

Development of an Environmentally Friendly Noise Suppression Sheet - Halogen-Free FLEX SUPPRESSOR -

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Abstract

Advancements in information and communication equipment such as notebook PCs and cellular phones have rapidly increased the design environments that are easily affected by electromagnetic noise radiated by electronic devices. NEC TOKIN has been leading the world in the development of noise suppression sheets that may be used to implement simple and safe noise countermeasures. On the other hand, the company is also making efforts to develop environmentally friendly products that do not use the specific harmful substances that are regulated by the European RoHS Directive and can meet the requirements of green procurement protocols. As one of the results of the above activities, the company has commercialized a halogen-free noise suppression sheet that features both enhanced noise suppression (with a magnetic permeability of 60) and a flame resistance capability (meeting UL94V-0), which is described in this paper.

Keywords

electromagnetic noise, halogen-free, noise suppression sheet, FLEX SUPPRESSOR, flame resistance
magnetic permeability, absorption, transmission noise, green procurement

1. Introduction

Advancements in information and communication equipment have increased the frequencies of digital signals and of design environments that are prone to interference by electromagnetic noise. The need for electromagnetic noise countermeasures and effective functional designs in the development of equipment has thereby increased. At NEC TOKIN we have developed and commercialized a noise suppression sheet (product name: FLEX SUPPRESSOR) aimed at simple and safe improvements for noise countermeasures.

The FLEX SUPPRESSOR noise suppression sheet is made of a composite material of magnetic powder and binder, and achieves an excellent electromagnetic noise suppression effect in the high-frequency domain, including in the gigahertz (GHz) band used by cellular phones. It is designed to be attached to a noise source, but its flexibility thanks to its sheet shape (**Photo 1**) enables it to be wrapped around a non-planar surface, including a sliding part or a cable. Thanks to the small sheet thickness of 25 μ m to 1mm, it is being used widely and particularly in Japan as a simple noise countermeasure

for compact and slim electronic equipment that uses frequencies of 10MHz or more.

On the other hand, in order to conform to the restrictions of use of harmful substances specified in the European RoHS Directive, etc., the FLEX SUPPRESSOR sheet has consistently been meeting standards since the commencement of sales. As we have recently been promoted our environmental friendliness policy, we began “development of an environmentally friendly noise suppression sheet” that is free of halogen as well as of organophosphorus and plasticizer (ester phthalate). Our aim was a product that meets the requirements of the green

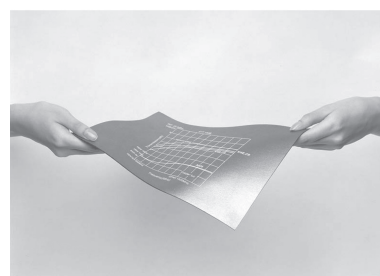


Photo 1 Noise suppression sheet “FLEX SUPPRESSOR”.

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procurement protocols.

In the following section, we will introduce a new noise suppression sheet that offers high performance and efficient flame resistance (safety) as well as providing sustainable environmental standards.

2. Environmental Measures and the Development of a High-Performance Noise Suppression Sheet

2.1 Halogen-Free Flame Resistance

The plastics used in electronic equipment are required to be flame-resistant from the viewpoint of fire prevention. We have therefore design electronic equipment to provide it with a retardation or self-extinguishing capability for any fire that may be produced due to heat generation or short-circuiting resulting from improper use.

However, most plastics are flammable because they are polymeric compounds of carbon and hydrogen. Consequently the addition of inactive substances is a means often used in order to provide them with flame resistance. The most usual traditional technique adopted to enable this is a combination of a bromine compound and antimony trioxide.

On the other hand, a noise suppression sheet is composed of magnetic powder that suppresses (absorbs) electromagnetic noise and a binder (polymer) for binding the powder. The magnetic powder is a metal alloy powder (Fe-Si-Al powder, etc.) that features excellent magnetic and environmental safety characteristics. However it tends to be oxidized rapidly at high temperatures in the 300 to 400°C range.

Combustion is a chemical reaction of matter accompanied by heat generation, and the polymer and metal alloy powder is oxidized very easily at high temperatures. Moreover, the magnetic powder content of the binder should be increased in order to improve the magnetic characteristics thus within limiting the content of substances that contribute to fire resistance. This concern presents problems in effectively providing flame resistance characteristics. The blending ratio should be determined by considering the performance of the noise suppression sheet and also by balancing this with the flame resistance, etc. Therefore, the provision of flame resistance for the noise suppression sheet presents difficulties compared to that of the plastics that are typically used in the cabinets and other parts of general electronic equipment.

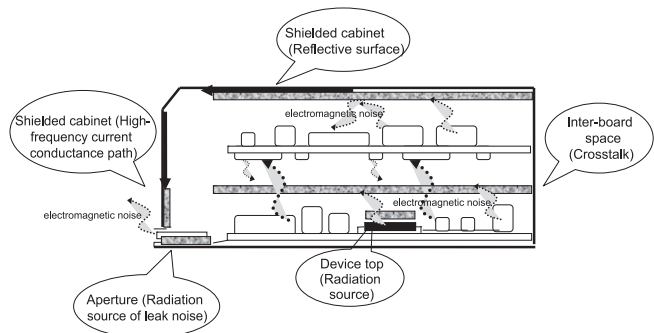


Fig. 1 Application examples of noise suppression sheet.

2.2 Design of the Noise Suppression Sheet

The noise suppression sheet is attached either to an electromagnetic noise radiation source or to a point transmitting noise (Fig. 1). By arranging it thus the distance between the radiation source and noise suppression sheet becomes less than the wavelength of the electromagnetic noise and belongs to the nearby magnetic field domain. Therefore, in order to prevent the electromagnetic noise from being reflected, it is necessary to increase the resistance of the noise suppression sheet surface. The magnetic powder is a metallic powder that is a good electrical conductor and in order to insulate it, it is effective to cover the powder surface with a binder.

Now, let us review the electromagnetic noise suppression mechanism. Initially, the electromagnetic noise is not reflected from the surface of the noise suppression sheet and is caught inside the sheet. Subsequently, the noise is attenuated mainly by a process of magnetic loss, converted into heat and consumed. This indicates that a magnetic powder that has a large magnetic loss is more effective for noise suppression and that a material with a high magnetic permeability is more suitable for the purpose.

The magnetic permeability of the noise suppression sheet can be improved by increasing its magnetization and decreasing the anisotropy field. We have actually used these techniques in order to improve the magnetic permeability. Fig. 2 demonstrates the changes in permeability that we have achieved over time.

With regard to the environmental considerations, we studied the possibility of achieving compatibility of high performance and fire resistance by using halogen-free materials. In order to provide a self-extinguishing capability we selected a halogen-free binder material that is optimum for flame resistance, reduced the flammable substances content as far as

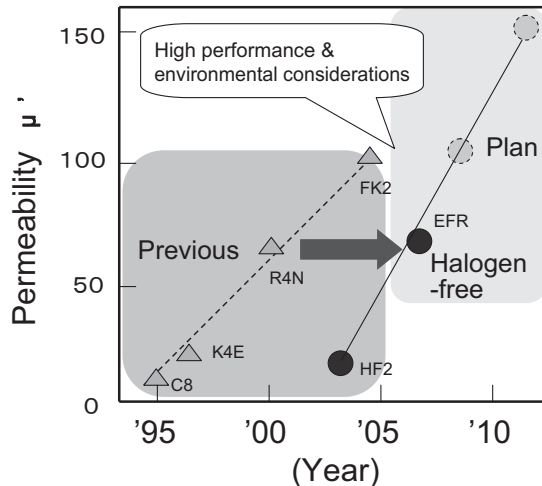


Fig. 2 Changes in the magnetic permeability of noise suppression sheets.

possible and added materials for generating nonflammable gases.

2.3 Examples of Developments of Halogen-Free Noise Suppression Sheets

The first noise suppression sheet to be capable of providing effective flame resistance (UL94V-0) without using halogen was the FLEX SUPPRESSOR “HF2” which was released in 2003. The FLEX SUPPRESSOR “HF2” was a noise suppression sheet featuring high thermal conductivity (2.0W/mK), which could also function as a heat radiation countermeasure. Recently, we have developed a noise suppression sheet called the FLEX SUPPRESSOR “EFR” (**Photo 2**). This offers a higher performance that features a flame resistance capability of UL94V-0 (thickness $t = 0.1$ to 1.0mm) and magnetic permeability (real part of the magnetic permeability) of 60 or more. Hitherto it had been difficult to achieve superior



Photo 2 Noise suppression sheet FLEX SUPPRESSOR “EFR”.

performances in both flame resistance and magnetic permeability at the same time.

Table 1 shows a comparison of specifications between the new FLEX SUPPRESSOR “EFR” and the previous FLEX SUPPRESSOR “R4N.” It also shows that the FLEX SUPPRESSOR “EFR” is inferior to the FLEX SUPPRESSOR “R4N” and that it has already been proven to be an effective noise suppression tool. **Fig. 3** shows the frequency dependency of the magnetic permeability of the “EFR” and “R4N” models. The real part of the magnetic permeability indicates the energy accumulation, the imaginary part indicates the energy loss, and the noise suppression effect is larger when

Table 1 Specifications of halogen-free noise suppression sheet.

Characteristic	New Product	Previous Product
Specifications	EFR	R4N
Structure	Single layer	
Frequency range	10MHz to 3GHz	
Magnetic permeability μ'	60	
Operating temperature ($^{\circ}\text{C}$)	-45 to +105	-25 to +85
Thickness (mm)	0.1, 0.2, 0.3, 0.5, 1.0	
Dimensions	Standard (mm)	80 × 80
	Max (mm)	240 × 240
Specific gravity	2.8 (typ.)	3.1 (typ.)
Tensile strength (MPa)	3.6 (min.)	3.8 (min.)
Surface resistance (Ω)	1.0×10^6 (min.)	
Certified standard	UL94 V-0 (File No. E176124)	
Environmental considerations	Halogen-free	Yes
	RoHS Directive	Yes

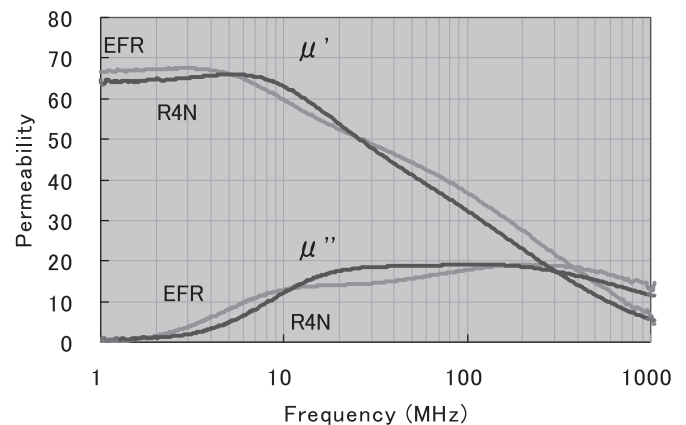


Fig. 3 Magnetic permeability of noise suppression sheets.

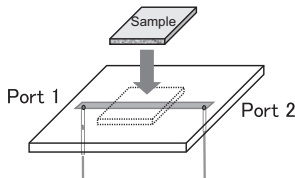
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these items become larger. The figure shows that the characteristics of the two products are almost identical.

Next, by using a measuring system assuming that electromagnetic noise (high-frequency current) is conducted on the PCB patterns (micro-stripline with 50Ω impedance) of electronic equipment, we evaluated the suppression effect of conductive noise that was enabled by the use of noise suppression sheets (Fig. 4). The results are shown in Fig. 5 . These tests evaluate the losses in the transmission characteristics with respect to occurrence. The maximum amount is standardized as 1 so the loss is larger when it is close to 1. These results confirm that the conductive noise loss of the “EFR” is similar to that of the “R4N,” and that the loss is dependent on the sheet thickness up to a frequency of 3GHz.

2.4 Measures Aimed at Environmental Considerations

From the beginning, we designed and commercialized the “FLEX SUPPRESSOR” noise suppression sheet to enable both high performance and flame resistance without using substances that would impose loads on the environment. With the



Substrate:FR-4, t=1.6[mm] 100mm square Microstrip line:Zc=50[Ω]

Fig. 4 Conductive noise suppression effect measurement system.

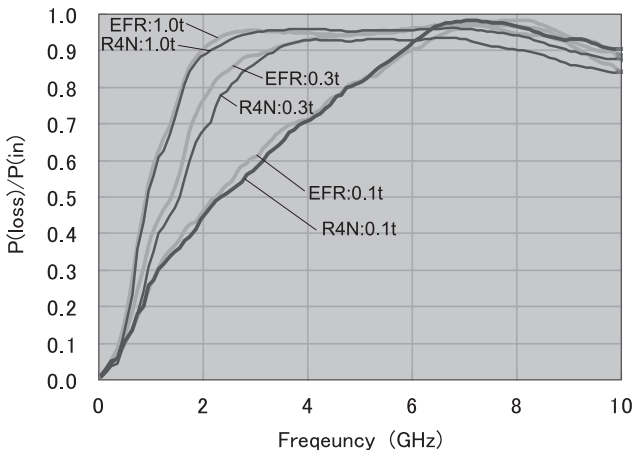


Fig. 5 Transmission noise attenuation characteristics of noise suppression sheets.

Table 2 Results of content evaluation of RoHS directive target substances.

Check Item	Analysis Result	Detection Limit
Cadmium	Not detected	< 1.6ppm
Lead	Not detected	< 10ppm
Mercury	Not detected	< 0.2ppm
Hexavalent chromium	Not detected	< 1.0ppm
Polybrominated biphenyl (PBB)	Not detected	< 5.0ppm
Polybrominated diphenyl ether (PBDE)	Not detected	< 5.0ppm

Table 3 Definitions of halogen-free materials.

Item	Details
Chlorine (Cl) content	≤ 0.09wt% (900ppm)
Bromine (Br) content	≤ 0.09wt% (900ppm)
Total Cl and Br content	≤ 0.15wt% (1500ppm)

Table 4 Halogen content in FLEX SUPPRESSOR “EFR”.

Fluorine	Chlorine	Bromine	Iodine
≤ 5ppm	15ppm	≤ 5ppm	≤ 1ppm

newly commercialized FLEX SUPPRESSOR “EFR,” we had a third-party organization evaluate the contents of substances dealt with by the RoHS Directive (lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyl and polybrominated diphenyl ether). The results of these evaluations are shown in Table 2 . It shows that the contents of all of the substances are below the detectable limit and can be regarded as being absent.

The Japan Electronics Packaging and Circuits Association and other organizations define that the halogen-freedom of material is judged according to the conditions as shown in Table 3 . Accordingly, we analyzed the amount of halogen in FLEX SUPPRESSOR “EFR” by measuring the contents of the halogen elements including fluorine, chlorine, bromine and iodine.

Table 4 shows the results of the analysis. It shows that the contents of fluorine, bromine and iodine are below detectable limits and can be regarded as being absent and that the content of chlorine is as low as only 15ppm while the standard value is 900ppm. As a result, we could confirm that the product achieves the requisite halogen-freedom.

3. Conclusion

We have recently commercialized FLEX SUPPRESSOR

“EFR” with a magnetic permeability of 60 and a flame resistance equivalent to UL94V-0 as a halogen-free noise suppression sheet that provides both high performance and flame resistance functions. In the future, we intend to advance our environmental policy by developing noise suppression sheets with even higher suppression effects.

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