an indication of the overall condition of the insulation system of a rotating electrical machine:

$\tan(\delta) = \frac{I_R}{I_C}$	Loss factor (Dissipation Factor/DF or tan delta)
$\cos(\phi) = \frac{I_R}{I_{test}}$	Power factor (PF)

The dissipation/power factor measurement is a high-voltage AC test. The value is measured by comparing the test object to a known standard reference capacitor (C). The test voltage and frequency as well the main insulation capacitance determine the required test current.

$$I_{Test} = 2 \times \pi \times f \times U_{Test} \times C_{Test}$$

The main insulation between phase-to-ground of generators and motors represents large capacitances. This means that the test object (represented by C_{Test}) would cause huge apparent power when applying high voltage. To ensure a lightweight system with a minimum need for power, the OMICRON approach is to use a parallel resonant system that compensates the test object capacitance together with parallel inductors.

The compensation depends on the capacitance of the test object. Therefore, the capacitance must be known. Previous tests, such as factory acceptance testing or measurements during previous maintenance periods, determine the value. If the capacitance is unknown, the capacitance can be measured on site initially with any TD device without losing additional setup time.

Figure 2 explains the principle of the compensation. Without any parallel resonators, the entire apparent charge needs to be delivered by the source, which is shown on the left-hand side. The large test capacitance requires high apparent power and therefore a source that can deliver it, which can make the solution quite bulky. On the right-hand side, a compensation was done with an inductance in parallel. If this compensation is done correctly, the apparent power reduces to a minimum and the source transforms to become a more portable solution.

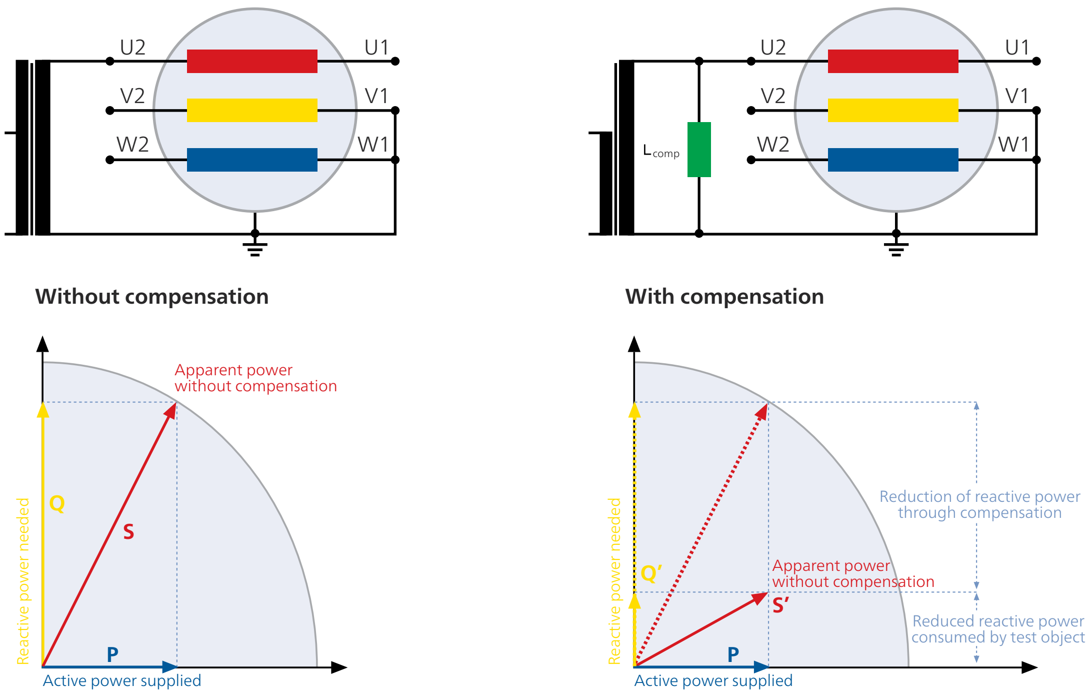

Figure 2: Simplified diagram of compensation with reactor

Once the capacitance is known, the compensation requirement can be calculated. This is done automatically either via the front panel of the CPC 100 or with the Primary Test Manager™ (PTM) software. The setup of the CP CR600 involves fast daisy chain connections of devices – the number of which is based on the capacitance of the Device Under Test (DUT). The following connection diagram shows the setup for two CP CR600 units.

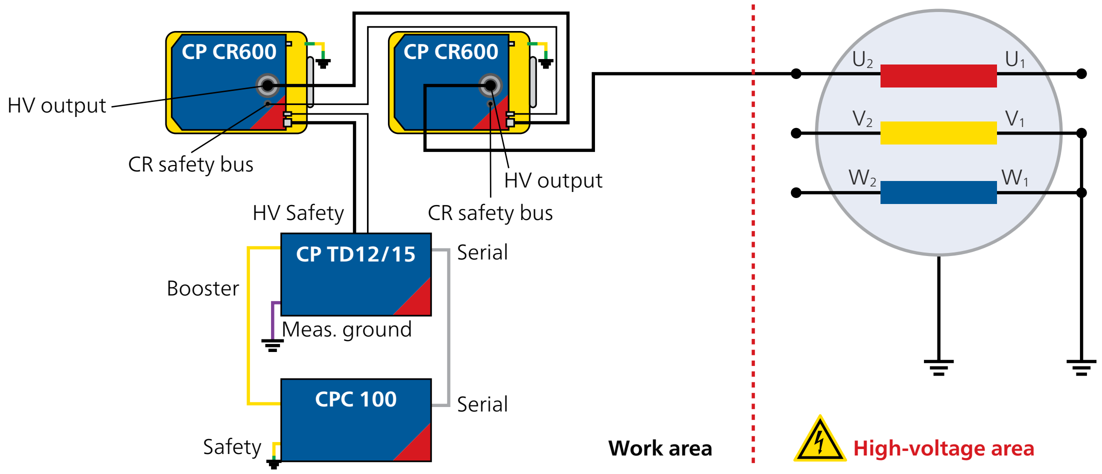

Figure 3: Setup for capacitance and dissipation factor measurement with a compensation of two CP CR600 units