THE BASICS

RESISTORS - POWER DISSIPATING ELEMENT

Linear model:

\[ \overline{U_R(t)} = R \cdot \overline{I_R(t)} \]

Or:

\[ I_R(t) = \frac{1}{R} \overline{U_R(t)} = G \cdot \overline{U_R(t)} \]

Conductance - SIEMENS

For \( I_R(t) = \cos \omega t \Rightarrow \overline{U_R(t)} = R \cos \omega t \) IN-PHAS

Instantaneous Power:

\[ P(t) = U(t) \cdot I(t) = I^2(t) \cdot R \]

Time-Averaged Power:

\[ P_{ave} = \frac{1}{T} \int_0^T P(t) \, dt = R \cdot \frac{1}{T} \int_0^T I^2(t) \, dt \]

\[ I_{RMS} = \sqrt{\frac{1}{T} \int_0^T I^2(t) \, dt} \]

\[ P_{ave} = I_{RMS}^2 R \]

Series:

\[ R_{SER} = R_1 + R_2 + \ldots + R_N \]

Parallel:

\[ R_{PAR} = \left( \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_N} \right)^{-1} \]
FREQUENCY DOMAIN

\[ V_R(s) = R I_R(s) \quad \text{WHERE} \quad V_R(s) = \mathcal{L}\{V_R(t)\} \]

IMPEDANCE-FREQUENCY DOMAIN PROPERTY

\[ Z(s) = \frac{V(s)}{I(s)} \quad \Rightarrow \quad Z_R = \frac{V_R(s)}{I_R(s)} = R \]

TYPICAL SPECIFICATIONS - PAGE 10
IMPERFECTIONS IN MODEL

TEMPERATURE DERATING

![Temperature Derating Graph]

Figure 7.3. Typical power derating curve for carbon-composition resistors.

STRAY CAPACITANCE - STORED ELECTRIC ENERGY

![Stray Capacitance Diagram]

(a) Physical Structure          (b) Circuit Model

Figure 18.2. Stray capacitance in a composition resistor.
Figure 18.4. Variation of $|Z|$ and $|Y|$ vs. $\omega$ for a parallel $R-C$ circuit.

LEAD INDUCTANCE - STORED MAGNETIC ENERGY

(a) Physical Structure
(b) Circuit Model

Figure 18.1. Lead inductance in a composition resistor.

Figure 18.3. Variation of $|Z|$ and $|Y|$ vs. $\omega$ for a series $R-L$ circuit.
SKIN EFFECT IN WIRES

IC RESISTORS

Fig. 3.11 Resistor examples: (a) Small value ($\approx 50 \, \Omega$); (b) Large value ($\approx 3000 \, \Omega$)

Fig. 3.13 Resistor equivalent circuit
**CAPACITORS - ELECTRIC ENERGY STORAGE**

**LINEAR MODEL**

\[ \dot{u}_c(t) = \frac{1}{C} \frac{du_c(t)}{dt} \quad \Rightarrow \quad u_c(t) = \frac{1}{C} \int_{t_0}^{t} \dot{u}_c(t') \, dt' + u_c(t_0) \]

For \( u_c(t) = \cos \omega_0 t \) \( \Rightarrow \dot{u}_c(t) = -C \omega_0 \sin \omega_0 t \)

**VOLTAGE LAGS CURRENT BY 90°**

**ENERGY STORED**

\[ \text{Energy stored} = W_e(t) = \frac{1}{2} C u_c^2(t) \]

**FREQUENCY DOMAIN**

\[ I_c(s) = C [s V_c(s) - u_c(0)] \]

For sinusoidal

\[ s = j \omega \text{ and } u_c(0) = 0 \]

\[ I_c(j\omega) = j\omega C V_c(j\omega) \]

**IMPEDANCE**

\[ Z_c = \frac{V_c}{I_c} = \frac{1}{j\omega C} \]

**PHASORS**

\[ \text{Phasor} \]

\[ Z_c = \frac{1}{j\omega C} = -j X_c \]

**REACTANCE**

\[ \frac{1}{X_c} = B_C = \omega C \]

**SUSCEPTANCE**

\[ \frac{1}{X_c} = B_C = \omega C \]
**IMPERFECTIONS**

LEAD INDUCTANCE/RESISTANCE

\[ \frac{1}{L_{\text{lead}}} \]

\[ \frac{1}{R_{\text{lead}}} \]

LEAKAGE RESISTANCE

---

**Figure 8.2.** Circuit model for a lossy capacitor.

\[ Y(\omega) = G(\omega) + j B(\omega) \]

**Dissipation Factor**

\[ D = \frac{G(\omega)}{B(\omega)} = \frac{G_p}{\omega C_p} \]

**Loss Tangent**

\[ \delta = \tan^{-1} \left( \frac{G(\omega)}{B(\omega)} \right) \]

**Self-Resonance**

\[ \omega_C = \frac{1}{\sqrt{L C}} \]

**Maximum Voltage Dielectric Breakdown**
"S" SERIES

TEMEX COMPONENTS has developed this series of ceramic chips capacitors for applications where a standard NPO chip does not give to the user the guarantee of a stable given E.S.R. and "Q" factor from one lot to another one.

Our "S" series is consequently featuring a Type 1 NPO temperature coefficient with a low E.S.R. and low loss characteristics (High "Q") in two popular sizes very well fitted to R.F. applications (0505 and 0603) dealing with frequency ranges 900 to 2500 MHz (and above).

**Electrical characteristics**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature range</td>
<td>-55 to +125°C</td>
</tr>
<tr>
<td>Temperature coefficient</td>
<td>0 ± 30 ppm</td>
</tr>
<tr>
<td>Tangent δ</td>
<td>≤ 2 x 10^-9 @ 25°C</td>
</tr>
<tr>
<td>Insulation resistance</td>
<td>≥ 1000 Ω @ 25°C</td>
</tr>
<tr>
<td>Voltage proof</td>
<td>2.5 x Ur (50 mA max.)</td>
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<tr>
<td>Test conditions</td>
<td>F = 1 MHz (± 50 KHz)</td>
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<tr>
<td>U = 1.0 ± 0.2 Vrms</td>
<td></td>
</tr>
<tr>
<td>E.S.R. versus Cr and F</td>
<td>See curve 2</td>
</tr>
<tr>
<td>Resonant frequency</td>
<td>See curve 3</td>
</tr>
<tr>
<td>Capacitance tolerance</td>
<td>Cr &lt; 10 pF</td>
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<tr>
<td>C = 10 pF</td>
<td>C = 10 pF</td>
</tr>
<tr>
<td>B = ± 0.1 pF</td>
<td>F = ± 1%</td>
</tr>
<tr>
<td>C = ± 0.25 pF</td>
<td>G = ± 2%</td>
</tr>
<tr>
<td>D = ± 0.5 pF</td>
<td>J = ± 5%</td>
</tr>
<tr>
<td>Capacitance / Voltage range</td>
<td>See table</td>
</tr>
</tbody>
</table>

**Capacitance / Voltage range**

<table>
<thead>
<tr>
<th>Cr (pF)</th>
<th>Cap code</th>
<th>0603</th>
<th>0505</th>
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</tr>
<tr>
<td>100</td>
<td>101</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Dimensions**

- **L**: 1.60
- **W**: 0.80
- **T max.**: 0.80
- **End band max.**: 0.40

---

**SALES OFFICES:** VISIT OUR WEB SITE AT
http://www.temex-components.com

6-34
How to order

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Case size</th>
<th>Series</th>
<th>Capacitance</th>
<th>Tolerance</th>
<th>Termination</th>
<th>Taping</th>
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</thead>
<tbody>
<tr>
<td>101</td>
<td>100 V</td>
<td>201</td>
<td>200 V</td>
<td>NPO</td>
<td>HF</td>
<td>E</td>
</tr>
</tbody>
</table>

1st two digits are significant; third digit denotes number of zeros.

- R = decimal
- 1R0 = 1.0 pF
- 101 = 100 pF

- B = ± 0.1 pF
- C = ± 0.25 pF
- D = ± 0.5 pF
- F = ± 1 %
- G = ± 2 %
- J = ± 5 %
- K = ± 10 %

For other case size: 0805 - 1111 - 1210, please consult us.
Air Dielectric Variable Capacitors

**CAPACITOR TYPES**

(a) Paper

- Metal foil
- Paper and impregnant

(b) Mica

- Mica sheet
- Metal foil

(c) Ceramic disc

- Dielectric disc
- Metallized surface

(d) Polar aluminum foil electrolytic

- Chemically formed dielectric layer
- Electrolyte
- Aluminum foil

(e) Wet tantalum

- Porous oxidized tantalum pellet
- Insulated seal

**Figure 8.6.** Basic construction of common capacitors.

**IC MODEL**

**INTERDIGITAL CAPACITORS**
INDUCTORS - MAGNETIC ENERGY STORAGE

LINEAR MODEL

\[ u_L(t) = L \frac{d}{dt} i_L(t) \]

\[ i_L(t) = \frac{1}{L} \int_{0}^{t} u_L(t) dt + i_L(0) \]

\[ w_m(t) = \frac{1}{2} L \dot{i}_L(t)^2(t) \]

\[ V_L(s) = L \left[ s I_L(s) - i_L(0) \right] \Rightarrow V_L(s) = j \omega L I_L(s) \]

\[ Z_L = j \omega L \quad Y_L = \frac{1}{j \omega L} = - \frac{j}{\omega L} \]

TO CONFINE FIELDS & INCREASE FIELDS

USE MAGNETIC FERRITE CORES

ENCLOSE IN METAL CANS TO SHIELD

TRAVERSEERS/BALUNS/EMI SUPPRESSION

IMPERFECTIONS

SERIES RESISTANCE OF WIRE OR OF FERRITE CORE

\[ Q = \frac{X(w)}{R(w)} \]

\[ Q - \text{factor (quality)} \]

\[ \text{Measure of ideal nature; higher Q, more nearly ideal} \]

Figure 9.9. Circuit model for a lossy inductor.
TYPICAL PRODUCTS - P20, 21

PRODUCT SPECIFICATIONS - P22

FERRITE BEADS - P23

IC INDUCTORS

Fig. 3.2 Layout of a single loop inductor

Fig. 3.3 Large value inductance using (a) meandered track and (b) spiral
Grounds & vias - must include inductance & resistance in model

Fig. 3.14 Grounding methods: (a) Through-substrate via-holes; (b) Wrap-around grounding; (c) Bond-wires

Fig. 3.15 An example of improper grounding: (a) FETs with a common source ground pad, leading to unwanted feedback; (b) FETs with separate source ground pads