Capacitors

for Use in Electronics

Capacitors

Iskra®

General technical data

ISKRA capacitors for use in electronics are made of dielectric materials as follow:
- polypropylene film
- polyester (polyethyleneterephtalate).

Survey of specific properties of individual dielectrics and use:

Polyester (polyethylenete-rephtalate) film

Dielectric constant (25 °C/1 kHz):
ε_r = 3,25; ASTM D 150-65T

Dielectric loss (25 °C/60 Hz):
tanδ ≤ 20,10^{-4} C;
ASTM D 150-65T

Dielectric strength (25 °C/60 Hz):
295 kV/mm; ASTM D 149-64,
ASTM D 2305-67

Temperature coefficient of capacitance:
TC ≈ + 500, 10^{-6} C/°C

Temperature range max.:
+ 125 °C

Water absorption (sink for 24 h):
0,8 % max.; ASTM D 570-63

Dielectric absorption:
0,2 to 0,8 %

Polyester capacitors are used mainly in electronic devices where special characteristics of electrical parameters are not required and where wider temperature range is required. Mainly they are used as conjuctive or block capacitors.

Polypropylene film

Dielectric constant (25 °C/1 kHz):
ε_r = 2,2; ASTM D 150

Dielectric loss (25 °C/1 kHz):
tanδ ≤ 5,10^{-4} C; ASTM D 150

Dielectric strength (25 °C/1 kHz):
300 to 380 kV/mm; ASTM D 149

Temperature coefficient of capacitance:
(- 100 ≤ TC ≤ -300) ,10^{-6}/°C

Temperature range max.:
+ 100 °C

Water absorption:
< 0,05 %; ASTM D 202

Dielectric absorption:
0,03 %

Polypropylene capacitors are used mainly in electronic circuits, where following requirements appear:

- small dielectric losses
- high insulation resistance
- negative and defined temperature coefficient (temperature compensation at oscillating circles with ferrite coil)
- high pulse loading
- loading with AC voltage.

Designation of dielectric in type code of capacitors

Type code is composed by three letters and four figures:

K	X	X		Y	Y	Y	Y
↓	↓	↓		↓	↓	↓	↓
1	2	3		4	5	6	7

1st Letter, "K" means capacitor

2nd Letter tells the type of dielectric (special for metallized version)

3rd Letter tells the purpose of use

4th, 5th, 6th, 7th Figure describes construction and design of capacitor and leads

Survey of letter used for single kinds of dielectric:

F - polyester film

E - metallized polyester film

L - polypropylene film

N - metallized polypropylene film

Electrical characteristics

1. Rated capacitance

Rated capacitance C_R values are available according to E-ranges. Available E-ranges (E6, E12, E24, E48, E96, on request E192) are stated at type descriptions in catalogue. The values from range E6 are privileged.

The E-ranges are put down in accordance to IEC-publ. 60063 and DIN 41426.

Required values from E-range are all values from table below, multiplied by positive or negative whole number power exponent of the number 10.

2. Tolerance of rated capacitance

Standard tolerances and belonging codes for marking tolerances of rated capacitances are as follow:

Tolerance	± 20 %	± 10 %	± 5 %	(± 2,5 %)	± 2 %	(±1,25 %)	± 1 %	± 0,5 %
Code	M	K	J	(H)	G	(E)	F	D

The narrowest possible tolerance is ± 1 pF (Z).

Available tolerances of rated capacitances are stated at type descriptions in catalogue.

3. Temperature dependence of capacitance

Temperature coefficient TC is defined for temperature range $\vartheta_1 \ldots \vartheta_2$ according to DIN 41380 as follows:

$$TC = \frac{C_2 - C_1}{C_3 (\vartheta_2 - \vartheta_1)}$$

C_1 - capacitance at temperature ϑ_1

C_2 - capacitance at temperature ϑ_2

C_3 - capacitance at temperature (25 ± 10) °C

Temperature coefficient for single type of capacitors is given in 10^{-6}/°C.

4. Rated voltage U_R

The rated voltage U_R is the maximum direct voltage which may be applied continuously to the terminals of a capacitor at any temperature between the lower category temperature and the rated temperature.

5. Category voltage U_C

Category voltage U_C is the maximum direct voltage which may be applied to the terminals of a capacitor at its upper category temperature. Adequate reducing of voltage for temperature range between upper rated temperature and category temperature is given at single types of capacitors in catalogue.

6. Alternating voltage loading

Allowed alternating voltage loading for single types is limited to frequency 50 to 60 Hz. The sum of applied alternating voltage (amplitude) and direct voltage to the terminals of a capacitor must not exceed category voltage U_C. In general mica and plastic foil capacitors are not suitable for connection to network, exept special versions of capacitors, which are suitable also for such purposes.

7. Allowed self-heating because of alternating voltage loading

If capacitors are loaded with alternating voltages of higher frequences with sinusoidal or unsinusoidal shape of alternating voltage, than self-heating and pulse loading is to consider.

Self heating of capacitor ($\Delta\vartheta$) is in operating of capacitor conditioned by belonging power loss (P_i) and outer surface of capacitor (S), and is calculated by the following from:

$$\Delta\vartheta(K) = \frac{P_i\,(mW)}{S(cm^2)\,\beta}$$

where the base for termoplastic case is used

$$\beta = 1\,\left(\frac{mW}{K \cdot cm^2}\right)$$

Power loss of capacitor (P_i) at loading with sinusoidal voltage of higher frequences is calculated as follows:

$$P_i = U_{ef}^2 \cdot 2\,\pi \cdot f \cdot C \cdot \tan\delta_{(f)}$$

where:

C = capacitance in F
U_{ef} = effective voltage in V
f = frequence in Hz
$\tan\delta_{(f)}$ = loss factor at frequence f
P_i = power loss in W

At un-sinusoidal alternating voltage it is to be dismantled according to Fourier's analysis to sinusoidal voltages and calculated the power loss as a sum of single partial sinusoidal power losses. For carrying-out the Fourier's analysis the voltage-time diagram is needed.

The sum of temperatures because of self-heating and temperature of surroundings of capacitor may be equal or lower than permitted category temperature with considering the category voltage U_C.

8. Pulse loading

The capacitors charged with un-sinusoidal voltage pulses with quick rise (high du /dt) will be loaded with high current pulses. Because of overloading of internal contacts and connections in capacitor the current must be limited, The boundary current for single types of capacitors depend on:

- amplitude and shape of pulse
- rated voltage of capacitor
- capacitance
- geometrical shape of capacitor.

At the repeating pulses the current loading will be limited by self-heating, surrounding temperature and cooling.

The limit of allowed current loading is given with allowed voltage rise in time (du/dt) in V/µs (volts per microsecond)

$$I_{max} = C_R \frac{du}{dt}$$

C_R = rated capacitance in µF
du/dt = allowed pulse loading in V/µs

At single types of capacitors the data of allowed pulse loading is valuable for unlimited number of pulses (charging and discharging of capacitors) up to rated voltage U_n. Minimum resistance in series with capacitor is then:

$$R = \frac{U_R}{C_R \cdot du/dt}$$

where:

U_R = rated voltage of the capacitor in V

C_R = rated capacitance in µF

R = min. series resistance in Ohm

At the pulses of lower voltage than rated voltage the given values of allowed pulse loading are to multiply with the relation factor rated voltage/ pulse voltage.

If the demanded pulse loading of the capacitor comply with the requests in certain case, the control is needed to be sure that power loss is not exceeded, resp. self-heating is in area of allowed pulse loading max. 15 °C. In critical cases the capacitor surface temperature is to measure and temperature fall of 5 °C inside capacitor is to consider.

9. Disipation factor tanδ

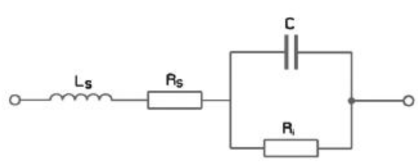
Every capacitor has beside desired capacitance also of her electrical properties, which are shown as constituent elements
in following by connection:

L_s - serial inductance

R_s - serial resistnace

R_i - insulation resistance
(parallel resistance)

C - capacitance



The real capacitor has always incorrectnesses as serial inductance L_s and loss resistance R_s and R_i. The inductance can be reduced but not to zero. At certain frequency f_0 the capacitance and inductance reactances are equal:

$$\frac{1}{\omega_0 C} = \omega_0 L$$

where

$\omega_0 = 2\pi f_0$

At frequencys higher than f_0 (the resonant frequency) the inductive component prevail. The resistance R_s is the resistance of the capacitor's wires, transitional resistance of electrode contacting, the resistance of capacitor electrodes and polarisation losses in capacitor dielectric. Resistance R_i is insulating resistance depending on insulating properties of dielectric in capacitor.

Values R_s and R_i determine losses in capacitor and depend on temperature, frequency, voltage and capacitance and cause heating of capacitor. The resistance R_i is much bigger then the resistance R_s so we can change both resistances only with equivalent serial resistance of capacitor ESR.

The relation between equivalent serial resistance of capacitor ESR and his reactance 1/ωC is dissipation factor of capacitor and is marked with tanδ.

$\tan\delta = ESR.\omega.C$

The values of dissipation factor (tanδ) are given at single types of capacitors in catalogue.

10. Insulation resistance R_i

Insulation resistance of capacitor is given as resistance R_i in MΩ or as time constant in seconds $R_i \cdot C_R$ = MΩ . µF.

The insulation resistance is the relation between the applied direct voltage and the current, after precise determined time. The limited values for insulation resistance are given for testing time 60 sec. at 20 °C.

Test voltages in accordance to rated voltages are as follow:

Rated voltage U_R	Test voltage
< 100 V	10 V
$100 V \leq U_R < 500 V$	100 V
≥ 500 V	500 V

Capacitors

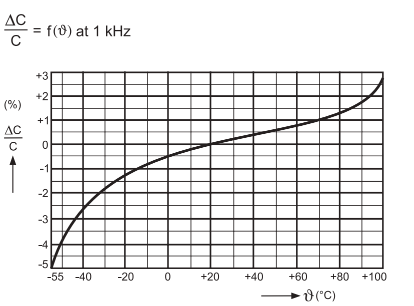
Type KEU | Metallized polyester capacitors

As a dielectric high quality polyester film with good electrical properties is used. Electrodes of capacitor are vacuum metallized aluminium. The thickness of aluminium is approximately
0,01 µF to 0,04 µF, so the capacitor is self-regenerative after break down. The weak point in dielectric because of un-homogene material in some microseconds regenerate with energy of current bow of charged capacitor. In this process metallized layer of aluminium in the area of weak point without any damage of dielectric burns out. The weak point is blameless insulated. So metallized capacitor withstands breakdowns without a permanent short circuit with considering self healing resp. regeneration. The majority of weak points are cleared during the high voltage burning-out in the manufacturing process.

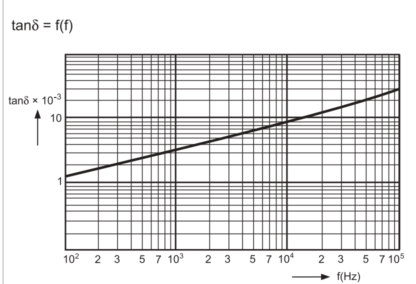
Contact surface is made by spraying the parts of metal contact material. Leads are electrically welded on contact surface. The technology and control system in production assure high liability of capacitors also in use on low voltages and high frequencies. In the case of pulse loading or loading the capacitor with alternative voltage of high gradient of growth is to consider allowed pulse loading du/dt resp. maximal allowed current.

Typical electrical characteristics of metallized polyester capacitors KEU

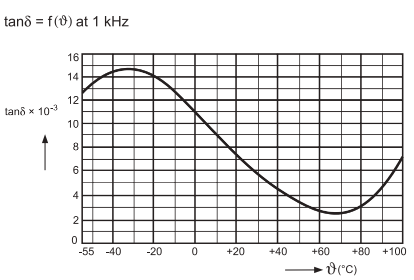
Variation of capacitance as a function of temperature



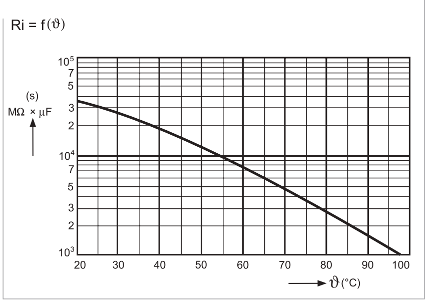
Variation of dissipation factor (tanδ) as a function of frequency



Variation of dissipation factor (tanδ) as a function of temperature



Variation of insulation resistance as a function of temperature



Variation of capacitance as a function of frequency