Introduction

This data book describes fixed capacitors with plastic film dielectrics. The characteristics and application possibilities of such film capacitors, which are also termed FK capacitors, are effected so strongly by the dielectric used that the capacitors are grouped and designated according to the type of dielectric.

1.1 Classification of film capacitors

Short identification codes for the type of construction, describing the dielectric and the basic technology applied, are defined in DIN 41 379. The last character in the short code indicates the type of dielectric:

- T = Polyethylene terephthalate (PET)
- P = Polypropylene (PP)
- N = Polyethylene naphthalate (PEN)

An M (Metallization) is prefixed to the short identification code of capacitors with metallized films.

Our product range covers all capacitor types shown in figure 1, with the exception of KT and KP capacitors.

1) MFP and MFT capacitors are constructed using a combination of metal foils and metallized plastic films. They are not covered by DIN 41 379.
1.2  Basic construction

FK capacitors are produced using either winding methods or stacking methods.

1.2.1  Capacitor winding technology

In the conventional production process, the capacitors are made by individually rolling the metalized films or the film/foils into cylindrical rolls and then covering them with an insulating sleeve or coating.

In the MKT, MKP and MFP type series, our production range includes capacitors with space-saving flat wound bodies with insulating coatings or in plastic cases, as well as cylindrical wound capacitors. Flat windings are produced by compressing the cylindrical rolls before they are placed in the casings, so that the casing form is optimally used.
1.2.2 Stacked-film technology

In stacked-film production technology, large rings of metallized film are wound onto core wheels (with diameters of up to 60 cm). In this way, the “master capacitors” are produced under well-defined and constant conditions.

Fig. 2 Stacked-film production technology

As a result, the capacitor production lots obtained when the rings are sawed apart to produce the actual stacked-film capacitor bodies are especially homogenous.

The pulse handling capabilities of stacked-film capacitors are of particular advantage. Since each individual layer acts as a separate capacitor element, any damage to the contacts due to overloading is restricted to the respective capacitor element and does not affect the entire capacitor, as is the case for wound capacitors.
1.2.3 Foil and film arrangements

To provide a better understanding of the differences in the internal structure of the capacitors, figure 3 shows some typical foil and film arrangements.

Fig. 3 Examples of typical foil and film arrangements

MKT, MKP, MKN

MFT and MFP
The relation between various foil and film arrangements and the capacitor types is shown in figure 4.

<table>
<thead>
<tr>
<th>Foil and film arrangements</th>
<th>Types</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple connection</td>
<td></td>
</tr>
<tr>
<td>Internal series connection</td>
<td></td>
</tr>
<tr>
<td>Double connection</td>
<td></td>
</tr>
<tr>
<td>Quad connection</td>
<td></td>
</tr>
<tr>
<td>Double connection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MKT B 32 5**</td>
</tr>
<tr>
<td></td>
<td>B 32 2**</td>
</tr>
<tr>
<td></td>
<td>MKP B 32 61*</td>
</tr>
<tr>
<td></td>
<td>B 32 62*</td>
</tr>
<tr>
<td></td>
<td>B 32 65*</td>
</tr>
<tr>
<td></td>
<td>B 32 66*</td>
</tr>
<tr>
<td></td>
<td>MKN B 32 840</td>
</tr>
<tr>
<td></td>
<td>EMI suppression capacitors</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal foil</td>
<td></td>
</tr>
<tr>
<td>Metallized plastic film</td>
<td></td>
</tr>
<tr>
<td>Plastic film without metallization</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 4  Schematic foil and film arrangements of various capacitor types
1.2.4 Metallized film capacitors

Capacitors with metallized plastic film have a decisive advantage over capacitors with metal foil electrodes: they have self-healing properties.

- These self-healing properties permit utilization of the full dielectric strength of the dielectric materials of metallized film capacitors, whereas metal-foil electrode capacitors must always be designed with a safety margin to allow for any possible faults in the dielectric.
- Metallized types thus have a distinct size advantage, which is particularly apparent with the larger capacitance ratings.
- With metallized-film designs, it is also possible to implement even complicated capacitor arrangements, e.g. multiple internal series connection to cope with high dc voltages coupled with high ac load capabilities.
- The combination of metal foils, metallized and plain film used in MFP and MFT capacitors gives an extremely high current carrying capability together with self-healing properties.

1.2.5 Self-healing

The metal coatings, which are vacuum-deposited directly onto the plastic film, have a thickness of only 20 ... 50 nm. If the dielectric breakdown field strength is exceeded locally at weak points, at pores or impurities in the dielectric, a dielectric breakdown occurs. The energy released by the arc discharge in the breakdown channel is sufficient to totally evaporate the thin metal coating in the vicinity of the channel. The rapid expansion of the plasma in the breakdown channel causes it to cool after a few microseconds, thus quenching the discharge. The insulated region thus resulting around the former faulty area will cause the capacitor to regain its full operation ability.

Since the absence of any form of pressure in the individual dielectric layers and a good homogeneity improves the self-healing properties, stacked-film capacitors have better self-healing properties than wound capacitors.

Note:

At low voltages, anodic oxidation of the metal coatings leads to an electrochemical self-healing process.

1.3 Characteristic properties

Different dielectrics and various foil and film arrangements enable a wide variety of characteristics to be achieved. A table of general typical values for comparison purposes is shown on page 10.
1.4 Capacitor designs and types of terminal

A variety of standard designs with corresponding types of terminal are available to suit different applications and operating environments.

**Stacked-film capacitors and wound capacitors, radial leads:**
- sealed in plastic case
- coated (powder dipped)
- uncoated (SilverCap)

**Fig. 5 Capacitor designs**

**Wound capacitors, axial leads:**
- cylindrical winding
- flat winding

**Surface-mount capacitors (SMD)**

**Customized capacitors**

**Stacked-film capacitors (partially coated or uncoated) with special dimensions**

These components have the special advantage that they can be adapted to the customer’s design requirements in an almost unlimited range of sizes without having to take consideration of case size standards or provide special tools for special casings.
Design rules:
The lead spacing (capacitor length \( l \)) is determined by the dielectric film cut-off width. However, the width \( b \) and height \( h \) can be adjusted within the following value range:

<table>
<thead>
<tr>
<th>Lead spacing (mm)</th>
<th>7,5</th>
<th>10</th>
<th>15</th>
<th>22,5</th>
<th>27,5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width ((b)) (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>min.</td>
<td>1,5</td>
<td>1,5</td>
<td>2,5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>max.</td>
<td>11</td>
<td>11</td>
<td>16</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Height ((h)) (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>min.</td>
<td>3,5</td>
<td>3,5</td>
<td>4</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>max.</td>
<td>13</td>
<td>13</td>
<td>20</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

In so doing the volume must remain approximately the same.

Fig. 6  Examples of special capacitors dimensions for same capacitance and voltage rating

2  Capacitance

2.1  Rated capacitance / measuring conditions

The rated capacitance \( C_R \) of a capacitor is the value which is indicated upon it. The capacitance is measured under standard ambient conditions in accordance with IEC 60068-1, section 5.3. In case of doubt, the measurements have to be carried out under the referee climate conditions in accordance with IEC 60068-1, section 5.2.

The measuring frequency is chosen in accordance with section 4.2.2 of the respective sectional specification. The reference temperature is 20 \(^{\circ}\)C (according to IEC 60068-1, section 5.1).

<table>
<thead>
<tr>
<th>Measuring conditions</th>
<th>Standard conditions</th>
<th>Referee conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>15 (^{\circ})C … 35 (^{\circ})C</td>
<td>(23 (\pm) 1) (^{\circ})C</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>45 % … 75 %</td>
<td>(50 (\pm) 2) %</td>
</tr>
<tr>
<td>Ambient atmos. pressure</td>
<td>86 kPa … 106 kPa</td>
<td>86 kPa … 106 kPa</td>
</tr>
<tr>
<td>Frequency</td>
<td>1 kHz</td>
<td>1 kHz</td>
</tr>
<tr>
<td>Voltage</td>
<td>0,03 (\cdot) (V_R) (max. 5 V)</td>
<td>0,03 (\cdot) (V_R) (max. 5 V)</td>
</tr>
</tbody>
</table>

Prior to being measured, a capacitor must be stored under measuring conditions until the entire capacitor has reached the measuring temperature and humidity.
2.2 Variation of capacitance with temperature

The capacitance of an FK capacitor will undergo a reversible change within a range of temperatures between the upper and lower category temperatures. The gradient of the capacitance/temperature curve is given by the temperature coefficient $\alpha_c$ of the capacitance. This is essentially determined by the properties of the dielectric and of the electrode foils, as well as by the capacitor construction and the manufacturing parameters. Polypropylene capacitors have negative temperature coefficients, i.e. the capacitance decreases with increasing temperature, polyester capacitors have positive temperature coefficients.

The temperature coefficient $\alpha_c$ is defined as the average capacitance change, in relation to the capacitance measured at $(20 \pm 2) \, ^\circ\text{C}$, occurring within the temperature range $T_1 \ldots T_2$. It is expressed in units of $10^{-6}/\text{K}$.

\[
\alpha_c = \frac{C_2 - C_1}{C_3 \cdot (T_2 - T_1)}
\]

$C_1$ Capacitance measured at temperature $T_1$
$C_2$ Capacitance measured at temperature $T_2$
$C_3$ Reference capacitance measured at $(20 \pm 2) \, ^\circ\text{C}$

Fig. 7 Capacitance change versus temperature (schematic curve)

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1) In accordance with IEC 60384-1, section 4.24.1 and CECC 30 000, section 4.24.1
If a capacitor is subjected to a temperature cycle from the reference temperature to $T_{\text{min}}$, up to $T_{\text{max}}$ and back to the reference temperature, small differences may be observed between the initial and the final capacitance (cf. figure 7).

This temperature-curve deviation is designated as the capacitance drift in sections 4.24.3 of both IEC 60384-1 and CECC 30000.

Generally, when making the measurements, it must be taken into consideration that every temperature change is accompanied by a relative humidity change, which will affect the measurement with the humidity effect time constant, depending on the capacitor type (also refer to chapter 2.4). The change in $\alpha_c$ caused by the humidity variations remain within the scatter limits specified for $\alpha_c$ if measurements are carried out under standard conditions and the temperature cycles are not too long.

Figure 8 shows typical temperature characteristics of the capacitances of different capacitor styles.

![Graph showing relative capacitance change $\Delta C/C$ versus temperature $T$ (typical values)](image)

**2.3 Variation of capacitance with humidity**

The capacitance of a plastic film capacitor will undergo a reversible change of value in relation to any change in the ambient humidity. Depending on the type of capacitor design, both the dielectric and the effective air gap between the films will react to changes in the ambient humidity and will thus affect the measured capacitance.

The humidity coefficient $\beta_c$ is defined as the relative capacitance change determined for a 1 % change in the humidity (at a constant temperature).

$$\beta_c = \frac{2 \cdot (C_2 - C_1)}{(C_2 + C_1) \cdot (F_2 - F_1)}$$

- $C_1$ capacitance value at relative humidity $F_1$
- $C_2$ capacitance value at relative humidity $F_2$
The following typical values apply to the humidity coefficients:

<table>
<thead>
<tr>
<th>Style</th>
<th>Relative humidity range</th>
<th>Humidity coefficient $\beta_c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>MKP, MFP capacitors</td>
<td>50% … 95%</td>
<td>+ (40…100) $\cdot 10^{-6}$/% rel. hum.</td>
</tr>
<tr>
<td>MKT, MFT capacitors</td>
<td>50% … 95%</td>
<td>+ (500…700) $\cdot 10^{-6}$/% rel. hum.</td>
</tr>
<tr>
<td>MKN</td>
<td>50% … 95%</td>
<td>+ (700…900) $\cdot 10^{-6}$/% rel. hum.</td>
</tr>
</tbody>
</table>

Figure 9 shows typical capacitance/humidity characteristics of the different capacitor styles.

![Figure 9](image-url)  

**Fig. 9**  
Relative capacitance change $\Delta C/C$ versus relative humidity (typical values)

The rate of the moisture absorption and drying processes will vary with time, depending on the water vapor diffusion. The time constant depends on the capacitor type and varies between 1/2 a day (e.g. for capacitors without coating) and several weeks (e.g. for capacitors with plastic cases).

At relative humidities below 30 %, the humidity coefficient is relatively low. Wide variations are to be expected at relative humidities above 85 %. 
### 2.4 Variation of capacitance with frequency

**MKT, MFT and MKN capacitors:**

![Graph showing relative capacitance change \( \frac{\Delta C}{C} \) versus frequency \( f \) for MKT, MFT and MKN capacitors (typical example)]

Up to a frequency of 1 MHz, the capacitance remains virtually unaffected by the frequency.

In the vicinity of the natural resonance frequency of the capacitors, the self-inductance leads to an additional decrease of the impedance. This has the same effect as an increase in the capacitance (also refer to the equivalent circuit diagram in chapter 4).

### 2.5 Variation of capacitance with time

The values stated for the time instability of the capacitance, the capacitance drift \( i_z = |\Delta C/C| \) do not take into consideration the reversible effects of temperature changes \( (\alpha_c) \) and changes in relative humidity \( (\beta_c) \) and are based on a two-year period.

The capacitance drift may exceed the specified values if the capacitor is subjected to frequent, large temperature changes in the vicinity of the upper category temperature and relative humidity limits.

The following \( i_z \) values can be applied as typical values for the various capacitor styles:

<table>
<thead>
<tr>
<th>Style</th>
<th>MKT, MFT</th>
<th>MKN</th>
<th>MKP, MFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacitance drift ( i_z ) (typical values)</td>
<td>3 %</td>
<td>3 %</td>
<td>2 %</td>
</tr>
</tbody>
</table>
3 Voltage and current

3.1 Rated voltage
The rated voltage $V_R$ is the maximum dc voltage which may be applied continuously to the terminals of a capacitor at any temperature between the lower category temperature $T_{\text{min}}$ and the rated temperature $T_R$.

3.2 DC test voltage
The dc test voltage to which the capacitor is subjected in the course of the final inspection test in production (100% electrical inspection) is stated for each type. The test may be repeated once as an incoming goods inspection test.

This dc test voltage also applies to the qualification approval test (duration: 60 s) and to the lot-by-lot quality conformance inspection (duration $\leq$ 2 s). An exception is made in the case of EMI suppression capacitors, for which the (lower) test voltages specified in the respective standards apply.

For details on the test circuit and equipment, refer to CECC 30 000 or IEC 60384-1, section 4.6 in both documents.

3.3 Maximum continuous voltage (category voltage)
The maximum voltage which may be applied continuously to a capacitor in the temperature range between the lower category temperature $T_{\text{min}}$ and the rated temperature $T_R$ is equal to the rated dc voltage $V_R$. In the temperature range between the rated temperature $T_R$ and the upper category temperature $T_{\text{max}}$ a voltage derating as shown in figure 11 and figure 12 must be applied. At the upper category temperature, the maximum continuous voltage is equal to the category voltage $V_C$.

Fig. 11 Maximum permissible continuous voltage in relation to the temperature $T$ for MKT, MFT, MKP and MFP capacitors
Fig. 12 Maximum permissible continuous voltage in relation to the temperature $T$ for MKN capacitors
3.4 Alternating voltage, alternating current

The ability of a capacitor to withstand a continuous (sine-wave) alternating voltage load $V_{\text{rms}}$ or alternating current $I_{\text{rms}}$ is a function of the frequency and is limited by three different factors (refer to figure 13):

- **Voltage limited by corona discharge**
- **Limited by thermal power dissipation $\tan \delta$**
- **Current limited by leads**

Fig. 13 Alternating voltage and alternating current load limits
**Region (a): Limit at which corona discharges start to occur, \( V_{\text{CD}} \):**

Below a certain frequency limit \( f_1 \), the applied ac voltage \( V_{\text{rms}} \) should not exceed the threshold voltage \( V_{\text{CD}} \) at which corona discharges (partial discharges) would start to occur with some intensity in air pockets in the capacitor and thus eventually endanger its dielectric strength. The following relation must be taken into consideration:

\[
V_{\text{rms}} \leq V_{\text{CD}} \quad \text{i.e.} \quad I_{\text{rms}} \leq V_{\text{CD}} \cdot 2\Pi \cdot f \cdot C
\]

This voltage limit is determined, above all, by the internal construction of the capacitors (which determines the field strength at the edges); it also depends, to a lesser extent, on the thickness of the dielectric. This voltage limit can be raised, in particular, by using internal series connection designs.

**Region (b): Limit due to thermal power dissipation:**

Above the frequency limit \( f_1 \), the permissible alternating voltage load must be reduced with increasing frequency in order to keep the power dissipation \( P_E \) resulting in the capacitor body:

\[
P_E = V_{\text{rms}}^2 \cdot 2\Pi \cdot f \cdot C \cdot \tan \delta
\]

below the power \( P_A \) which can be dissipated in the form of thermal energy by the surface area \( A \) of the capacitor:

\[
P_A = \alpha \cdot A \cdot \Delta T
\]

where: \( \alpha = \) heat transfer coefficient.

In order to prevent permanent damage to the capacitor, the steady-state overtemperature \( \Delta T \) attained at the hottest part of the capacitor surface in relation to the surrounding atmosphere must not exceed a certain value.

By equating the power generated and the power that can be dissipated as thermal energy:

\[
P_E = P_A
\]

the conditions for the maximum permissible alternating voltages and alternating currents in this region can be deduced as:

\[
V_{\text{rms}} \leq \frac{\alpha \cdot A \cdot \Delta T}{2\Pi f \cdot C \cdot \tan \delta} \quad \text{or} \quad I_{\text{rms}} \leq \frac{2\Pi f C \alpha A \Delta T}{\tan \delta}
\]

This can be simplified by the following close approximation:

\[
V_{\text{rms}, \text{max}} \leq \frac{1}{f} \cdot \frac{4}{\sqrt{f}} \quad \text{or} \quad I_{\text{rms}, \text{max}} \leq \frac{4}{\sqrt{f}}
\]

The frequency limit \( f_1 \) is the maximum frequency at which the full permissible ac voltage \( V_{\text{ac}} \) may be applied to the capacitor without the maximum permissible power dissipation being exceeded.

\[
f_1 = \frac{\alpha \cdot A \cdot \Delta T}{V_{\text{rms}, \text{max}}^2 \cdot 2\Pi \cdot C \cdot \tan \delta} \quad \text{or} \quad f_1 = \frac{I_{\text{rms}, \text{max}}^2 \cdot \tan \delta}{2\Pi \cdot C \cdot \alpha \cdot A \cdot \Delta T}
\]
Thus, within a certain voltage series, the frequency limit $f_1$ is inversely proportional to the respective capacitance value:

$$f_1 \sim \frac{1}{C}$$

Region (C): Limit due to maximum current handling capability

Above the frequency limit $f_2$ the permissible ac voltage load is limited by the current limit $I_C$ which is the maximum current that can pass through the terminals effective electrical cross-section of the leads, the metal layers, the sprayed-on metal terminations, contact resistance of soldered and welded joints etc.) without causing overheating due to associated resistive losses.

$$V_{\text{rms}} \leq \frac{I_C}{2\pi \cdot f \cdot C} \text{ or } I_{\text{rms}} \leq I_C$$

The frequency limit $f_2$ is calculated by applying the limit condition:

$$f_2 = \frac{I_C^2 \tan \delta}{2\pi \cdot C \cdot \alpha \cdot A \cdot \Delta T}$$

In the data sheets for the individual types, several exemplary graphs of the permissible ac loads are shown for various voltage ranges and capacitor sizes.

Usually, practical applications will not involve loads with perfect sine-wave functions. In most cases, however, it is possible to estimate the loads accurately enough by approximating them to sine waves. In extreme cases, the voltage or current curves must be assessed by means of Fourier-analyses. If we are to assist in such cases, please send us scaled graphs.

It must be stated here, though, that the ac load capability figures given in the data sheets are based on very generalized assumptions which do not enable any clear statements to be deduced in critical cases, where this is especially important. In such cases the final decision should always be based on practical testing in the particular circuit.

Note:

Even if the graphs shown for the ac load capability of the capacitors cover the line voltage range, standard film capacitors are basically not suitable for operation in direct connection to public power networks. In this context, we would like to point out the EMI suppression capacitors of the type series B81***/B3292*, which are specially designed for power line applications (refer to chapter on “EMI suppression capacitors”).
3.5 Pulse handling capability, pulse characteristic

Voltage pulses with rapid voltage changes $dV/dt$ (i.e. high rates of voltage rise) will lead to strong currents $i$ (peak current) in the capacitor.

Rate of voltage rise:  \[
\frac{dV}{dt} = \frac{V_{pp}}{\tau}
\]

Peak current:  \[
i = C \cdot \frac{dV}{dt}
\]

$V_{pp}$ Peak-to-peak voltage  
$\tau$ Voltage rise or decay time  
$C$ Capacitance of capacitor

This current will generate heat in the contact regions between the sprayed-on metal terminations and the metal layers. The heat energy $Q$ generated is calculated by the equation:

\[
Q = \int i^2 \cdot R_i \cdot dt
\]

$R_i$ Internal resistance

**Pulse characteristic $k_0$**

By inserting construction-related parameters of the respective capacitor, a characteristic factor $k_0$ can be deduced for the capacitor. This so-called pulse characteristic $k_0$ is:

\[
k_0 = 2 \int (\frac{dV}{dt})^2 \, dt
\]

A good approximation is provided by:

\[
k_0 = 2 \left( \Delta V_1 \cdot \frac{\Delta V_1}{\Delta t_1} + \Delta V_2 \frac{\Delta V_2}{\Delta t_2} + \ldots \right)
\]
From this equation, it is clear that the thermal load on the contact areas does not depend on the rate of voltage rise $\frac{\Delta V}{\Delta t}$ alone, but is determined by the product of $\frac{\Delta V}{\Delta t}$ and $\Delta V$.

![Voltage-time curve across capacitor](image)

Fig. 14 Voltage-time curve across capacitor

$\Delta V_1$, $\Delta t_1$, etc. are the related voltage and time stages of a straight-line polygon approximation of the voltage pulse.

It is also possible to use oscillograms to calculate the pulse characteristic for the respective pulse load waveform to be analysed, as follows:

For pulse-type voltages with straight-line transients (trapezoidal, sawtooth pulses):

$$k_0' = 2 \cdot \frac{V_{pp}^2}{\tau}$$

$V_{pp}$ Peak-to-peak voltage  
$\tau$ Rise time or decay time of the voltage

For passive and short-circuit-type discharging:

$$k_0' = \frac{V_{ch}^2}{R \cdot C}$$

$V_{ch}$ Charging voltage  
$R$ Ohmic resistance of discharge circuit  
$C$ Capacitance

The pulse characteristic calculated in this way, $k_0'$, can now be compared to the maximum permissible pulse characteristic $k_0$ given in the data sheets.
Maximum rate of voltage rise $V_{pp}/\tau$

For the special application case where the capacitor is discharged from the full rated voltage, the maximum permissible rate of voltage rise $V_{pp}/\tau$ is given in addition to the respective pulse characteristic $k_0$.

Example:

MKT stacked-film capacitor B 32 520/lead spacing 7.5 with $V_R = 250 V_{dc}$:

The maximum permissible pulse characteristic is given as: $k_0 = 100 000 V^2/\mu s$

The maximum permissible rate of voltage rise (rise rate or decay rate) for discharge from the full rated voltage ($V_{pp} = V_R$) is then:

$$\frac{V_{pp}}{\tau} = \frac{k_0}{2 \cdot V_{pp}} = \frac{100000 V^2/\mu s}{2 \cdot 250 V} = 200 V/\mu s$$

From the pulse characteristic $k_0$, it is also possible to calculate the (higher) permissible rate of voltage rise for lower peak-to-peak voltages.

For a lower peak-to-peak voltage, of e.g. $V_{pp} = 100 V_{dc}$, we obtain:

$$\frac{V_{pp}}{\tau} = \frac{k_0}{2 \cdot V_{pp}} = \frac{100000 V^2/\mu s}{2 \cdot 100 V} = 500 V/\mu s$$

Both types of discharge have the same pulse load effect (i.e. the same pulse characteristic $k_0$!), although the maximum permissible rates of voltage rise are clearly different.

The pulse handling capability of a capacitor is determined, in particular, by the internal structure of the capacitor element. (Construction variants are shown in figure 4.)

Apart from the layer structure variants, stacked-film capacitors have basic advantages over wound capacitors in terms of pulse-handling capabilities. Since, in principle, a stacked-film capacitor comprises a large number of independent capacitors in parallel, any contact weakness occurring can only affect the individual capacitor element.

3.6 Dielectric strength at low air pressure (altitude safety)

The flashover safety at the capacitor terminations is reduced as the atmospheric pressure drops.

The capacitors can be used at pressures down to 40 kPa without a voltage derating being necessary. This corresponds to an altitude of 7000 m (approx. 23 000 ft) above mean sea level.

Capacitors for use at altitudes above 7000 m are available upon special request.

4 Dissipation factor

The dissipation factor $\tan \delta$ is the ratio of the equivalent series resistance to the capacitive resistance in the equivalent series circuit or of effective power (power dissipation) to reactive power for sine-wave loads.
4.1 Measuring conditions
The generic standards and the sectional standards specify the same measuring conditions for meas-
uring the dissipation factor \( \tan \delta \) as for measuring the capacitance (refer to chapter 2.1). For MKT,
MFP and MKP capacitors, an additional measuring frequency of 10 kHz is used for determining the
dissipation factor for capacitors with \( C_R \leq 1 \mu F \).

4.2 Variation of dissipation factor with frequency
If the inductance \( L_S \) is neglected and for frequencies \( f \approx f_r \), where \( f_r = 1/(2\pi \sqrt{L_S \cdot C}) \) is the natu-
ral resonance frequency) the dissipation factor \( \tan \delta \) is a combination of a parallel component
\( \tan \delta_P \), a series component \( \tan \delta_S \) and a dielectric component \( \tan \delta_D \):

\[
\tan \delta = \tan \delta_P + \tan \delta_S + \tan \delta_D
\]

\[
\tan \delta_P = \frac{1}{R_p \cdot 2\pi f \cdot C}
\]

\[
\tan \delta_S = \frac{R_S \cdot 2\pi f \cdot C}{R_p \cdot 2\pi f \cdot C}
\]

\[
\tan \delta_D = \text{a characteristic of the dielectric}
\]

The parallel component \( \tan \delta_P \) is negligible in the entire frequency range since it contributes virtually
nothing to the overall dissipation factor even at very low frequencies \( f << 1 \text{ kHz} \) due to the extreme-
ly high insulation resistance (parallel resistance \( R_p \)). Because of this, the dissipation factor \( \tan \delta \) at
low frequencies is solely determined by the dielectric component \( \tan \delta_D \), which, for MKP and MFP
 capacitors is independent of the frequency up to frequencies far into the multi-MHz-range and will
typically result in a value of approximately \( 10^{-4} \).
Fig. 15 Dissipation factor versus measuring frequency (schematic representation using two polypropylene capacitors of different capacitances as examples)

However, with rising frequency \((f > 1 \text{ kHz})\), the series component \(\tan \delta_s\) of the dissipation factor, which is proportional to the capacitance, increases more and more rapidly, until it is the dominating component in the dissipation factor curve. The measured value of the series component is determined by the series resistance \(R_s\), which represents the sum of the contact resistances (terminations) and the resistances of leads, metal layers and electrode foils.

Because the dielectric of MKT capacitors contributes a considerably greater dielectric component \(\tan \delta_D\), MKT capacitors display a noticeably higher overall dissipation factor, especially at lower frequencies, than, for example, MKP and MKN capacitors (cf. figure 16).

Fig. 16 Frequency dependence of the dissipation factor, e.g. for \(C_R = 0,10 \mu\text{F}\) (typical behavior)
4.3 Variation of dissipation factor with temperature, humidity and voltage

The dissipation factor of capacitors with polypropylene dielectrics is largely unaffected by the temperature, whereas MKT and MFT capacitors show a characteristic dissipation factor minimum at approximately 70 °C.

Fig. 17  Dissipation factor tan δ versus temperature T for f = 1 kHz (typical values)

The dissipation factor values may increase under humid conditions. It is virtually impossible to detect any variation of the dissipation factor with voltage.

5 Insulation resistance

5.1 Measuring conditions

The insulation resistance $R_{\text{is}}$ is measured by determining the ratio of the applied dc voltage to the current flowing through the capacitor after a period of 1 min ± 5 s.

As specified by section 4.5.2. of both CECC 30 000 and IEC 60384-1, the measuring voltage is:

<table>
<thead>
<tr>
<th>Rated voltage $V_R$ of capacitor</th>
<th>Measuring voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10 \text{ V} \leq V_R &lt; 100 \text{ V}$</td>
<td>$(10 \pm 1) \text{ V}^1$</td>
</tr>
<tr>
<td>$100 \text{ V} \leq V_R &lt; 500 \text{ V}$</td>
<td>$(100 \pm 15) \text{ V}$</td>
</tr>
<tr>
<td>$500 \text{ V} \leq V_R$</td>
<td>$(500 \pm 50) \text{ V}$</td>
</tr>
</tbody>
</table>

1) When it can be demonstrated that the voltage has no influence on the measuring result, or that a known relationship exists, measurements can be carried out at any voltages up to the rated voltage $V_{\text{R}}$. (In case of referee measurements, 10 V shall be used).
If the measurement is made at temperatures other than 20 °C a correction shall be made to the measured value to obtain the equivalent value for 20 °C by multiplying the measurement result by the appropriate correction factor.

In case of doubt a referee measurement at 20 °C and (50 ± 2) % relative humidity is decisive.

In the data sheets for the individual types, the insulation resistance $R_{is}$ is given as a minimum as-delivered value and as a limit value attained after the “damp heat, steady-state” test.

For capacitors with capacitance ratings $> 0,33 \mu F$ the insulation is given in terms of a time constant $\tau = R_{is} \cdot C_R$ in s.

(Conversion tip: $1 \text{ M}\Omega \cdot \mu \text{F} = 1 \text{ s}$)

### 5.2 Factors affecting the insulation resistance

As could already be deduced from the correction factor tables (chapter 5.1), the insulation resistance is affected by the temperature. In figure 18 the typical behavior of individual types is shown.

![Insulation resistance vs. temperature](image)

**Fig. 18** Insulation as self-discharge time constant $\tau = R_{is} \cdot C_R$ in s ($\equiv \text{M}\Omega \cdot \mu \text{F}$) versus temperature $T$ (typical values)

The insulation resistance is also affected by humidity (the humidity coefficient of the insulation resistance is negative).
6 Climatic stress

6.1 Upper and lower category temperature
In the respective generic specification, the upper category temperature $T_{\text{max}}$ and the lower category temperature $T_{\text{min}}$ are defined as the maximum and the minimum ambient temperature for which a capacitor has been designed to operate continuously.

*Note:* Due to the associated self-heating, a capacitor’s surface temperature may be higher than the ambient temperature when it is operated with ripple current loads.

6.2 Rated temperature
The rated temperature $T_R$ is defined as the maximum ambient temperature at which the rated voltage $V_R$ may be applied continuously.

In the respective sectional specifications, a single rated temperature is specified for MKT, MFT, MKP and MFP capacitors listed in this data book:

$T_R = 85 \, ^\circ\text{C}$

For MKN capacitors:

$T_R = 105 \, ^\circ\text{C}$

6.3 Reference temperature for measurements
According to IEC 60068-1, Section 5.1, the reference temperature for all electrical measurements is defined as $20 \, ^\circ\text{C}$ . If required, measurement results obtained at different temperatures can be converted to the reference temperature. For conversion factors for insulation resistance, refer to table on page 306.

6.4 Reference temperature for reliability specifications
In the reference conditions for reliability specifications, DIN 40 039 an ambient temperature of $40 \, ^\circ\text{C}$ is defined as the reference temperature. For a table of conversion factors for the failure rate, refer to the chapter on quality.
6.5  **Storage temperature**
All capacitors listed in this data book can be stored at any temperature within the entire category temperature range.
Criteria for taped capacitors:
- storage temperature –20 °C to +40 °C,
- maximum relative humidity 80 %,
- duration max. 12 months.

6.6  **Climatic category**
The climatic category is identified by three groups of figures, separated by slashes, as specified in IEC 60068-1, Appendix A.

Example: 55/085/56

1st group of figures:
Absolute value of the lower category temperature $T_{\text{min}}$ as test temperature for test Aa (cold) in accordance with IEC 60068-2-1

2nd group of figures:
Upper category temperature $T_{\text{max}}$ as test temperature for test Ba (dry heat) in accordance with IEC 60068-2-2
duration of test: 16 h

3rd group of figures:
Number of days, duration of test Ca (damp heat, steady state) in accordance with IEC 60068-2-3
at (93 +2/−3) % rel. humidity and 40 °C ambient temperature

The limit values permissible after the damp heat test are given in the data sheets for the respective capacitor types. Capacitance changes due to the effects of humidity are reversible.
7 Notes on processing and applications

7.1 Soldering

Solderability of leaded capacitors

The solderability of the terminal leads is tested in accordance with IEC 60068-2-20, test Ta, method 1. Before the solderability test is carried out, the terminals are subjected to an accelerated ageing procedure (in accordance with IEC 60068-2-2, test Ba: 4 hours exposure to dry heat at 155 °C). Since the ageing temperature is far higher than the upper category temperature of the capacitors, the terminal wires should be cut off from the capacitor before the ageing procedure in order to prevent the solderability being impaired by the products of any capacitor decomposition that might occur.

Solder bath temperature: (235 ± 5) °C
Immersion time: (2,0 ± 0,5) s
Immersion depth: distance from standoff surface or capacitor body: (2,0+0/-0,5) mm
Evaluation criterion: wetting of wire surface by new solder ≥ 90%, free-flowing solder.

Solderability of SMD capacitors

The solderability of the terminals is tested in accordance with IEC 60068-2-58, test Td and CECC 00 802.

Before the solderability test is carried out, the terminals are subjected to an accelerated ageing procedure (in accordance with IEC 60068-2-2, test Ba: 4 hours exposure to dry heat at 155 °C).

Solder bath temperature: 215 °C
Immersion time: (3,0 ± 0,3) s
Evaluation criterion: wetting of wire surface by new solder ≥ 90%, free-flowing solder.

Resistance to soldering heat for leaded capacitors

The resistance to soldering heat is tested in accordance with IEC 60068-2-20, test Tb, method 1A.

Solder bath temperature: (260 ± 5) °C
(For uncoated and partially coated capacitors, refer to note on next page.)
Shield: heat-absorbing board, (1,5 ± 0,5) mm thick, between capacitor body and liquid solder
Soldering time: MKT capacitors, except types with case (2,5×6,5×7,2) mm: (10 ± 1) s all others: (5 ± 1) s
Immersion depth: (2,0+0/-0,5) mm from standoff surface or capacitor body
Evaluation criteria: No visible damage
\[ \tan \delta \] as specified in sectional specification

<table>
<thead>
<tr>
<th>Permissible capacitance change</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 %</td>
<td>MKT/MFT/MKP/MFP</td>
</tr>
<tr>
<td>5 %</td>
<td>EMI suppression capacitors</td>
</tr>
</tbody>
</table>
General notes on soldering

Permissible heat exposure loads on film capacitors are characterized by the upper category temperature $T_{\text{max}}$. Long exposure to temperatures above this type-related temperature limit can lead to changes in the plastic dielectric and thus change a capacitor's electrical characteristics irreversibly.

High temperatures are encountered during soldering, but these are only applied briefly.

Apart from being dependent on the solder bath temperature and the soldering time, the thermal load is also affected by the initial (pre-heating) and the post-soldering (cooling) temperatures. Shadowing by neighboring components or subsequent heating due to heat dissipation by these has a similar effect.

Since the soldering heat is transmitted into the components mainly via the leads, the thermal resistance of the terminals is the deciding factor for the heat transmitted, especially for smaller capacitor sizes. Thus a poor thermal conductivity is desirable from this aspect, however, this is contrary to the good electrical conductivity required in order to achieve low dissipation factors (refer to explanation of series resistance $R_S$ in section 4), since the electrical conductivity is generally proportional to the thermal conductivity.

Usually, the utilization of suitable measures, e.g.
– maximum possible distance from the solder bath,
– cooling by forced ventilation,
– use of solder-resist coatings, etc.

enables even sensitive types to be soldered for the solder periods stated above at solder bath temperatures of up to 265 °C. If pre-heating cannot be avoided, the soldering conditions may possibly have to be re-adjusted (especially the cooling process immediately following soldering).

Uncoated capacitors:

For uncoated MKT capacitors with lead spacings $\leq 10$ mm (B 32 560/B 32 561) the following measures are recommended:
– pre-heating to not more than 80 °C in the preheater phase,
– maximum solder bath temperature 245 °C,
– maximum soldering time 4 s
– rapid cooling after soldering.

For SMD capacitors refer to respective data sheet.
7.2 Cleaning

To determine whether the following solvents, often used to remove flux residues and other substances, are suitable for the capacitors described, refer to the table below:

<table>
<thead>
<tr>
<th>Type</th>
<th>Ethanol, isopropanol, n-propanol</th>
<th>n-propanol-water mixtures, water with surface tension-reducing tensides (neutral)</th>
<th>Solvent from table A</th>
<th>Solvent from table B</th>
</tr>
</thead>
<tbody>
<tr>
<td>MKT, MKP (uncoated)</td>
<td>suitable</td>
<td>unsuitable</td>
<td>in part suitable</td>
<td>unsuitable</td>
</tr>
<tr>
<td>MKT, MKN (chip capacitors)</td>
<td>suitable</td>
<td>suitable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MKT, MKP, MFP, MFT (in plastic case)</td>
<td>suitable</td>
<td>suitable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table A
Manufacturers’ designations for trifluoro-trichloro-ethane -based cleaning solvents (selection)

<table>
<thead>
<tr>
<th>Trifluoro-trichloro-ethane</th>
<th>Mixtures of trifluoro-trichloro-ethane with ethanol and isopropanol</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freon TF</td>
<td>Freon TE 35; Freon TP 35; Freon TES</td>
<td>Du Pont</td>
</tr>
<tr>
<td>Frigen 113 TR</td>
<td>Frigen 113 TR-E; Frigen 113 TR-P; Frigen TR-E 35</td>
<td>Hoechst</td>
</tr>
<tr>
<td>Arklone P</td>
<td>Arklone A; Arklone L; Arklone K</td>
<td>ICI</td>
</tr>
<tr>
<td>Kaltron 113 MDR</td>
<td>Kaltron 113 MDA; Kaltron 113 MDI; Kaltron 113 MDI 35</td>
<td>Kali-Chemie</td>
</tr>
<tr>
<td>Flugene 113</td>
<td>Flugene 113 E; Flugene 113 IPA</td>
<td>Rhone-Progil</td>
</tr>
</tbody>
</table>

Table B
Manufacturers’ designations of unsuitable cleaning solvents (selection)

<table>
<thead>
<tr>
<th>Mixtures of chlorinated hydrocarbons and ketones with fluorated hydrocarbons</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freon TMC; Freon TA; Freon TC</td>
<td>Du Pont</td>
</tr>
<tr>
<td>Arklone E</td>
<td>ICI</td>
</tr>
<tr>
<td>Kaltron 113 MDD; Kaltron 113 MDK</td>
<td>Kali-Chemie</td>
</tr>
<tr>
<td>Flugene 113 CM</td>
<td>Rhone-Progil</td>
</tr>
</tbody>
</table>

Even when suitable solvents are used, a reversible change of the electrical characteristics may occur in uncoated capacitors immediately after they are washed. Such capacitors should be dried (e.g. 4 hours at 70 °C) before being subjected to subsequent electrical testing.

Note:
The use of all chlorinated and fluorated hydrocarbons, as well as mixtures containing these (tables A and B), should be avoided for environmental reasons. The use of these substances is no longer permitted in Germany.
7.3 Mechanical robustness of leads

The mechanical robustness of the leads is tested in accordance with IEC 60068-2-21.

Tensile strength: (Test Ua1)

<table>
<thead>
<tr>
<th>Wire diameter $d_1$ in mm</th>
<th>Tensile force</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0,3 &lt; d_1 \leq 0,5$</td>
<td>5 N</td>
</tr>
<tr>
<td>$0,5 &lt; d_1 \leq 0,8$</td>
<td>10 N</td>
</tr>
<tr>
<td>$0,8 &lt; d_1 \leq 1,25$</td>
<td>20 N</td>
</tr>
</tbody>
</table>

Bending strength: (Test Ub)

<table>
<thead>
<tr>
<th>Wire diameter $d_1$ in mm</th>
<th>Bending force</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0,3 &lt; d_1 \leq 0,5$</td>
<td>2,5 N</td>
</tr>
<tr>
<td>$0,5 &lt; d_1 \leq 0,8$</td>
<td>5 N</td>
</tr>
<tr>
<td>$0,8 &lt; d_1 \leq 1,25$</td>
<td>10 N</td>
</tr>
</tbody>
</table>

Torsional strength: (Test Uc)

Tests Ub and Uc are only carried out on types having axial wire leads.

7.4 Resistance to vibration

The capacitor’s ability to withstand vibration e.g. as occurs in applications involving rotating machinery, is tested in accordance with IEC 60068-2-6.

The test procedure used here involves continuous vibration with continuously varying frequency and the following severities:

Test Fc: vibration, sinusoidal

<table>
<thead>
<tr>
<th>Test conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplitude of displacement (below the 57,6 Hz transition frequency)</td>
</tr>
<tr>
<td>Amplitude of acceleration (above the 57,6 Hz transition frequency)</td>
</tr>
<tr>
<td>Frequency range</td>
</tr>
<tr>
<td>Test duration (in three orthogonal axes)</td>
</tr>
</tbody>
</table>

7.5 Flammability

7.5.1 Passive flammability

The passive flammability test is applied to ensure that components bearing the corresponding qualification contribute less energy to the combustion behavior of their immediate vicinity than is required to ignite them. This measure is meant to contain any localized fire which may occur.

In the respective tests, the capacitors are subjected to a standardized flame in order to be able to evaluate the combustion behavior by checking whether the flame persists longer than a maximum permissible period or not. The test severity is essentially determined by the test flame and the exposure time. In principle, the smaller the capacitor, the more easily flammable it is (see table: this fact is taken into consideration in the IEC 60040 (CO) 752 flammability categories). The following tests are used:
Unless the detail specifications specify otherwise, EMI suppression capacitors are tested in accordance with CECC 32 400, section 4.17, test severity category C.

### 7.5.2 Active flammability

For an explanation of the active flammability of EMI suppression capacitors, refer to page 227.

### 7.5.3 Flammability of materials

In some cases, specifications regarding the flammability of materials in accordance with UL 94 are requested in addition to the results of capacitor flammability tests. The UL 94 safety standards describe a material test carried out on test specimens for classifying the flammability of plastics. In the test according to UL 94 V, the test specimens (length 127 mm / 5", 12.7 mm / 0.5") are arranged vertically and exposed to a flame twice; they are then classified into flammability categories:

<table>
<thead>
<tr>
<th>Flammability category</th>
<th>UL 94 V-0</th>
<th>UL 94 V-1</th>
<th>UL 94 V-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material burning persistence (s):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual flame exposure</td>
<td>≤ 10</td>
<td>≤ 30</td>
<td>≤ 30</td>
</tr>
<tr>
<td>Total of ten flame exposures (5 specimens)</td>
<td>≤ 50</td>
<td>≤ 250</td>
<td>≤ 250</td>
</tr>
<tr>
<td>Ignition of supporting layer by dropping burning particles</td>
<td>not permitted</td>
<td>permitted</td>
<td></td>
</tr>
</tbody>
</table>

The thickness of the test specimens must always be stated in order to enable evaluation of the flammability category!

E.g.: UL 94 V-0 (3,2 mm) does not imply that the material will also comply with UL 94 V-1 (1,6 mm).

The sole object of UL 94 is to enable comparison of the relative flammability of various materials. It does not provide any information on the actual combustion characteristics of a capacitor.
7.6 Embedding of capacitors in finished assemblies

In many applications, finished circuit assemblies are embedded in plastic resins. In this case, both chemical and thermal influences of the embedding ("potting") and curing processes must be taken into account.

Our experience has shown that the following potting materials can be recommended: non-flexible epoxy resins with acid-anhydride hardeners; chemically inert, non-conducting fillers; maximum curing temperature 100 °C.

Caution:

Please consult us first if you wish to also embed other uncoated component types!

8 Self-inductance, resonant frequency

At high frequencies the self-inductance of a capacitor causes it to have a natural resonance which can have an undesirable effect when designing circuits. The self-inductance is influenced by the contact paths to the electrodes and the structure of the windings. As far as possible, all capacitors described in this data book are constructed with low-inductance bifilar electrode current paths or extended-foil contacts. A general rule for deducing the self-inductance states that the maximum value is 1 nH per mm lead length and capacitor length.

The frequency range of the natural resonance (also termed self-resonance) as a function of the capacitance can be read off the following diagram.

Fig. 19 Resonant frequency versus capacitance (typical values)
9 Capacitor markings

The individual data sheets state what information is provided by the identification markings on the capacitors. Depending on the capacitor size, the markings are positioned either on the side and/or the top of the component. The coded forms specified in IEC 60062 are used to indicate the rated capacitance, capacitance tolerance and date of manufacture (date code).

All radial capacitors in plastic case with lead spacings 10 to 37.5 mm as well as EMI suppression capacitors are marked with a lot number (production batch number). This ensures unique identification of a particular capacitor and allows, together with the date of manufacture, exact assignment to the process data of the entire production run (traceability).

MKT, MKP and MFP capacitors (examples):

Boxed

MKT, lead spacing = 5 mm
(side stamping)

Dipped

MKT, lead spacing = 10 mm

MKP/MFP/MKT, lead spacing ≥ 15 mm

Explanation of first line (capacitors in plastic case):

- AAAAA batch number (up to 5 figures)
- T5XX MKT capacitor B325**
- P6XX MKP capacitor B326**
- FT5XX MFT capacitor B325**
- FP6XX MFP capacitor B326**
- TSXX MKT special capacitor B325**-S****
- PSXX MKP special capacitor B326**-S****
- FTSXX MFT special capacitor
- FPSXX MFP special capacitor

Imprinted in code in the second line of the stamp are rated capacitance, rated tolerance, rated voltage and date of manufacture (year, month) as defined by IEC 60062.
Example for EMI suppression capacitors:

```
<table>
<thead>
<tr>
<th>Rated capacitance</th>
<th>In accordance with IEC 60062</th>
<th>Short code</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 pF</td>
<td>100p</td>
<td>n1</td>
</tr>
<tr>
<td>150 pF</td>
<td>150p</td>
<td>n15</td>
</tr>
<tr>
<td>1 nF</td>
<td>1n0</td>
<td>1n</td>
</tr>
<tr>
<td>1,5 nF</td>
<td>1n5</td>
<td>±</td>
</tr>
<tr>
<td>10 nF</td>
<td>10n</td>
<td>±</td>
</tr>
<tr>
<td>100 nF</td>
<td>100n</td>
<td>µ1</td>
</tr>
<tr>
<td>150 nF</td>
<td>150n</td>
<td>µ15</td>
</tr>
<tr>
<td>1 µF</td>
<td>1µ0</td>
<td>1µ</td>
</tr>
<tr>
<td>1,5 µF</td>
<td>1µ5</td>
<td>±</td>
</tr>
<tr>
<td>10 µF</td>
<td>10µ</td>
<td>±</td>
</tr>
</tbody>
</table>
```

Codes for date of manufacture (acc. DIN 41 314)

```
<table>
<thead>
<tr>
<th>Year</th>
<th>Code letter</th>
<th>Month</th>
<th>Code numeral</th>
<th>Month</th>
<th>Code numeral/letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>H</td>
<td>January</td>
<td>1</td>
<td>July</td>
<td>7</td>
</tr>
<tr>
<td>1997</td>
<td>J</td>
<td>February</td>
<td>2</td>
<td>August</td>
<td>8</td>
</tr>
<tr>
<td>1998</td>
<td>K</td>
<td>March</td>
<td>3</td>
<td>September</td>
<td>9</td>
</tr>
<tr>
<td>1999</td>
<td>L</td>
<td>April</td>
<td>4</td>
<td>October</td>
<td>O</td>
</tr>
<tr>
<td>2000</td>
<td>M</td>
<td>May</td>
<td>5</td>
<td>November</td>
<td>N</td>
</tr>
<tr>
<td>2001</td>
<td>N</td>
<td>June</td>
<td>6</td>
<td>December</td>
<td>D</td>
</tr>
<tr>
<td>2002</td>
<td>P</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>T</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

E.g.: M9 = 2000 September

Codes for capacitance tolerance

```
<table>
<thead>
<tr>
<th>Capacitance tolerance</th>
<th>Code letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>± 5 %</td>
<td>J</td>
</tr>
<tr>
<td>± 10 %</td>
<td>K</td>
</tr>
<tr>
<td>± 20 %</td>
<td>M</td>
</tr>
</tbody>
</table>
```

1) Capacitance tolerances for which no code letter is defined can be indicated by an A. The meaning of code A must then be mutually specified in other documentation.
10 How to determining the ordering code

A component and the packing in which it is to be delivered are unambiguously defined by the ordering code (part number), which has up to 15 digits.

For all capacitors the ordering codes are explicitly stated (together with the corresponding tolerance and/or packing variants) in the data sheets.

Should there be any doubt about the coding system, however, then it is better to order the capacitor using a plain text description (i.e. without a code). In this case, the translation into the part number, which is required for internal handling of the order, will be done by us. The components are delivered by part numbers only.

Basic structure of the ordering code:

<table>
<thead>
<tr>
<th>Digit</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B = Passive components</td>
</tr>
</tbody>
</table>
| 2, 3  | 32 = Metallized film capacitors  
          81 = EMI suppression capacitors |
| 4 ... 6 | Type (Block 1 is termed the “type number”) |
| 7     | Revision status |
| 8     | Rated dc voltage, coded (not for EMI suppression capacitors) |
| 9 ... 11 | Rated capacitance (coding method for value in pF)  
                   Examples: |

<table>
<thead>
<tr>
<th>Digit</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 3 2 6 5 2 - A 3</td>
<td>15</td>
<td>4</td>
<td>K</td>
</tr>
</tbody>
</table>

1st and 2nd significant figure of capacitance value

Exponent

<table>
<thead>
<tr>
<th>12</th>
<th>Capacitance tolerance, code letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>13 ... 15</td>
<td>Codes for lead and taping parameters (refer to respective data sheet)</td>
</tr>
</tbody>
</table>
11 Standards and specifications

The capacitors described in this data book largely comply with German and international standards and regulations. For all specifications listed (DIN, CECC, IEC) the editions or issues valid on the 1st October 1994 apply.

11.1 Generic specifications

DIN 45 910 Generic specification: Fixed capacitors
September 1985 (only available in German)

CECC 30 000 Generic specification: Fixed capacitors
Issue 3, 1983

IEC 60384-1 Fixed capacitors for use in electronic equipment

11.2 Sectional specifications

<table>
<thead>
<tr>
<th>Style</th>
<th>DIN</th>
<th>CECC</th>
<th>IEC</th>
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<tr>
<td>MKT</td>
<td>DIN 45 910-11</td>
<td>CECC 30 400</td>
<td>IEC 60384-2</td>
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<td>MKP</td>
<td>DIN 45 910-23</td>
<td>CECC 31 200</td>
<td>IEC 60384-16</td>
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<td>MFP</td>
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<td>CECC 31 900</td>
<td>IEC 60384-17</td>
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<td></td>
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<td>WG3 (Secr) 239A</td>
<td>1st edition 1987</td>
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<td>EMI suppression capacitors</td>
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<td>CECC 32 400</td>
<td>IEC 60384-14</td>
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<td></td>
<td></td>
<td>Issue 1 1992</td>
<td>2nd edition 1993</td>
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<td>EN 132400</td>
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11.3 Detail specifications

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<th>Style</th>
<th>Type</th>
<th>Specification</th>
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<tbody>
<tr>
<td>MKT</td>
<td>B 32 231</td>
<td>DIN 44 113 (August 1967): Metallized polyethylene terephthalate film capacitors 100 to 1000 V dc</td>
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<tr>
<td>MKT</td>
<td>B 32 232</td>
<td>DIN 45910-112 (September 1991)</td>
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<td>MKT</td>
<td>B 32 560 - 564</td>
<td>Manufacturer’s detail specification: Metallized polyethylene terephthalate film capacitors, DC 100 to 400 V, general-purpose grade, climatic category 55/100/21</td>
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<td>MKT</td>
<td>B 32 520 - 529</td>
<td>DIN 45 910 - 113 (September 1991), Manufacturer’s detail specification: Metallized polyethylene terephthalate film capacitors, DC 63 to 630V, general purpose-grade, climatic category 55/100/56</td>
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<tr>
<td>MKN-SMD</td>
<td>B 32 840</td>
<td>CECC 32200</td>
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