Confirming the Emission Noise Reduction Effect Through Experiments

On AC power lines, various types of noise are superimposed. When classifying noise according to voltage level and rise time, it can be divided into three categories, as shown in Table 1.

High-frequency noise

- This mainly consists of the harmonic components of switching frequencies of computers or switching power sources, etc. Generally, EMI noise refers to this type of noise. Its voltage level is relatively low, from several mV to several tens of mV.

Impulsive noise

- This noise generates at the time of switching of relays or induction motors. Its voltage level is high, and the peak voltage may reach several thousand V.

Surge noise

- This noise generates in power lines by induced lightning, etc. This type of noise has a large amount of energy as well as very high voltage and current. The peak voltage may reach several tens of kV.

Table 1 Three Types of Conducted Noise

<table>
<thead>
<tr>
<th>Waveform</th>
<th>Voltage level</th>
<th>Rise time</th>
<th>Energy</th>
<th>Surge noise</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Several V</td>
<td>1 ns max.</td>
<td>Several mJ</td>
<td>- Several 10 kV</td>
</tr>
<tr>
<td></td>
<td>- Several kV</td>
<td>0.5 µs max.</td>
<td>Several 100 mJ</td>
<td>- Several J - several kJ</td>
</tr>
</tbody>
</table>

Prevents Noise Infiltration from AC Power Lines and Noise Leakage from Devices

As shown in Figure 1, since each device is connected to a common power line, one device may have errors due to noise generated in other devices, or may cause errors in other devices.

The AC power supplies of the devices are entrances for noise energy, in addition to being an exit for noise generated in each device. By mounting an EMC filter to an AC power line, infiltration of external noise and noise leakage into the power line can be reduced.

In every country around the world, immunity against external noise or limits for leakage noise are provided, and devices need to conform to these. EMC filters for AC power lines are used in order to meet such standards.

Figure 1 Noise Generated in each Device is Transmitted Through the AC Power Line

Concerning built-in type EMC filters, the classifications of filters for AC power lines are shown in Table 2, and the appearances of the actual products are shown in Photo 1.

The built-in type filters are directly built into the AC power supplies of electronic devices, and there are various types of appearances and user terminal structures. When using these filters, it is necessary to check that they conform to the noise regulations and safety standards of the countries where the filters are used, in addition to the electrical characteristics of the devices, such as rated values or attenuation characteristics.
1) Three-phase filters (general use):
   RTEN series

2) Three-phase filters (wide-band, high attenuation):
   RTHN series

3) Three-phase filters (wide-band, high attenuation):
   RTHC/RTHB series

4) Single phase filters (general use):
   RSEN series

5) Single phase filters (wide-band, high attenuation):
   RSHN series

6) Compact type single phase filters:
   RSEL-W/RSEL-A series
Reminders in Selecting Filters

If high energy noise, such as impulsive noise or surge noise, enters into an AC power line EMC filter, the core of the coils used in the filter may become saturated and cause a significant decrease in the noise attenuation characteristics. When selecting a filter, it is necessary to check the attenuation characteristics of the core for impulsive noise. Amorphous cores do not easily become saturated even when a high energy surge voltage is applied.

Amorphous materials have excellent permeability and frequency characteristics. Compared to ferrite cores of an equivalent shape and amount of winding, amorphous cores exhibit much greater attenuation characteristics over a broader input voltage range, as shown in Figure 2, since their cores have higher saturation flux densities.

In areas including the Hokuriku area (Japan) in winter, surges exceeding 1 kV occur in power lines several times a year. In such cases, it is effective to apply surge absorption elements such as varistors or lightning arresters to the power input sides of EMC filters.

Figure 2 Example in Which an Amorphous Core is more Resistant to Saturation than a Ferrite Core

(a) Attenuation characteristics

(b) Measured circuit
EMC filters for AC power lines are connected to the primary sides of electronic devices; therefore, a high level of safety is required in order to prevent the occurrence of electrification, smoke or fire. Safety standards as shown in Table 3 are provided in each country. It is necessary to select filters that are approved in the safety standards of the country where the filters are used.

Table 3  Safety Standard of each Country

<table>
<thead>
<tr>
<th>Country</th>
<th>Organization</th>
<th>Standard</th>
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<tbody>
<tr>
<td>United States</td>
<td>UL</td>
<td>UL1283</td>
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<td>Japan</td>
<td>Japan Electrical Testing Laboratory</td>
<td>Product Safety Electrical Appliance &amp; Material</td>
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