Hipot Tests :
Real current and total current

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Introduction

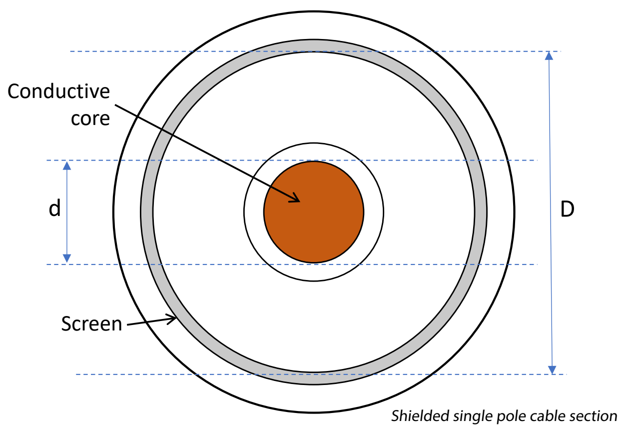
During dielectric strength tests under AC voltage, measurement problems can appear linked to the capacitive effect generated by som equipment to be tested such as :

- sheated or shielded electrical wires
- capacitors
- insulating materials or protection equipement
- electronic equipment

In the case of a capacitor, this effect is obviously coming from the DUT's nature and function, but for other equipment, it comes from their design and depends on the elements they are made of.

Example of a shielded monopolar cable

In the case of a monopolar electric cable, we see that by construction, it can behave at 50 or 60 Hz like a capacitor. The insulating material it is made of contributes to the parasitic capacitive effect created between the core of the cable and its outer shielding.



Shielded single pole cable section

This parasitic capacity is generally specified by linear quantities, the unit used being a sub-multiple of the Farad per kilometer.

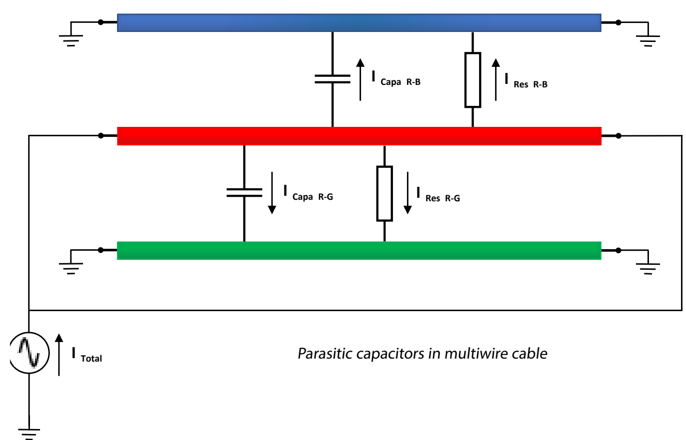
The value of the equivalent capacitor in the case of a shielded cable monopolar is equal to:

$$C = \frac{\varepsilon_0 \times \varepsilon_r}{18 \times \ln(D/d)} \quad \text{exprimé en } \mu F/km$$

ε_0 vacuum permittivity ($8{,}85 \times 10^{-12}$ F/m) and ε_r relative permittivity of the insulator or insulating material, eg. 2.25 for polyethylene.

Example of a shielded monopolar cable and harness.

Cables or wire harnesses are subjected to numerous operations during their manufacture, for example crimping connectors, laser marking, bending, etc. which are liable to deteriorate the quality of their insulation and must undergo rigidity tests to validate their use. The cable harnesses used in railway and aeronautical applications have lengths which can reach several hundred meters and therefore also have a significant capacitive effect between each wire and its environment. This will eventually generate capacitive currents that are greater than the resistive currents. It is therefore essential to separate the measurement of the two currents in order to properly qualify the insulation resistance of the wire harness.



Parasitic capacitors in multiwire cable

Consequences of the capacitive effect during an AC dielectric strength measurement:

In a breakdown test, the goal is to measure the resistive leakage current flowing through an insulator. However, we have just seen that a parasitic capacitive effect can appear, generating a leakage current which should not be considered to characterize the dielectric quality of the equipment under test.

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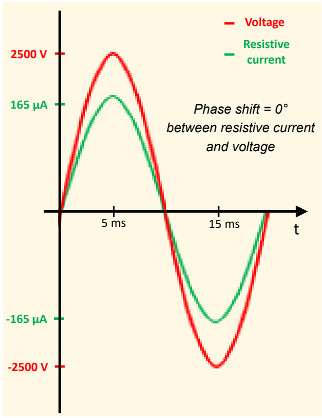
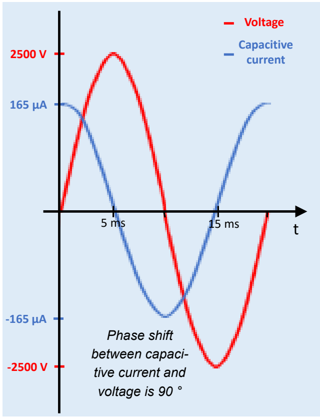
The total current measured is the result of the vector sum of two currents :

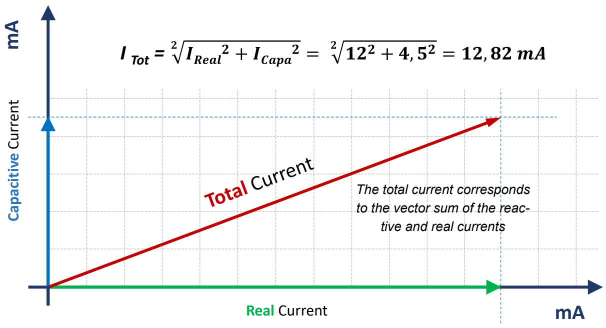
- Resistive current, called **real** current
- Capacitive current, called **reactive** current

Applying an AC dielectric strength test voltage to a capacitive element such as a cable generates a reactive current that is 90 ° out of phase with the applied voltage. The resistive leakage current is in phase with the voltage.

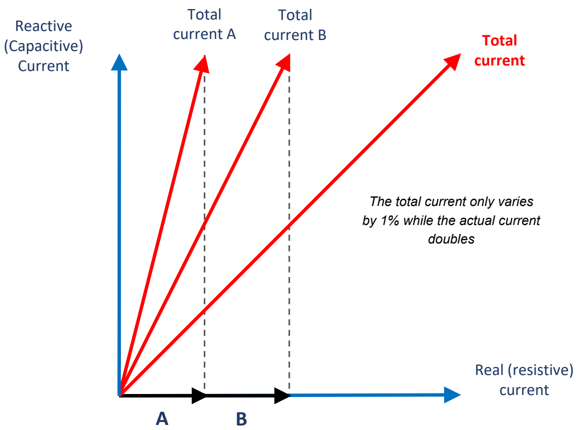




The leakage current that is measured by most dielectric strength testers is the vector sum (square root of the sum of squares) of the reactive current (capacitive current) and the actual current (resistive current). The resistive current is related to the insulation resistance and the voltage applied to the item under test.



When the capacitive currents are greater than the resistive currents, it becomes essential to separate the measurement of the two currents in order to correctly qualify the insulation resistance of the equipment under test, for example a wire harness. Due to unbalanced capacitive (high) and resistive (low) current values, doubling the resistive current may only cause an increase of 1% of the total current and therefore not be detected if we do not measure each current separately.



$$\frac{I_{real\ B}}{I_{real\ A}} = 2$$

$$\frac{I_{total\ B}}{I_{total\ A}} = 1,1$$

$$\frac{I_{reactive\ B}}{I_{reactive\ A}} = 1$$

AC or DC hipot tests

To avoid having to distinguish between reactive and real currents, it is possible to perform dielectric strength tests with a DC voltage. The advantage of this method is that the influence of the reactive current occurs only during the charging phase, but once the voltage is reached only the resistive current linked to the insulation resistance of the cable flows.

However, there are some disadvantages to performing dielectric strength tests in DC voltage, here are some examples:

- the standards do not always allow a DC test voltage.
- DC voltages must be higher than in AC (ratio 1.414).
- the tests are done with a single polarity and are therefore less stressful than in AC.
- the measuring devices must differentiate between the load current and the established voltage current.
- the cable or equipment must be dsicharged after the test .

So the interest of dielectric strength tests in AC remains important if the measuring devices are able to differentiate the resistive and capacitive currents.

Real and total current measurement with the SEFELEC 5x range

The SEFELEC 5x range of single and multi-function measuring devices allows you to carry out stiffness tests in AC or DC. Thanks to the performance of their measurement core and their large touch screen, all models display the total current and the actual current.

SEFELEC 506-S performing hipot test displays real and total currents

It is of course possible to set the IMAX detection thresholds on one or the other of the currents (real or total).

Model	Power	Voltage range	Detection threshold
SEFELEC 56 - H/D/S	50 VA	$100\ V_{DC}$ - $6000\ V_{DC}$ $100\ V_{AC}$ - $5000\ V_{AC}$	0,001mA to 9,999 mA by steps of 1µA
SEFELEC 506 - H/D/S	500 VA		0,01mA to 110 mA by steps of 10 µA

Additional functions such as programming of rise / hold / fall times, multi-rigidity or recording of measurements at defined intervals (data-logging) are also available on the 5x range.

The Winpass MX software allows the control of the device by PC and the edition of personalized reports.

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