Components

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Specific components
Solutions – Essential rules

- Technical vs. economical constraints
- Global concept / Early stage
- If not, the risk is additional cost (3 to 5%)
- The margin to solve the problem is decreasing when time is running
- Another risk: additional delay
- No exact solution but engineering rules to follow
- Do not neglect any element (cabling, connections to ground…)
- Step by step solution to solve the problems.
**Passive components vs. H.F.**

- parasitic effects: parasitic R, L, C
- coil: saturation, hysteresis
- C: parasitic R for dielectric losses (f)

\[
\begin{align*}
R & \ldots [R \ L_s \ (nF)] \ C_p \ (pF) \\
C & \ldots [C \ R_p] \ L_s \ R_s \\
L & \ldots [L \ R_s] \ C_p
\end{align*}
\]

- electrolytic tantalum ceramic or film class X (MD) or Y (MC)

**Specific components**

- **conducted**
- **radiated**

performance measurement?
- = decreasing of disturbance (U, I, P)
- = Insertion Loss I.L.

\[
\frac{\text{amplitude of disturbance without component}}{\text{amplitude of disturbance with component}}
\]
**Specific components**

Insertion loss

\[ \text{Att} = 20\log_{10}\left(\frac{E_0}{E}\right) = 20\log_{10}\left(\frac{|Z_G + Z_L + Z_S|}{|Z_G + Z_L|}\right) \]

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**Conducted**

- some components are bidirectional (EMI / EMS)
- importance of source and load impedances (see previous equation)
- take into account the type of ports (power / signal)
- CM / DM or both
- …
**Power Lines**

**Filters**
- to decrease disturbances from EUT to mains
- to decrease disturbances from mains to EUT

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Efficient low-pass filter:

\[
C \longleftrightarrow Z_s \text{ ou } Z_L \gg
\]

\[
L \longleftrightarrow Z_s \text{ ou } Z_L \ll
\]
A correct implementation is mandatory

[EN 50174-2]
A correct implementation is mandatory.

Power Lines

**Isolation transformers**
- to allow changing earthing system (IT, TN…)
- to insure a good galvanic isolation in LF

\[ C_{12} = 50 \text{ pF for 100VA} \]
\[ \text{some nF for some kVA} \]
### Power Lines

#### Isolation Transformers

<table>
<thead>
<tr>
<th>Transformer Type</th>
<th>Representation</th>
<th>Isolation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td><img src="image1.png" alt="Diagram" /></td>
<td>OK Medium</td>
</tr>
<tr>
<td>Simple screen</td>
<td><img src="image2.png" alt="Diagram" /></td>
<td>OK Medium</td>
</tr>
<tr>
<td>Double screen</td>
<td><img src="image3.png" alt="Diagram" /></td>
<td>OK High</td>
</tr>
</tbody>
</table>

\[ C_{12} < \text{qq} \text{pF} \]

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A correct implementation is mandatory

![Diagram](image4.png)

[EN 50174-2]
Power Lines

Components for transients

Different kinds of components are used for the protection against overvoltages.

1. Spark gap ("éclateurs" en français)
2. Varistors
3. Semi-conductor components

Ideal protection criteria?

In the presence of a disturbance, the ideal protection component should limit immediately the voltage to a level lower than the lower value of the maximum acceptable voltage for the circuit.

Regarding consumption, it should consume:

- The minimum of energy during permanent regime
- The maximum of energy during disturbance

Protections in series or in parallel: check the defect mode of the component (open circuit or short circuit).
Components for transients
Spark gap

Main characteristics:
• Very low residual voltage (+)
• Very low parasitic capacitor (+)
• Very high flowing capacity (+)
• Sparking time is related to gas ionisation (-)

Criteria:
• sparkling voltage > maximum voltage of circuit (x 1.5)
• maximum sparking current < destruction value
• lifetime
Components for transients

**Varistors (varistances)**

This is a component with a resistance varying according to the reverse of applied voltage

\[ J = KV^\alpha \]

Varistors ZnO prepared by sintering (frittage) of different oxydes (chemical mixture and thermal treatment are very important).

Criteria:
- Calculation of dissipation energy
- Stability of characteristics (dc, ac and pulse)

**Advantages:**
- moderate cost
- small response time (< 50 ns)
- different values of knee voltage available.

**Drawbacks:**
- slope I-U is soft
- high parasitic capacitor
  (not efficient for quick signals)
- slow destruction by fatigue, carbonisation risk and burst
Components for transients

Semi-conductors

- diodes inversely polarised (Zener and avalanche)
- thyristor effect component
- « surge suppressor » group of components, integrated on the silicium level.

Characteristics:
Easy to use (+), economic (+), very quick (+), nearly perfect characteristics (+), steady voltage in conduction regime (+), limited absorption energy capacity (-), end of life as short-circuit (-).

### Table: Components for Transients

<table>
<thead>
<tr>
<th>Device</th>
<th>Tension de service du circuit presse (V)</th>
<th>Temps de réponse</th>
<th>Possibilité d’absorption d’énergie</th>
<th>Capacité (μF)</th>
<th>Courant de fuite au repos</th>
<th>Gamme de température d’utilisation (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diode direct (2.1)</td>
<td>0,5 à 10</td>
<td>très rapide</td>
<td>faible</td>
<td>faible</td>
<td>important</td>
<td>-40 à + 85</td>
</tr>
<tr>
<td>Diodes Zener et à avalanche (1 2.2.2)</td>
<td>5 à 200</td>
<td>très rapide</td>
<td>faible</td>
<td>faible</td>
<td>importante</td>
<td>-65 à + 125</td>
</tr>
<tr>
<td>Dispositif à effet thyristor (2.2.3)</td>
<td>75 à 360</td>
<td>10 à 50 (fonction du diode)</td>
<td>bonne quelques jous</td>
<td>moyenne</td>
<td>faible</td>
<td>Sibire</td>
</tr>
<tr>
<td>Varistors (ZVO) (2.3)</td>
<td>5,5 à 5 600</td>
<td>&lt; 1</td>
<td>très bonne</td>
<td>moyenne</td>
<td>faible</td>
<td>50 à + 125 (modèles standard)</td>
</tr>
<tr>
<td>Étriers à gaz (SI)</td>
<td>100 à 20 000</td>
<td>&lt; 1</td>
<td>très bonne</td>
<td>très faible</td>
<td>très faible</td>
<td>50 à + 125 (modèles de forte puissance)</td>
</tr>
</tbody>
</table>
Gas tube

Varistor

Semi-conductor
Components for transients

- In EMC efficient components are mandatory but a good implementation is also mandatory.
- Those components are efficient regarding transients, but fuses and breakers are still mandatory on the input of power circuits.
- To install components as near as possible.
- Energy to ground.
- In case of components in parallel, take care of their non linearity.
- Importance of equipotentiality.

Signal lines
Filters for signals

Individual filtering for signal lines
Signal lines
Filters for signals

Filter I/O on printed circuit board

Connector-filter in Pi [Amphenol®]
Signal lines

Isolation transformers for signals
DM (transmitted) - CM (blocked)

With mid-point:
• $I_{MC}$: OK
• galvanic insulation of ground: KO

With screen for signal bus

Optical couplers

By-pass $C_p$

Internal $C_p$ (between LED and photosensitive element)

L’opto-coupleur

Perturbation victimale

Produit victime
**Signal lines**

**Optical couplers**

Importance of a correct implementation

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**Power / signal lines**

**Baluns – CM inductances**
Power / signal lines

Ferrites (magnetic ceramic MFe2O4)

- Nickel
- Manganese
- Zinc
- Copper
- ...

Manganese-Zinc (MnZn):
- high permeability
- low resistivity
- usable frequencies <10MHz

Nickel-Zinc (NiZn):
- low permeability
- high resistivity
- usable frequencies >10MHz & <1GHz

<table>
<thead>
<tr>
<th>Type</th>
<th>Material</th>
<th>$B_p$ (G)</th>
<th>$H_c$ (Oe)</th>
<th>$N_s$ (volts)</th>
<th>Frequency (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese-Zinc</td>
<td>A1</td>
<td>5000</td>
<td>350</td>
<td>85</td>
<td>&lt;10</td>
</tr>
<tr>
<td>A2</td>
<td>6000</td>
<td>450</td>
<td>85</td>
<td>&lt;10</td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>7000</td>
<td>550</td>
<td>75</td>
<td>&lt;10</td>
<td></td>
</tr>
<tr>
<td>A4</td>
<td>8000</td>
<td>650</td>
<td>75</td>
<td>&lt;10</td>
<td></td>
</tr>
<tr>
<td>A5</td>
<td>9000</td>
<td>750</td>
<td>75</td>
<td>&lt;10</td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>1000</td>
<td>850</td>
<td>75</td>
<td>&lt;10</td>
<td></td>
</tr>
<tr>
<td>B2</td>
<td>1100</td>
<td>950</td>
<td>75</td>
<td>&lt;10</td>
<td></td>
</tr>
<tr>
<td>B3</td>
<td>1200</td>
<td>1050</td>
<td>75</td>
<td>&lt;10</td>
<td></td>
</tr>
<tr>
<td>B4</td>
<td>1300</td>
<td>1150</td>
<td>75</td>
<td>&lt;10</td>
<td></td>
</tr>
<tr>
<td>B5</td>
<td>1400</td>
<td>1250</td>
<td>75</td>
<td>&lt;10</td>
<td></td>
</tr>
<tr>
<td>NiZn</td>
<td>A1</td>
<td>1500</td>
<td>125</td>
<td>15</td>
<td>&gt;1000</td>
</tr>
<tr>
<td>A2</td>
<td>1600</td>
<td>135</td>
<td>15</td>
<td>&gt;1000</td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>1700</td>
<td>145</td>
<td>15</td>
<td>&gt;1000</td>
<td></td>
</tr>
<tr>
<td>A4</td>
<td>1800</td>
<td>155</td>
<td>15</td>
<td>&gt;1000</td>
<td></td>
</tr>
<tr>
<td>A5</td>
<td>1900</td>
<td>165</td>
<td>15</td>
<td>&gt;1000</td>
<td></td>
</tr>
</tbody>
</table>

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Power / signal lines
Ferrites

Equivalent circuit

\[ Z = j\omega L + R = j\omega L_e (\mu - j\mu_0) \]

with

\[ \omega L_e = \omega L_0 \mu_0 \]
\[ LR_e = \omega L_0 \mu_0^2 \]
\[ L_a = \frac{4\pi N^2 10^{-6}}{C_1} \]
Ferrite core = localised effect
Distributed effect?

Power / signal lines
Lossy cables

Typical attenuation versus frequency
**Power / signal lines**

**Lossy cables**

**VMVB**

**LiMYCY**

**Twisted cables**

(NB: les torsades sont grossies pour les besoins du schéma)
Shielded cables

A shielded cable is characterised by its transfer impedance $Z_t$. Let's consider a coaxial cable over a conductive plane (figure). We connect at one end between shielding and ground plane a source $E_0$ with an internal impedance $Z_0$. At the other end, the shielding is connected to the ground plane with a short-circuit. $I_0$ is the induced current in the shielding. The central conductor is open at one end and short-circuit at the other end. $V_{in}$ is the image of the shielding defects ($I_0$ on the shielding).

$Z_t$ is $V_{in}$ over $I_0$, in $\Omega/m$. $Z_t$ is a function of physical characteristics and geometry:
- homogeneous tubular shielding
- braided shielding
- helicoidally shielded

Same lineic resistance $6\Omega/m$ (typ.)

Do not confuse metallic armature (mechanical) and shielding.
Shielded cables

Multi-pair cable
Double shielding
with aluminium sheet and
tinned braid

Multi-pair cable
Shielding for each pair
and general shielding
(tinned copper braid)

Multiconductor cable
aluminium shielding

Multiconductor cable
+ shielding
(tinned copper braid)
Shielded cables

(a)

(b)

(c)
Shielded cables

End of shielding braid? Solutions [Radialex®]