AC Power Line EMC Filters that Prevent Noise Infiltration and Leakage

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1 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.

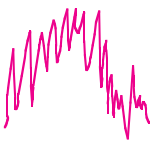
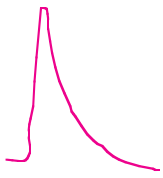
▶ Impulsive noise

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

	High-frequency noise	Impulsive noise	Surge noise
Voltage level	- Several V	- Several kV	- Several 10 kV
Rise time	–	1 ns max.	0.5 μs max.
Energy	Several mJ	Several 100 mJ	Several J – several kJ
Waveform			

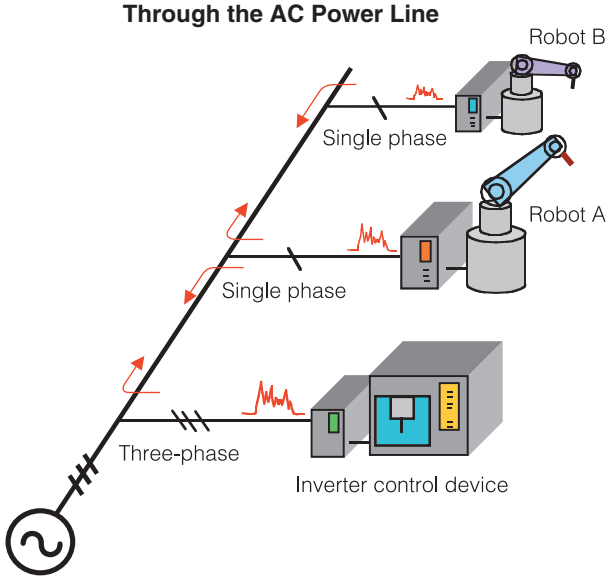
2 Prevents Noise Infiltration from AC Power Lines and Noise Leakage From Devices

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



3 Classifications and How to Select Filters

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.

Photo 1 Appearance of EMC Filters for AC Power Lines (photos)

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

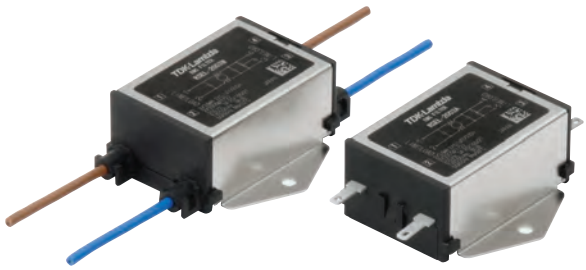


Table 2 Selection Chart by Target

Target set	Power supply	Performance	Type	Series	Rated current (A)	Safety standards		
						UL	CSA	EN
General-purpose inverters AC servos, etc.	Three-phase	General use	Low profile	RTEN	6 to 300	✓ (to 150 A)		✓
		Wide-band, high attenuation	Low profile	RTHN	6 to 1000	✓ (to 150 A)		✓ (to 300 A)
		Wide-band, high attenuation	Cubic	RTHC	6 to 300	✓ (to 150 A)		✓
		Wide-band, high attenuation	Book	RTHB	6 to 150	✓		✓
	Single phase	General use	Low profile	RSEN	3 to 300	✓ (to 60 A)	✓ (to 60 A)	✓ (to 60 A)
		Wide-band, high attenuation	Low profile	RSHN	3 to 300	✓ (to 60 A)	✓ (to 30 A)	✓ (to 60 A)
Large-sized machine tools	Three-phase	General use	Low profile	RTEN	6 to 300	✓ (to 150 A)		✓
		Wide-band, high attenuation	Low profile	RTHN	6 to 1000	✓ (to 150 A)		✓ (to 300 A)
		Wide-band, high attenuation	Cubic	RTHC	6 to 300	✓ (to 150 A)		✓
		Wide-band, high attenuation	Book	RTHB	6 to 150	✓		✓
Medical equipment	Three-phase	General use	Low profile	RTEN	6 to 300	✓ (to 150 A)		✓
		Wide-band, high attenuation	Low profile	RTHN	6 to 1000	✓ (to 150 A)		✓ (to 300 A)
		General use	Low profile	RTAN	6 to 60	✓		✓
		Wide-band, high attenuation	Low profile	RTMN	6 to 60	✓		✓
	Single phase	General use	Small	RSEL	0.5 to 6	✓	✓	✓
				RSAL	0.5 to 6	✓	✓	✓
		General use	Low profile	RSEN	3 to 300	✓ (to 60 A)	✓ (to 60 A)	✓ (to 60 A)
		Wide-band, high attenuation	Low profile	RSHN	3 to 300	✓ (to 60 A)	✓ (to 30 A)	✓ (to 60 A)
Semiconductor manufacturing equipment Robots	Three-phase	General use	Low profile	RTEN	6 to 300	✓ (to 150 A)		✓ (to 300 A)
		Wide-band, high attenuation	Low profile	RTHN	6 to 1000	✓ (to 150 A)		✓ (to 300 A)
	Single phase	General use	Low profile	RSEN	3 to 300	✓ (to 60 A)	✓ (to 60 A)	✓ (to 60 A)
		Wide-band, high attenuation	Low profile	RSHN	3 to 300	✓ (to 60 A)	✓ (to 30 A)	✓ (to 60 A)
Amusement machines	Single phase	General use	Small	RSEL	0.5 to 6	✓	✓	✓
				RSAL	0.5 to 6	✓	✓	✓

Reminders in Selecting Filters

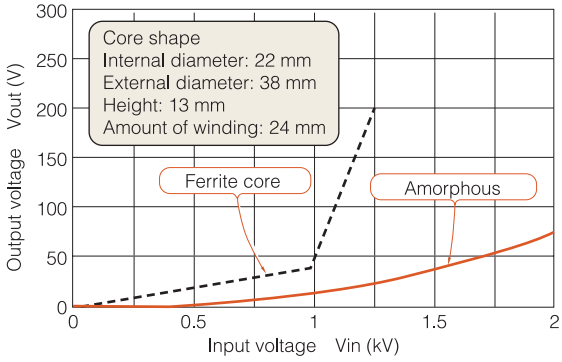
If high energy noise, such as impulsive noise or surge noise, enters into an AC power line EMC filter, the core of the coils used in the filter may become saturated and cause a significant decrease in the noise attenuation characteristics. When selecting a filter, it is necessary to check the attenuation 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.

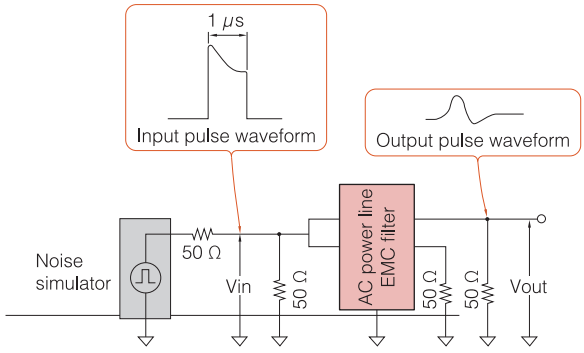
In areas including the Hokuriku area (Japan) in winter, surges exceeding 1 kV occur in power lines several times a year. In such cases, it is effective to apply surge absorption elements such as varistors or lightning arresters to the power input sides of EMC filters.

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

Country	Organization	Standard
United States	UL	UL1283
Canada	CSA	CSA C22.2 No. 8
Germany	VDE/TÜV	EN60939
Norway	NEMKO	
Sweden	SEMKO	
Finland	FIMKO	
Denmark	DEMKO	
Switzerland	SEV	
Japan	Japan Electrical Testing Laboratory	Product Safety Electrical Appliance & Material

References

Tim Williams, EMC for Product Designers, Second Edition, Newnes, 1996