2 Capacitor Characteristics

The essential characteristics for a capacitor are presented and explained in detail in this chapter. These characteristics are crucial in the selection of a capacitor for a certain application.

2.1 Capacitance of a capacitor

Capacitance C

The most important characteristic of a capacitor is its capacitance C. The capacitance C describes the property of a capacitor's capability to store electrical energy if a (given) voltage U is applied. Capacitance denotes how many units of charge can be stored in the capacitor per voltage unit. Furthermore, the capacitance is important for the AC resistance of a capacitor at certain frequencies, essentially the properties when used in filters.

The unit in which capacitance is specified is a Farad. This was named after the English natural scientist and prominent experimental physicist Michael Faraday (1791 to 1867). A capacitor which is charged to one Volt with one Coulomb of charge (this means that one Ampere of current flows for one second) has a capacitance of one Farad.

The following relationship applies:

$$1\mathrm{F} = 1\,\frac{\mathrm{AS}}{\mathrm{V}} \tag{2.1}$$

The capacitance of a capacitor is normally specified in pF, nF or µF. The most common capacitors today lie within this order of magnitude. Values greater than one Farad are attained in the field of super-capacitors. The trend is towards achieving increasingly large capacitance values.

The capacitance of a capacitor essentially depends on the area jointly covered by the electrodes, the separation of the electrodes, the dielectric used and its thickness (see Chapter 1.8 Capacitor).

The capacitance of a capacitor can be increased by means of the following design parameters:

- increase in the effective area of the electrodes
- reduction in the separation between the electrodes
- thinner layer of dielectric
- increase in insulation with a suitable dielectric with higher permittivity or improved dipole formation

2.1.1 Dependence on voltage

By applying a voltage, some insulators used in capacitors as dielectric experience a change in permittivity ε_r and consequently a reduction in capacitance. This can be explained in the case of the dielectrics mentioned here in that once a specific voltage is applied to the electrodes, a defined polarization of the molecules occurs. This reduces the permittivity ε_r of the material or dielectric.

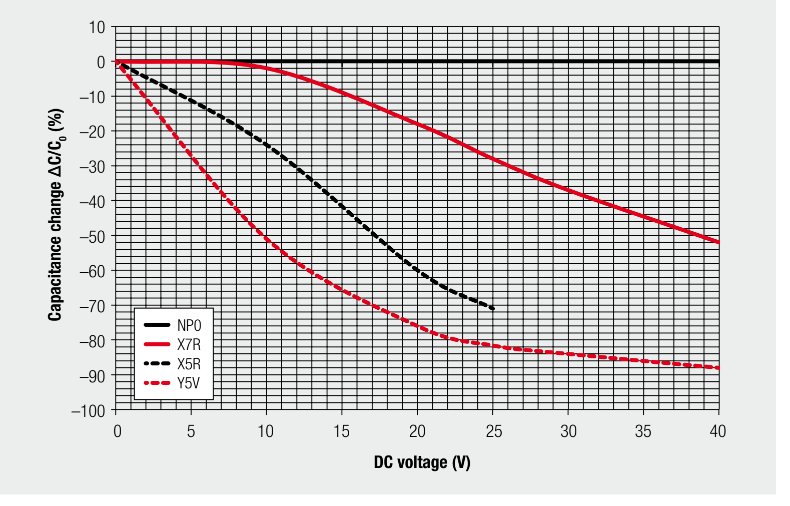

Fig. 2.1: Voltage-dependent capacitance change, example: ceramic capacitors

2.1.2 Dependence on frequency

Capacitor types exist for which a frequency-dependent change in permittivity ε_r occurs. Generally the capacitance of a capacitor drops when the voltage applied increases.

This can be illustrated with the example of an X2 film capacitor in which polypropylene is used as the dielectric. The graph in Figure 2.2 shows the percentage change in capacitance over the frequency band from 1 kHz to 100 kHz.

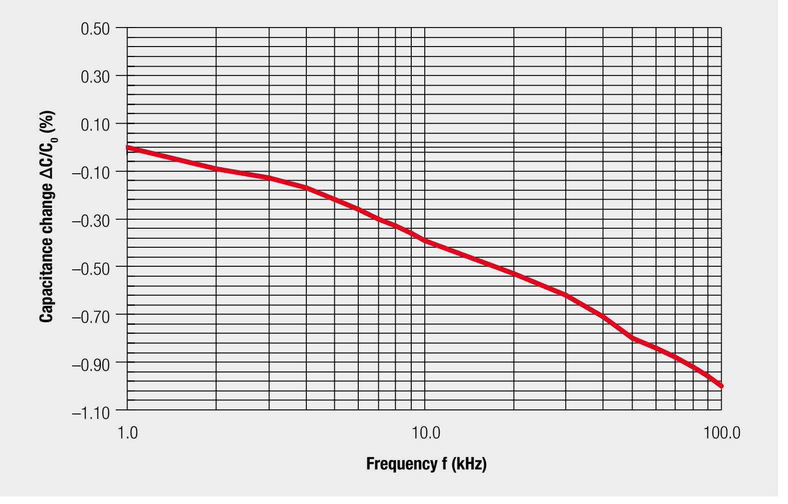

Fig. 2.2: Frequency-dependent capacitance change, example: MKP film capacitor

2.1.3 Dependence on time

Changes in capacitance can occur over time or use in the application. Possible effects:

a) time-limited capacitance change due to temperature change
If the capacitor is subjected to large temperature changes, which are still within the permissible and specified temperature limits, it may occur that the capacitor does not show the intended capacitance value for a certain time The dependence of capacitance on temperature is presented in detail in Chapter 2.10 Temperature coefficient/temperature dependence.

b) Capacitance change due to aging
Aging of a capacitor is caused by its type and the materials it contains. The respective aging behavior has to be taken by the user from the capacitor datasheet or ascertained from the manufacturer.