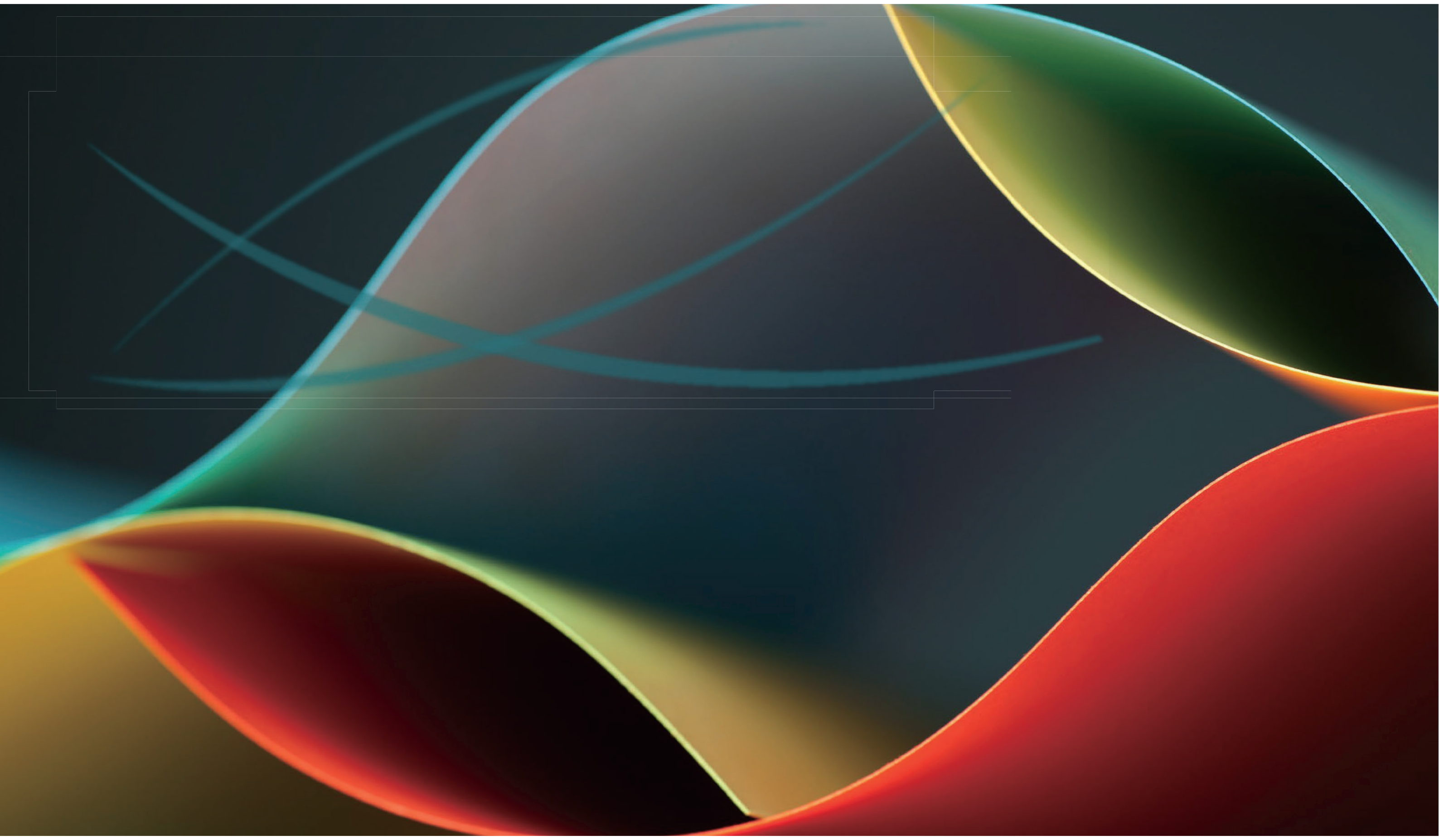
Niterra
Niterra Materials

Amorphous Magnetic Parts

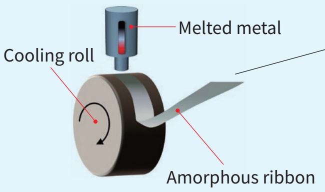


Niterra Materials' amorphous products

Niterra Materials has been leading the world in research and development, focusing on the excellent magnetic properties of amorphous magnetic alloys, which have no crystalline structure. In particular, for cobalt-based amorphous alloys, we have a consistent domestic manufacturing process that covers everything from mass production of thin ribbon materials using the liquid quenching method to componentization. Magnetic parts that take advantage of the characteristics of cobalt-based amorphous alloys have made it possible to downsize electronic devices, thereby saving energy and reducing noise, making them environmentally friendly products.

Main manufacturing process for amorphous magnetic parts.

We manufacture the thin ribbons in house.



1 Casting

Molten metal is sprayed onto a rotating cooling roll and rapidly cooled to produce a thin ribbon of amorphous alloy.

2 Slits

Slits are made to the product width.

3 Insulation treatment

The surface of theamorphous ribbon is insulated.

4 Forming

The amorphous ribbon is wound into a toroidal shape.

5 Heat treatment

Magnetic annealing in a continuous furnace.

6 Assembly

This involves storing the components in a plastic case andwinding the wires.

7 Inspection and Packaging

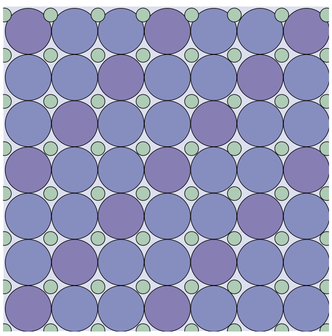
8 Shipping

What is cobalt-based amorphous?

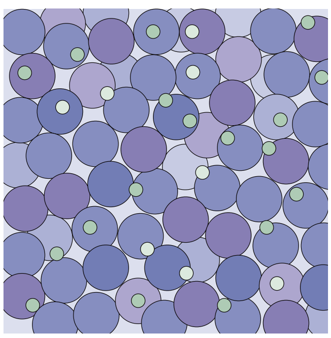
Amorphous alloys are a general term for metals in which the arrangement of atoms does not have a crystalline structure. Normal alloys have a regular metallic crystalline structure, but in amorphous alloys the atoms are arranged randomly. In terms of magnetic properties, because amorphous alloys do not have a crystalline structure, they have no crystalline magnetotropy and also have a high specific resistance. At the same time, because they are directly manufactured into ultra-thin ribbons, eddy current losses are reduced, resulting in significantly improved magnetic properties.

Cobalt-based amorphous alloys in particular have a high relative permeability, which contributes to energy savings in electronic components.

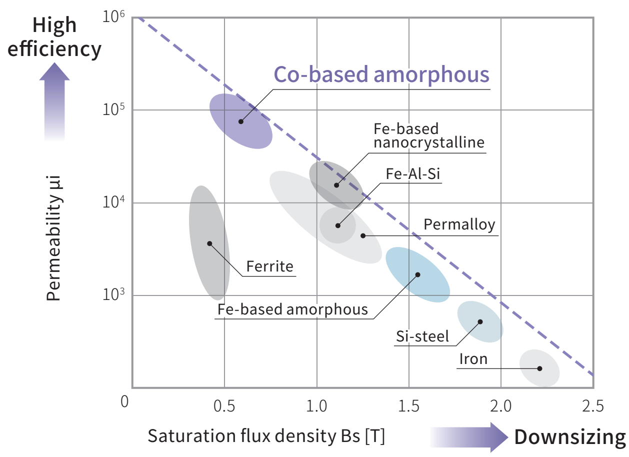
Models of Atomic Arrangement



Regular Alloy
(Crystalline Structure)



Amorphous Alloy
(Non Crystalline Structure)



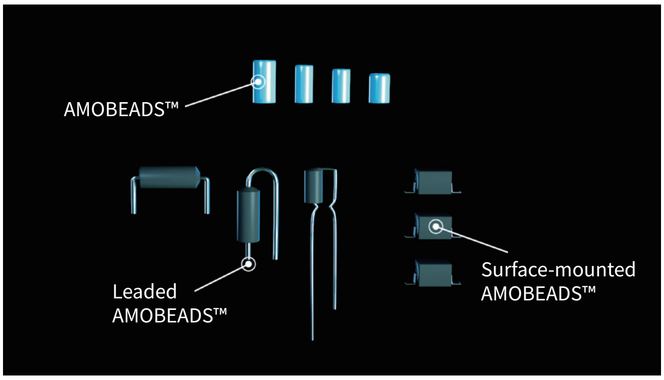
Amorphous magnetic components

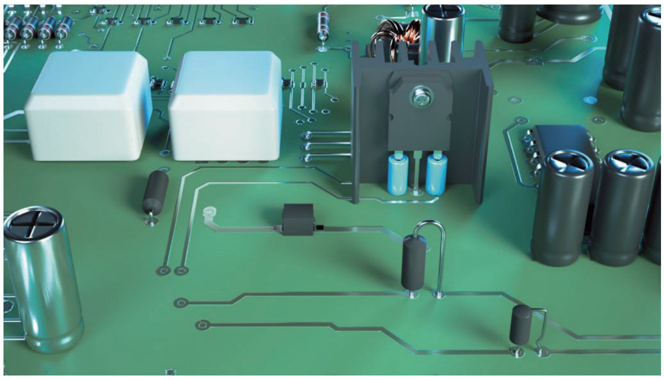
Table of contents

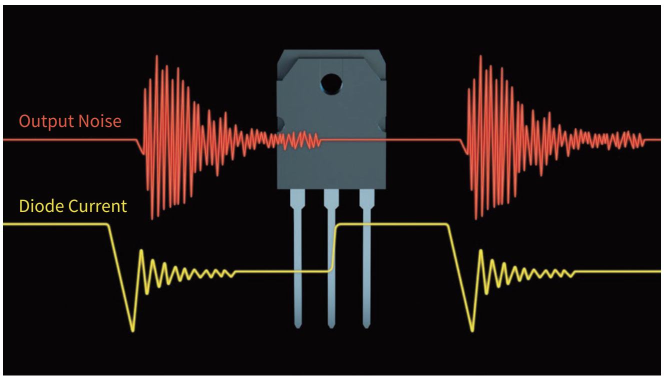
1 Noise suppression elements AMOBEADS™ and SPIKE KILLER™

1.1 What are noise suppression elements?

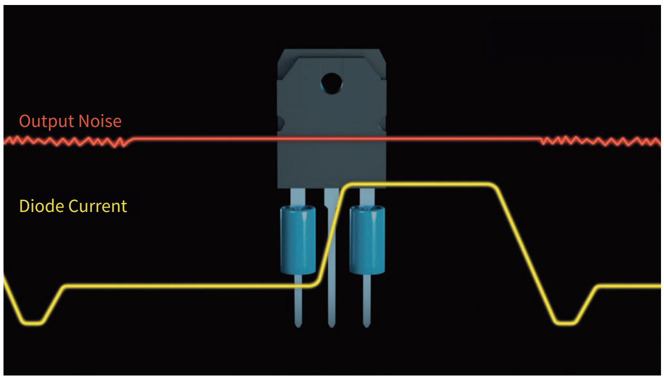
The amorphous noise suppression elements "AMOBEADS™" and "SPIKE KILLER™" are unique noise suppression elements that were created from a completely different perspective than conventional noise filters. The main purpose of normal noise suppression components is to absorb noise that has already been generated, so the noise attenuation characteristics depending on the frequency are important.
In contrast, amorphous noise suppression elements suppress the generation of noise itself by removing the parts of the current and voltage that are the source of noise. In other words, since the high-frequency components of noise are suppressed by eliminating the source of noise, the attenuation characteristics at the noise frequency are not relevant.
Amorphous noise suppression elements are components that make the most of the magnetic properties of cobalt-based amorphous alloys. We have commercialized "AMOBEADS™", which provides excellent noise suppression effects simply by penetrating the leads of semiconductors, etc., and "SPIKE KILLER™", which provides even higher noise suppression effects when wound. In addition, "AMOBEADS™" is also available in leaded and surface-mounted types.







No solution



Implemented AMOBEADS™

1.2 AMOBEADS™ ABW/DY series

ABW series

Product name symbol	Finished dimensions [mm]			Total magnetic flux*1 φc [μWb] min	AL value*2 L [μH] min	Insulating Covers*3	Packaging unit [pcs/box]
	Outer diameter max	Inner diameter min	Height max				
AB3x2x3W	4.0		4.5	0.9	3.0		
AB3x2x4.5W			6.0	1.3	5.0		
AB4x2x4.5W		1.5		2.7	9.0	Blue PBT	2,000
AB4x2x6W	5.0		7.5	3.6	12.0		
AB4x2x8W			9.5	4.8	16.0		

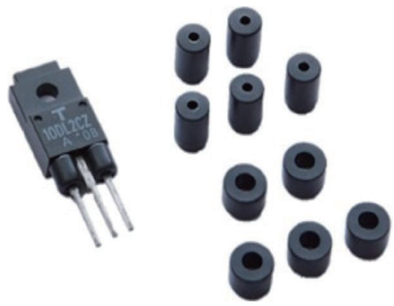
*1 1kHz,100mA(sine wave),The inductance at room temperature is calculated from L1.φc[μWb]=0.282xL1[μH]
*2 Measurement conditions: 50kHz, 1V, 1turn, room temperature
*3 UL standard 94V-0 certified material
•The values in the table are reference values and are not guaranteed values.

ABDY Series

Recommended for customers with many orders in 10,000-piece units.
By adopting a new case material and structure, it has better cost performance than the conventional W series products.

Product name symbol	Finished dimensions [mm]			Total magnetic flux*6 φc [μWb] min	AL value*7 L [μH] min	Insulated exterior*8	Packaging unit [pcs/box]
	Outer diameter max	Inner diameter min	Height max				
AB2.8x4.5DY			0.9	0.9	3.1	Black PBT	
AB3x2x3DY	4.2	(1.4)*4					10,000
AB3x2x4.5DY			1.3	1.3	4.6	Gray PBT	
AB4x2x6DY	5.2		3.6	3.6	12.7	Black PBT	5,000
AB5x4x3DY	6.2	(2.6)*5	0.5	0.45	1.5		

*4 The dimensions are such that a 1.2 x 0.7 mm lead can penetrate through.
*5 The dimensions are such that a 2.5 x 0.7 mm lead can penetrate through.
*6 Calculated from the inductance value L1 at 1 [kHz], 100 [mA] (sine wave), and room temperature. Φc [μWb] = 0.282XL1 [μH]
*7 Reference value
*8 UL standard 94V-0 certified material
•The values in the table are reference values and are not guaranteed values.



1.3 AMOBEADS™ with leads LB series

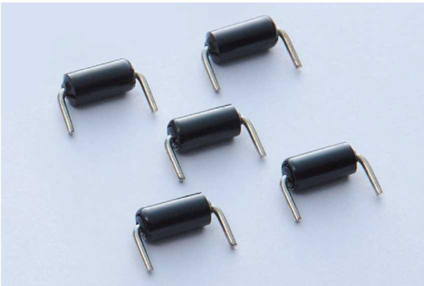
LB series

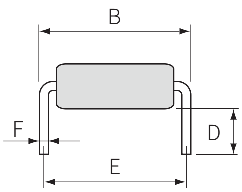
Leads have been attached to AMOBEADS™ to improve mounting. This type makes it easy to replace ferrite beads with leads. We also have a radial taping type that allows for automatic mounting.

Lead type

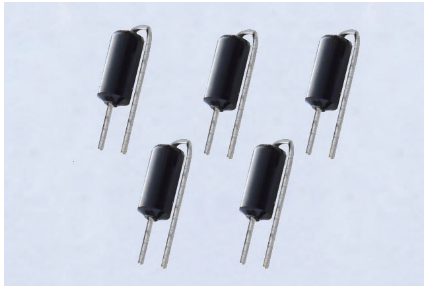
Product name symbol	Finished dimensions [mm]				Current*1 [A]	Total magnetic flux*2 φc[μWb] min	AL value*3 L [μH] min	Insulating Covers*4	Packaging unit [pcs/box]
	Length B	Lead D	Pitch E	Lead diameter F					
LB4x2x8F	16.0	14.0±0.5	14.0±1.0	φ1.25±0.1	(8.0)	4.8	16.0	Black PBT	1,000
LB4x2x8U	20.0	5.0±0.5	5.0±1.0						

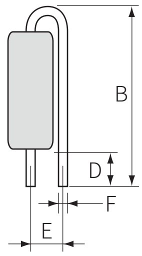
*1 The current value is a reference value calculated from the cross-sectional area of the winding.
*2 1kHz,100mA(sine wave),The inductance at room temperature is calculated from L1.φc[μWb]=0.282xL1[μH]
*3 Measurement conditions:50kHz,1V,1turn,room temperature.
*4 UL standard 94V-0 certified material
•The values in the table are reference values and are not guaranteed values.





LB4x2x8F



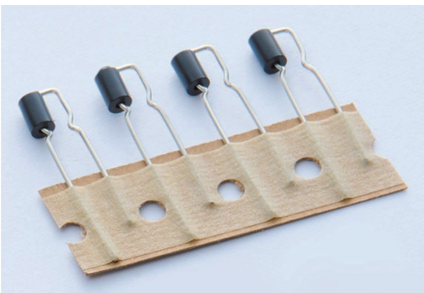


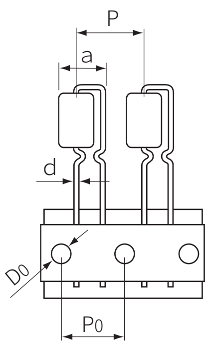
LB4x2x8U

Radial taping type

Product name symbol	Finished dimensions [mm]					Current*1 [A]	Total magnetic flux*2 φc [μWb] min	Packaging unit [pcs/box]
	Pitch P	Pitch P_0	Guide hole diameter D_0	Outer diameter a	Lead wire diameter d			
LB2.8x4.5U	12.7	12.7	φ4.0	9.0 max	φ0.8	(5)	0.9	3,000

*1 The current value is a reference value calculated from the cross-sectional area of the winding.
*2 1kHz,100mA(sine wave),The inductance at room temperature is calculated from L1.φc[μWb]=0.282xL1[μH]
•The values in the table are reference values and are not guaranteed values.





LB2.8x4.5U

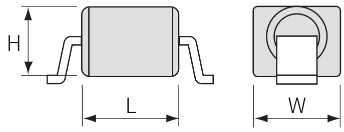
1.4 Surface mount AMOBEADS™ SMD series

SMD series

Radial taping type that allows automatic mounting.

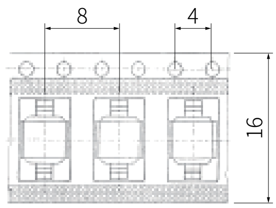
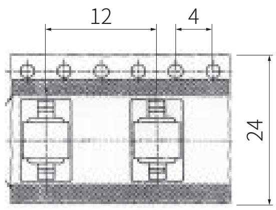
Product name symbol	Finished dimensions [mm]				Current*1 [A]	Total magnetic flux*2 φc [μWb] min	AL value*3 L [μH] min	Insulating Covers*4	Packaging unit [pcs/box]
	Width max	Length max	Height max	Lead Dimensions					
AB3x2x3SM	5.3	5.3	4.3	(1.8 x 0.35)	(6.0)	0.9	3.0	Black LCP	2,000
AB4x2x6SM	6.3	8.3	5.3	(1.8 x 0.52)	(4.8)	3.6	12.0		1,000

*1 The current value is a reference value calculated from the cross-sectional area of the winding.
*2 1kHz,100mA(sine wave),The inductance at room temperature is calculated from L1.φc[μWb]=0.282xL1[μH]
*3 Measurement conditions:50kHz,1V,1turn,room temperature.
*4 UL standard 94V-0 certified material
•The values in the table are reference values and are not guaranteed values.

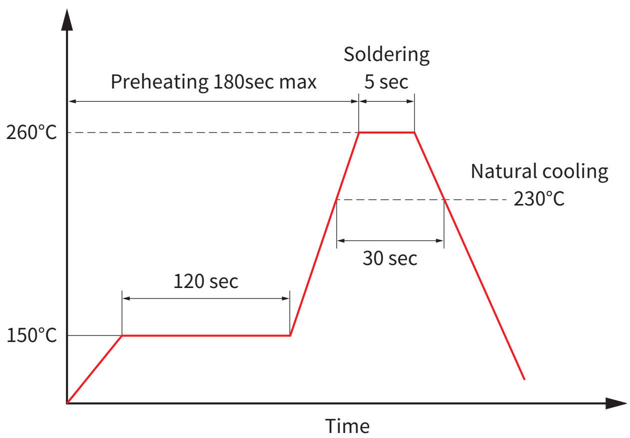


AB3x2x3SM、AB4x2x6SM

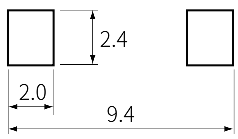
Surface mount taping standard specifications

Product name symbol	External dimensions [mm]
AB3x2x3SM	
AB4x2x3SM	

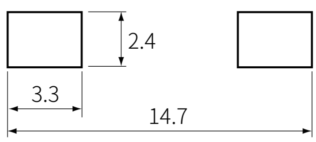
Soldering pattern example



Recommended land pattern [unit: mm]



AB3x2x3SM



AB4x2x6SM

RoHS compliant products

1.5 SPIKE KILLER™ SS Series

SS Series

If the circuit voltage is high and the diode reverse recovery time is long, we recommend the SPIKE KILLER™ SS Series, which has a high total magnetic flux.

<table>
<tr><th rowspan="2">Product name symbol</th><th colspan="3">Finished dimensions [mm]*1</th><th colspan="3">Core Size [mm]*2</th><th rowspan="2">Effective core cross section*2 Ae [mm2]</th><th rowspan="2">Mean Flux Path Length*2 Lm [mm]</th><th rowspan="2">Total magnetic flux*3 ϕc [μWb] min</th><th rowspan="2">Coercive Force*3 Hc [A/m] max</th><th rowspan="2">Rectangular Ratio*3 Br/Bm [%] min</th><th rowspan="2">Insulating Covers*4</th></tr>
<tr><th>Outer diameter</th><th>Inner diameter</th><th>Height</th><th>Outer diameter</th><th>Inner diameter</th><th>Height</th></tr>
<tr><td>SS7x4x3W</td><td>9.1</td><td>3.3</td><td>4.8</td><td>7.5</td><td>4.5</td><td>3.0</td><td>3.38</td><td>18.8</td><td>3.15</td><td rowspan="6">22</td><td rowspan="6">90</td><td rowspan="6">Black PET</td></tr>
<tr><td>SS10x7x4.5W</td><td>11.5</td><td>5.8</td><td rowspan="5">6.6</td><td>10</td><td>7</td><td rowspan="5">4.5</td><td>5.06</td><td>26.7</td><td>4.73</td></tr>
<tr><td>SS12x8x4.5W</td><td>13.8</td><td rowspan="2">6.8</td><td>12</td><td rowspan="2">8</td><td>6.75</td><td>31.4</td><td>6.31</td></tr>
<tr><td>SS14x8x4.5W</td><td>15.8</td><td>14</td><td rowspan="2">10.1</td><td>34.6</td><td rowspan="2">9.46</td></tr>
<tr><td>SS18x12x4.5W</td><td>19.8</td><td>10.8</td><td>18</td><td>12</td><td>47.1</td></tr>
<tr><td>SS21x14x4.5W</td><td>22.8</td><td>12.8</td><td>21</td><td>14</td><td>11.8</td><td>55.0</td><td>11.0</td></tr>
</table>

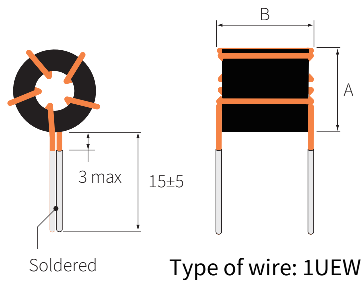
*1 Tolerance ±0.2mm *2 Reference
*3 Measurement conditions: 100kHz,80A/m(sine wave,room temperature)
*4 UL standard 94V-0 certified material
•The values in the table are reference values and are not guaranteed values.

SPIKE KILLER™ with winding

This is a type of SPIKE KILLER™ SS series with winding.If the circuit voltage is higher and the diode reverse recovery time is longer, consider the SPIKE KILLER™ with winding, which has a higher total magnetic flux.

<table>
<tr><th rowspan="2">Product name symbol</th><th rowspan="2">Core No.</th><th rowspan="2">Current*1 [A]</th><th rowspan="2">Wire Dia. ϕ [mm]</th><th rowspan="2">N [turn]</th><th rowspan="2">Flux*2 [uWb]</th><th colspan="2">Finished dimensions [mm]</th></tr>
<tr><th>Outer diameter A max</th><th>Height B max</th></tr>
<tr><td>SS07S0309</td><td>SS7x4x3W</td><td>0.5</td><td>0.3</td><td>9</td><td>28.3</td><td>12</td><td rowspan="4">8</td></tr>
<tr><td>SS07S0507</td><td>SS7x4x3W</td><td rowspan="6">1.5</td><td rowspan="6">0.5</td><td>7</td><td>22.1</td><td rowspan="3">12</td></tr>
<tr><td>SS07S0510</td><td>SS7x4x3W</td><td>10</td><td>31.5</td></tr>
<tr><td>SS07S0515</td><td>SS7x4x3W</td><td>15</td><td>47.3</td></tr>
<tr><td>SS10S05105</td><td>SS10x7x4.5W</td><td>5</td><td>23.7</td><td rowspan="3">14</td><td rowspan="3">10</td></tr>
<tr><td>SS10S05107</td><td>SS10x7x4.5W</td><td>7</td><td>33.1</td></tr>
<tr><td>SS10S05110</td><td>SS10x7x4.5W</td><td rowspan="2">10</td><td rowspan="2">47.3</td></tr>
<tr><td>SS10S09110</td><td>SS10x7x4.5W</td><td rowspan="2">5</td><td rowspan="2">0.9</td><td>15</td><td rowspan="3">11</td></tr>
<tr><td>SS14S09108</td><td>SS14x8x4.5W</td><td>8</td><td>75.7</td><td rowspan="2">20</td></tr>
<tr><td>SS14S09205</td><td>SS14x8x4.5W</td><td>10</td><td>0.9x2</td><td>5</td><td>47.3</td></tr>
</table>

*1 The current value is a reference value calculated from the cross-sectional area of the winding.
*2 Total flux of core x turn
•The values in the table are reference values and are not guaranteed values.



Type of wire: 1UEW

Environmental specifications for AMOBEADS™ and SPIKE KILLER™

Storage temperature range	-20 to 50°C (ambient temperature)
Usage temperature range	-20 to 120°C (including core self-temperature rise. Natural air cooling)

Electrical characteristics of AMOBEADS™ and SPIKE KILLER™

Item (guaranteed value)	Specification
Insulation resistance	DC500V is applied between the core and core exterior surface, and the insulation resistance is over 1000MΩ.
Withstand voltage	Even if AC500V is applied for 1 minute between the core and core exterior surface,Assume there is no abnormality.

1.6 Introducing sample kits and sample shelves

For carrying and evaluating in laboratories

Sample kit AMOBEADS™

Dimensions: W87 x L60 x H20 mm (common)

Contents: (10 pcs each)

◎AB3x2x3W ◎AB3x2x4.5W ◎AB4x2x4.5W
◎AB4x2x6W ◎AB4x2x8W ◎AB5x4x3DY

Sample kit SPIKE KILLER™

Dimensions: W87 x L60 x H20mm

Contents: (15 pcs each)

◎SS7x4x3W ◎SS10x7x4.5W ◎SS14x8x4.5W

For permanent placement in the noise evaluation laboratory (anechoic chamber)

Sample shelf

Dimensions: W235 x L235 x H255mm

Core breakdown (example)

AB3x2x3DY AB3x2x4.5DY	100pcs 100pcs	AB5x4x3DY AB4x2x4.5DY	100pcs 100pcs
AB4x2x6DY AB2.8x4.5DY	100pcs 100pcs	SS7x4x3W SS10x7x4.5W	100pcs 100pcs
AB4x2x8W	100pcs	AB3x2x4.5W	100pcs
AB3x2x3DY	100pcs	SS14x8x4.5W	100pcs
NZK3723GW	3pcs	NZK2515GW	5pcs

NZK is a high permeability microcrystalline core for common mode chokes.

Sample kits and sample shelves
If you have any requests for sizes or varieties, please let us know. We also offer customization.

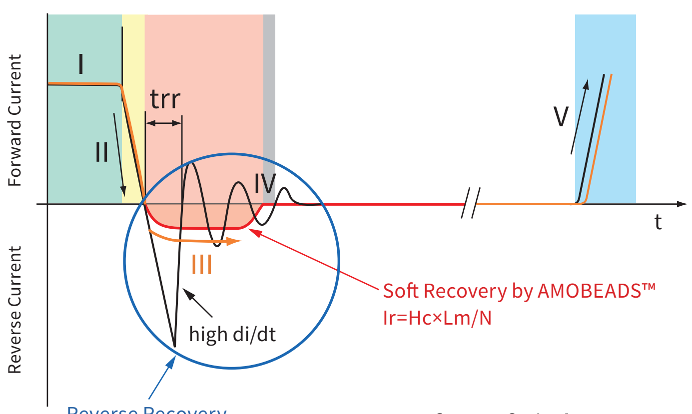
2 [Technicalexplanation] Examples of the effectiveness of noise suppression elements

2.1 Operation principle of noise suppression elements 10

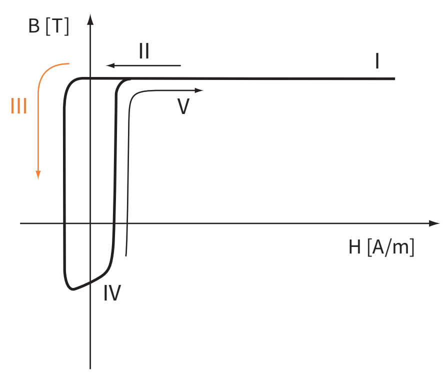
This explains how "AMOBEADS™" work when attached to the leads of an output diode built into a switching power supply.

Period I [Diode ON]	During Period I when the diode is ON and a forward current is flowing, the magnetization state of the "AMOBEADS™" is in the saturated state "I" and has almost no inductance.
Period II [when the diode turns off]	In Period II, when the diode current starts to turn off and the current decreases toward zero, the magnetization state of "AMOBEADS™" changes to "II", but there is almost no inductance until the current crosses zero. One of the features of "AMOBEADS™" is that since there is no inductance in Period II, the slope of the diode current at turn-off is not changed. Conversely, if a material such as ferrite is used, inductance will be generated in Period II, which will change the slope of the current at turn-off and increase the diode loss.
Period III [during reverse recovery]	In period III, when reverse recovery current is about to flow in the reverse direction of the diode, the magnetization curve of the "AMOBEADS™" changes to "III" and the inductance increases rapidly. At this time, the large inductance of the "AMOBEADS™" works to block the recovery current, making the current a soft recovery. Through this action, the "AMOBEADS™" mitigate the sudden current changes (high di/dt) that cause noise, and suppress the generation of noise.
Period IV [end of reverse recovery]	In period IV, when the diode's reverse recovery current ends, the magnetization state of the "AMOBEADS™" is at "IV" on the vertical axis.
Period V [when the diode turns on]	The next on-pulse is applied, and during period V when the diode turns on, the magnetization of the "AMOBEADS™" changes like "V" and returns to a saturated state. At this time, the effect of delaying the rise of the current is achieved.

"AMOBEADS™" repeat five stages, periods I to V, at the operating frequency, and in period III, they demonstrate the effect of suppressing noise by eliminating the sudden change in the diode's reverse recovery current, which is the cause of noise generation. "AMOBEADS™," which use a cobalt-based amorphous alloy with low coercive force at high frequencies as their core material, thus demonstrate an extremely excellent noise suppression effect.



Current Waveform of Diode

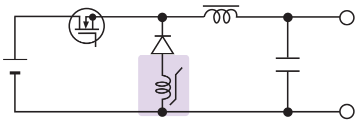


Actual BH Curve

2.2 Examples of application circuits and characteristic diagrams

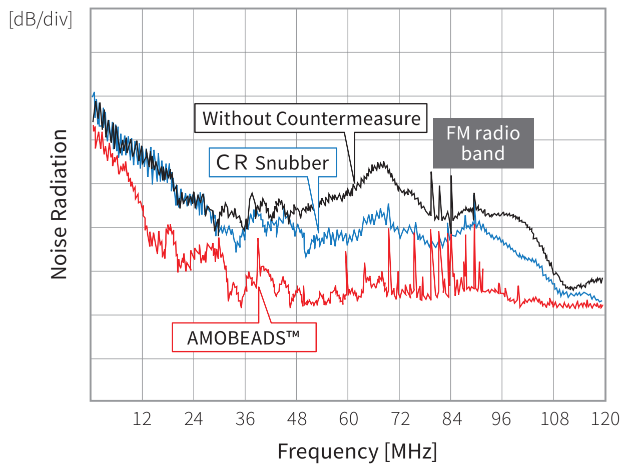
Example of applied circuit and radiation noise suppression effect (chopper converter)

Example of applied circuit

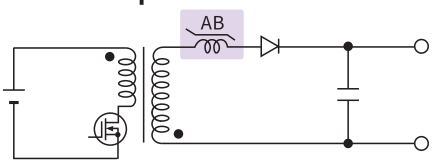


Chopper converter

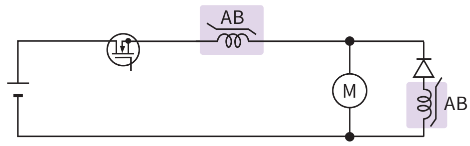
Radiation noise measurement (Test conditions)	
Input	20 [V]
Output	12 [V]/2 [A]
Operating frequency	90kHz
Rectifier diode	FRD
Detection	Using simple loop antenna



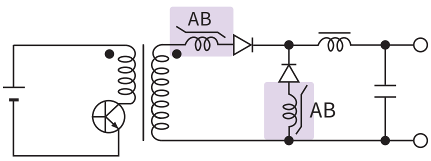
Other applicable circuit examples



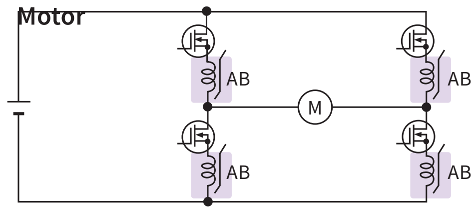
Flyback Converter



Control Circuit for Motor

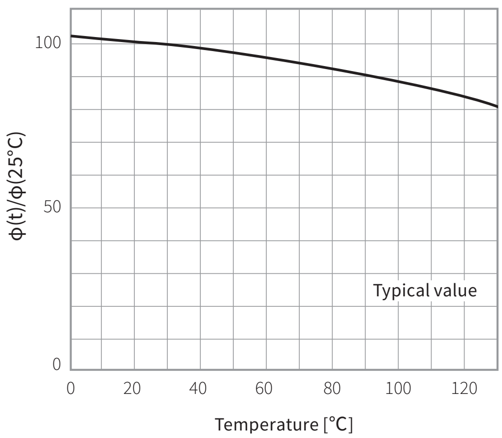


Forward Converter

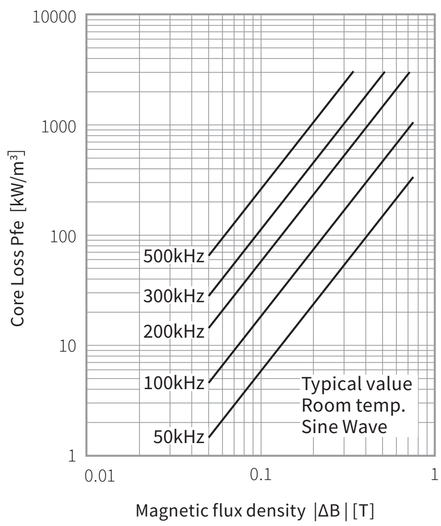


Motor Driving Circuit

Characteristics (Typical value)



Flux(Φ) Decline Ratio vs. Temperature



Coreloss Characteristic [AMOBEADS™]

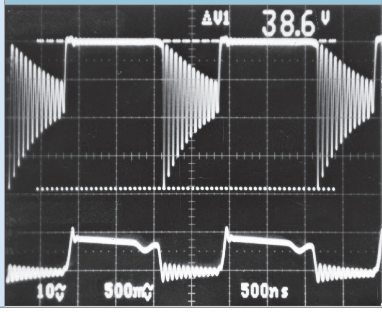
2.3 Example of the effect of the noise suppression element "AMOBEADS™"

Spike voltage suppression

Using "AMOBEADS™" suppresses spike voltage and prevents ringing. This protects Schottky barrier diodes (SBDs) from reverse voltage overload destruction.

Measurement conditions:
- Frequency:500kHz
- Output voltage/current:5V-20A

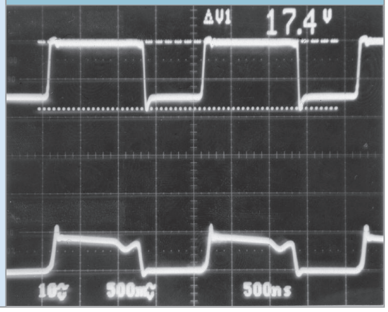
No countermeasures



Diode voltage V_D 10V/div

Diode voltage I_D 5A/div

AMOBEADS™ "AB4x2x4.5W"

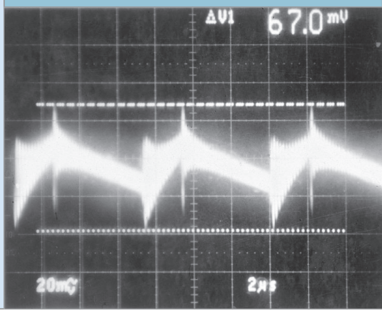


Output noise reduction

By replacing the ferrite beads of the secondary output diode (FRD) of the forward converter with "AMOBEADS™", the output noise is reduced. Both the noise peak value and amplitude range are suppressed.

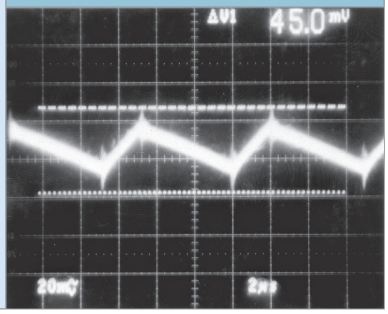
Measurement conditions:
- Frequency:150kHz
- Output voltage/current:15V-10A

CR snubber + ferrite beads



Output noise V_N 20mv/div

AMOBEADS™ "AB4x2x4.5W"

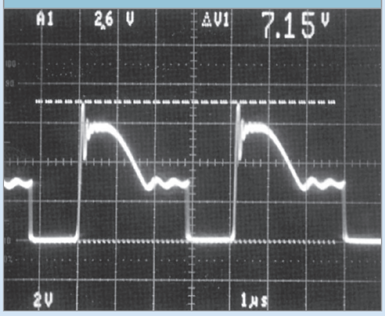


Primary side surge voltage

When "AMOBEADS™" are used for the secondary output diode (SBD) of a forward converter, output noise is reduced and the adverse effect on the primary side is smaller than with ferrite beads. This is due to the difference in the slope of the actual B-H.

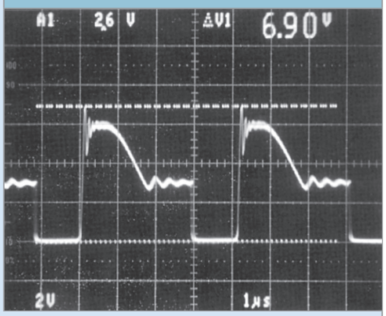
Measurement conditions:
- Frequency:250kHz
- Output voltage/current:5V-15A

Ferrite beads 4x2x4

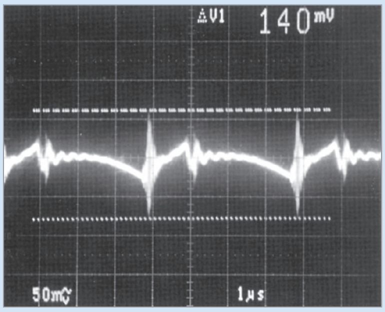


MOS-FET drain-source voltage V_{DS} 200V/div

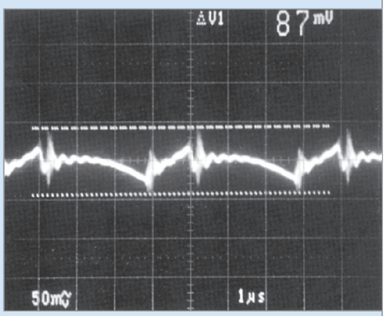
AMOBEADS™ "AB4x2x4.5W"



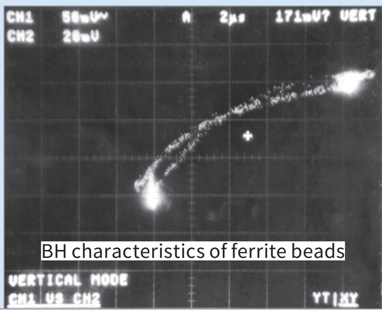
Output noise



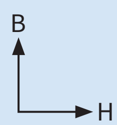
Output noise V_N 50mv/div

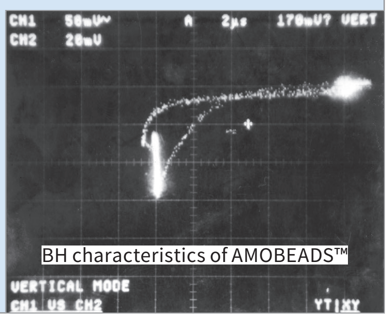


Actual BH characteristics



BH characteristics of ferrite beads

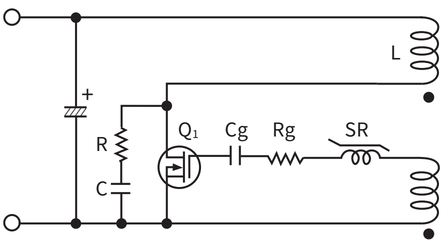




BH characteristics of AMOBEADS™

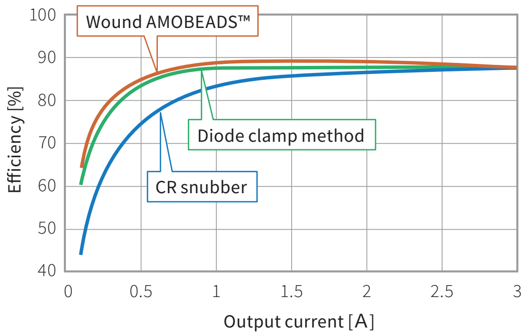
2.4 Examples of the effectiveness of delay elements "Wound AMOBEADS™"

Application circuit example: Application example to RCC self-excited flyback circuit



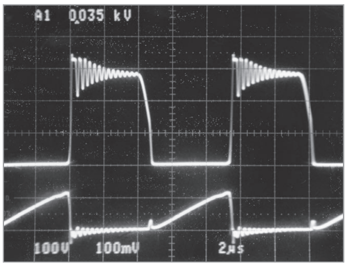
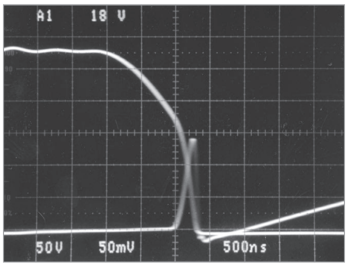
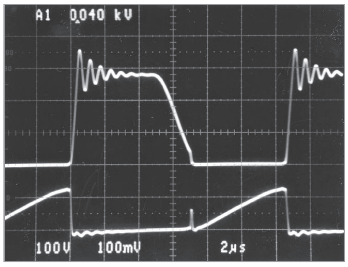
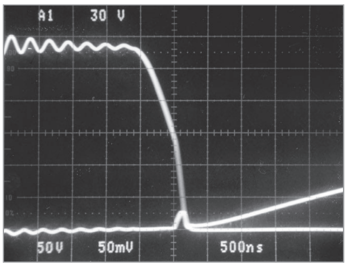
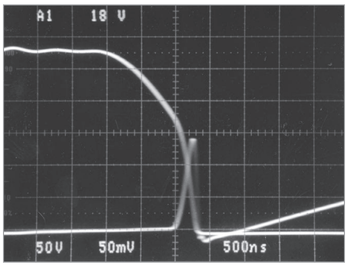
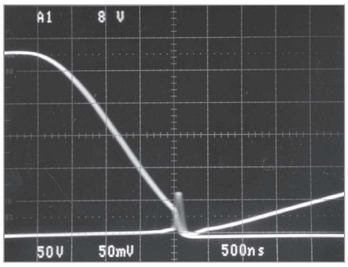
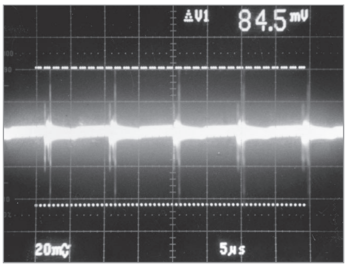
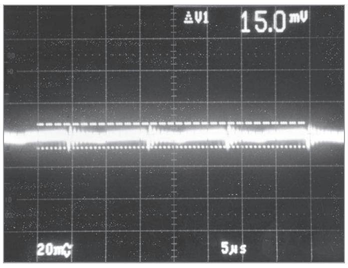
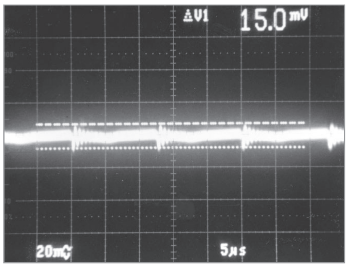
SR: Wound AMOBEADS™

Power supply efficiency



Power supply efficiency
(input voltage: DC140V, output voltage 24V)

Example of effect (delay element)

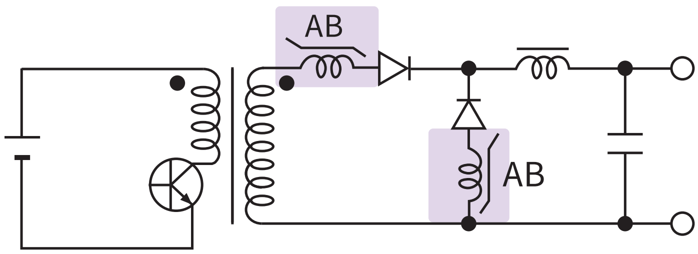
	Diode clamp (68kΩ, 0.022μF)	**CR snubber** (10Ω, 1500pF)	**AMOBEADS™ with winding**
Switching waveform Vds 100V/div Id 1A/div			
Turn-on waveform Vds 100V/div Id 0.5A/div			
Output voltage noise Vn 20mV/div			

Wound AMOBEADS™ are mainly inserted on the primary side of a self-excited flyback power supply (R.C.C.), between the gate and drive winding of the switching element MOSFET, to delay the timing of the MOSFET turn-on. By utilizing the LC resonance phenomenon caused by the inductance L of the transformer primary winding and the snubber capacitor C, the switching element is turned on when the transformer voltage drops, reducing noise caused by surge currents as well as switching losses.
Note that the diode clamp method tends to have higher output noise.

2.5 How to select AMOBEADS™ and SPIKE KILLER™

The type of noise suppression element such as AMOBEADS™ or SPIKE KILLER™ is determined by the circuit conditions.
In general, the following points are used as a guide to determine the type.

	AMOBEADS™	SPIKE KILLER™
Output voltage	~ 24V	Other than the above
Recovery time (trr)	~ 60nsec	Other than the above
Mounting space	Not required (Penetration through the leads)	Required (Wound products)



Example of circuit (forward converter)

(A) AMOBEADS™

The purpose is to suppress the sudden time change (di/dt) of the current, such as diode recovery, which is a cause of noise voltage. It suppresses the initial part of the recovery current's "zero crossing".
Select a small core size that satisfies the voltage-time product in the following formula.

$\phi c \geqq Vc \times trr$ [Wb]

ϕc : Total magnetic flux of the core [Wb]
Vc : Voltage across the diode or core [Wb]
trr : Recovery time [sec]

AMOBEAD is passed through the diode lead, so select a core with more than the required magnetic flux.
If the magnetic flux of the core is insufficient, use a SPIKE KILLER™.

(B) SPIKE KILLER™

When designing with a SPIKE KILLER™, the length of the diode must be taken into consideration when it is converted into a diode. The magnetic flux $\Delta\phi$ required to suppress the diode is

$\Delta\phi = 3 \times Vc \times trr$ [Wb] ・・・・・・・・・・・(1)

Next, select the core size. As with the design of the mag amp, select a size with a core capacity that satisfies the following conditional formula.

$\phi c \cdot Aw \geqq \Delta\phi \times Io/(Kf \times J)$・・・・・・・・・・・(2)

Core capacity [μWb・mm²] Total magnetic flux x window area
Io: Rated current [A]
Kf: Winding factor (≒0.4) Ratio of winding area to window area
J: Average current density (≒5~8[A/mm²] during natural cooling)

Substituting formula (1) into formula (2) and rearranging, we get

$\phi c \cdot Aw \geqq 1.5 \times Vc \times trr \times Io$・・・・・・・・・・・・・(3)

Therefore, select a core that satisfies formula (3) from the separate table.

Once the core size is selected, calculate the winding specifications (wire diameter, number of wires, number of turns).

The winding wire diameter d is calculated from the rated current Io and the average current density J.

$d \geqq 2 \times \sqrt{Io/(\pi \times J)}$ [mmφ]・・・・・・・・・・(4)

If the average current density is 5[A/mm²], formula (4) becomes

$d \geqq 0.5 \times \sqrt{Io}$ [mmφ]・・・・・・・・・・(5)

(Due to winding workability, etc., the wire diameter should be φ1.0 or less. If it exceeds φ1.0, increase the number of turns to accommodate.)

The number of turns N is calculated using the following formula.

$N \geqq \Delta\phi/\phi c$ [turn]・・・・・・・・・・(6)

φc : Total magnetic flux of the core [Wb]

The above is the basic design.

The core size and number of turns have been determined through the design up to this point, but since there will be differences in the noise suppression effect depending on the diode's specific recovery characteristics and circuit configuration, please ultimately check operation using an actual switching power supply.

[Design example]

(1) AMOBEADS™

We will design AMOBEADS™ using specific values.

Output voltage: 12V

Recovery time: 50nsec

On duty: 0.3

(A) Core selection

First, the required magnetic flux $\Delta\phi$ is

$\Delta\phi > (12/0.3) \times 50 \times 10\text{-}9$ [Wb]

$= 2.0\mu Wb$

From this, we select "AB4 x 2 x 4.5W" with a total magnetic flux ϕc of 2.7μWb.

(2) SPIKE KILLER™

Output voltage: 24V

Output current: 2A

Recovery time: 60nsec

On duty: 0.3

(A) Core selection

The required core capacity ϕcAw is

$\phi cAw > 1.5 \times (24/0.3) \times 60 \times 10\text{-}9 \times 2 > 14.4$ [μWb・mm²]

From the separate table, select "SS10 x 7 x 4.5W" which has a core capacity larger than 14.4 μWb・mm².

(B) Winding diameter d

Wire diameter d is $d > 0.5 \times \sqrt{2} > 0.7$ [mmφ]

(C) Number of turns

The required voltage-time product $\Delta\phi$ is

$\Delta\phi = 3 \times (24/0.3) \times 60 \times 10\text{-}9 = 14.4$ [μWb]

Also, from the table, the total magnetic flux ϕc of the selected core is 1.82 [μWb]

Therefore, the number of turns N is

$N > 14.4/1.82 > 7.9$ turns

Round up to 8 turns.

From the above, the design result with the SPIKE KILLER™ is

Core used: SS10 x 7 x 4.5W

Winding specifications: 0.7mmφ (AWG#21), 8 turns

Finally, please check the noise suppression effect and temperature rise with an actual switching power supply.
If the noise suppression effect does not increase, try increasing the core size.
Please contact us if the capacity of the standard core is insufficient depending on the circuit conditions.

[Appended table]

Standard AMOBEADS™ specifications

<table>
<tr><th rowspan="2">Product name symbol</th><th colspan="3">Finished dimensions [mm]</th><th rowspan="2">Total magnetic flux *1
ϕc [μWb]
min</th></tr>
<tr><th>Outer diameter
max</th><th>Inner diameter
min</th><th>Height
max</th></tr>
<tr><td>AB4x2x8W</td><td rowspan="3">5.0</td><td rowspan="5">1.5</td><td>9.5</td><td>4.8</td></tr>
<tr><td>AB4x2x6W</td><td>7.5</td><td>3.6</td></tr>
<tr><td>AB4x2x4.5W</td><td rowspan="2">6.0</td><td>2.7</td></tr>
<tr><td>AB3x2x4.5W</td><td rowspan="2">4.0</td><td>1.3</td></tr>
<tr><td>AB3x2x3W</td><td>4.5</td><td>0.9</td></tr>
</table>

*1 Calculated from the inductance value L1 at 1 [kHz], 100 [mA] (sine wave), and room temperature. Φc [μWb] = 0.282XL1 [μH]
•The values in the table are reference values and are not guaranteed values.

Standard SPIKE KILLER™ specifications

<table>
<tr><th rowspan="2">Product name symbol</th><th colspan="3">Finished dimensions [mm] *2</th><th rowspan="2">Total magnetic flux *1
ϕc [μWb]
min</th><th rowspan="2">Core capacity
ΦcAw [μWb]
mm²</th></tr>
<tr><th>Outer diameter
max</th><th>Inner diameter
min</th><th>Height
max</th></tr>
<tr><td>SS21x14x4.5W</td><td>22.8</td><td>12.8</td><td rowspan="5">6.6</td><td>11.0</td><td>1371</td></tr>
<tr><td>SS18x12x4.5W</td><td>19.8</td><td>10.8</td><td rowspan="2">9.46</td><td>834</td></tr>
<tr><td>SS14x8x4.5W</td><td>15.8</td><td rowspan="2">6.8</td><td>323</td></tr>
<tr><td>SS12x8x4.5W</td><td>13.8</td><td>6.31</td><td>215</td></tr>
<tr><td>SS10x7x4.5W</td><td>11.5</td><td>5.8</td><td>4.73</td><td>116</td></tr>
<tr><td>SS7x4x3W</td><td>9.1</td><td>3.3</td><td>4.8</td><td>3.15</td><td>23</td></tr>
</table>

*1 Calculated from the inductance value L1 at 1 [kHz], 100 [mA] (sine wave), and room temperature. Φc [μWb] = 0.282XL1 [μH]
*2 Tolerance technician 0.2
•The values in the table are reference values and are not guaranteed values.

Please contact us for winding requests or sizes other than those listed above.
Our saturable core MS/MT series can also be used as a noise suppression core.
We have a lineup of relatively large sizes, so please make use of them.

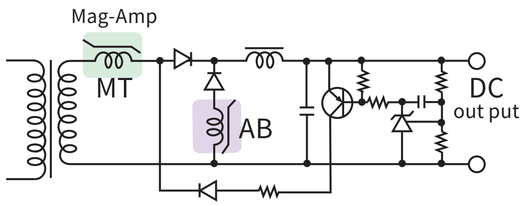
3 Saturable cores for mag-amps

3.1 Saturable cores for mag-amps

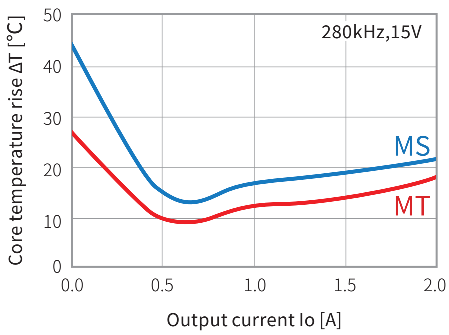
The Mag-amp method is one of several output voltage regulation methods used in switching power supplies. A saturable core is used in the secondary side of the main transformer to regulate voltage by magnetic pulse width modulation (PWM). The Mag-amp method is especially effective and economically attractive in low voltage/high current circuits and is frequently used in power supplies for information processing equipment, such as desktop PCs and computer servers, in power supplies for office equipment such as photocopy machines and printers, and in power supplies for communication equipment, such as mobile phone stations.

Miniaturization, high efficiency, low noise, high reliability, and high precision can be easily realized by adopting the Mag-amp method.

Utilizing the unique magnetic characteristics of cobalt-based amorphous alloys, we have realized low loss at high frequencies which cannot be realized using other materials. Our lineup consists of MS series cores, which are well suited for general purpose applications, and MT cores, which have lower loss than the MS series.

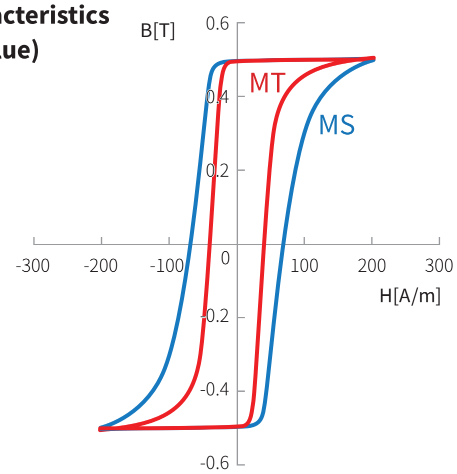


Basic Circuit Diagram of Mag-Amp method

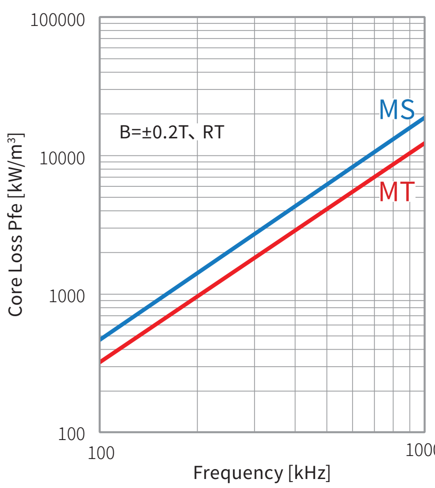


Comparison of Core Temperature Rise in a Power Supply

Basic Characteristics (Typical Value)

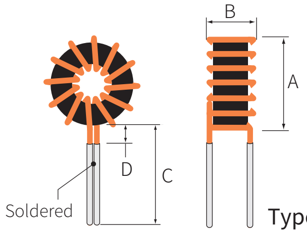


B-H Curve (500kHz, RT)



Core Loss

3.2 MT/MS series standard specifications



MT Standard Wired Series

Type of wire: 1UEW

Product name symbol	Core Type No.	Wire Diameter φ[mm]	Parallel Number	N [turn]	Flux *1*2 [μWb]	Example of Circuit (150kHz)*3		Finished Dimensions [mm]				Packaging unit [pcs/box]
						Vo [V]	Io [A]	A max	B max	C	D max	
MT12S115	MT12x8x4.5W	1.0	1	15	94.7	5	6	20	13	20±5	3	1,000
MT12S208		0.9	2	8	50.5	3.3	10					
MT15S125	MT15x10x4.5W	1.0	1	25	197	12	6	25	15			
MT15S214		0.9	2	14	110	5	10					
MT18S130	MT18x12x4.5W	1.0	1	30	284	15	6	28				
MT18S222		0.9	2	22	208	12	10					
MT21S134	MT21x14x4.5W	1.0	1	34	375	24	6	32				
NT21S222		0.9	2	22	243	15	10					

*1 The amount of magnetic flux is equal to (N)×(ϕc). *2 Measuring condition : 100kHz, 80A/m (sine wave), R.T.
*3 Recommend for designing (note : A design of a transformer in the case may be unable to use this data. Please set up the operating magnetic flux 70% or less of the magnetic flux.)
•The values in the table are reference values and are not guaranteed values.

MT Series

Product name symbol	Finished Dimensions [mm]*4			Core Size [mm]*5			Effective core cross section*5 Ae [mm²]	Mean Flux Path Length*5 Lm [mm]	Total magnetic flux*2 ϕc [μWb] min	Coercive Force*2 Hc [A/m] max	Rectangular Ratio*2 Br/Bm [%] min	Φc·AW [μWb·mm²]	Insulating Covers*6
	Outer diameter	Inner diameter	Height	Outer diameter	Inner diameter	Height							
MT10x7x4.5W	11.5	5.8	6.6	10	7	4.5	5.06	26.7	4.73	20	94	116	A
MT12x8x4.5W	13.8	6.8		12	8		6.75	31.4	6.31			215	
MT14x8x4.5W	15.8			14			10.1	34.6	9.46			323	
MT15x10x4.5W	16.8	8.8		15	10		8.44	39.3	7.88			457	
MT16x10x6W	17.8	8.3	8.1	16		6.0	13.5	40.8	12.6			649	B
MT18x12x4.5W	19.8	10.8	6.6	18	12	4.5	10.1	47.1	9.46			834	A
MT21x14x4.5W	22.8	12.8		21	14		11.8	55.0	11.0			1371	

*2 Measuring condition : 100kHz, 80A/m (sine wave), R.T. *4 Dimensions of the Finished Insulating Covers ; Tolerance : ±0.2mm *5 Reference value
*6 UL standard 94V-0 certified material. A:Black PET, B:Black PBT
•The values in the table are reference values and are not guaranteed values.

MS Series

Product name symbol	Finished Dimensions [mm]*4			Core Size [mm]*5			Effective core cross section*5 Ae [mm²]	Mean Flux Path Length*5 Lm [mm]	Total magnetic flux*2 ϕc [μWb] min	Coercive Force*2 Hc [A/m] max	Rectangular Ratio*2 Br/Bm [%] min	Φc·AW [μWb·mm²]	Insulating Covers*6
	Outer diameter	Inner diameter	Height	Outer diameter	Inner diameter	Height							
MS7x4x3W	9.1	3.3	4.8	7.5	4.5	3.0	3.38	18.8	3.15	25	94	23	A
MS10x7x4.5W	11.5	5.8	6.6	10	7	4.5	5.06	26.7	4.73			116	
MS12x8x4.5W	13.8	6.8		12	8		6.75	31.4	6.31			215	
MS12x8x4.5W-HF													D
MS14x8x4.5W	15.8			14			10.1	34.6	9.46			323	A
MS15x10x4.5W	16.8	8.8		15	10		8.44	39.3	7.88			457	
MS16x10x6W	17.8	8.3	8.1	16		6.0	13.5	40.8	12.6			649	B
MS18x12x4.5W	19.8	10.8	6.6	18	12	4.5	10.1	47.1	9.46			834	A
MS21x14x4.5W	22.8	12.8		21	14		11.8	55.0	11.0			1371	
MS26x16x4.5W	29.5 max	13.0 min	8.0 max	26	16		16.9	65.9	15.8			2097	B

*2 Measuring condition : 100kHz, 80A/m (sine wave), R.T. *4 Dimensions of the Finished Insulating Covers ; Tolerance : ±0.2mm *5 Reference value
*6 UL standard 94V-0 certified material. A:Black PET, B:Black PBT, D:Halogen -free
•The values in the table are reference values and are not guaranteed values.

• Those other than standard winded articles can be manufactured. Please ask to sales department.
• MT sample kits are prepared. Please ask to sales department.

3.3 Advantages of mag-amp power supplies

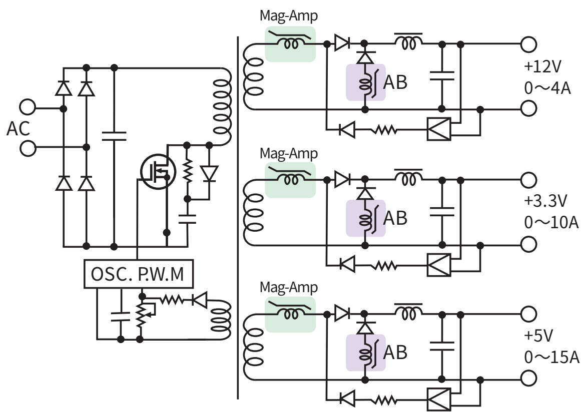
Since the Mag-amp method uses saturable cores to regulate voltage, there is a big advantage that cannot be achieved by semiconductor-based regulation methods. The advantage is especially clear when there are large changes in the current.

Miniaturization (Downsizing)	Large currents can be handled by small size cores. Also, there is no need for a heat sink and the number of parts as the regulation circuit is small. This results in a smaller mount area compared to semiconductor-based methods.
Power Saving	Because cobalt-based amorphous alloy is used, the operating loss at high frequencies is small. Also, the power needed for control of the Mag-amp is smaller, enabling power to be saved.
Low Noise	The noise from the output diode is small because the Mag-amp is connected in series with the output diode. In semiconductor-based methods, since the number of switching elements increases, so also does the noise.
High Reliability	Since Mag-amps are magnetic parts, the cores are not destroyed by surges in voltage and current. For this reason, they have been used in power supplies requiring reliability such as those for electricity or large computers.
High Precision	The Mag-amps realize precise output voltage because the secondary side of the main transformer is directly controlled. It is possible to conduct voltage torelance with high precision (±1%), from no-load conditions to full-load conditions.

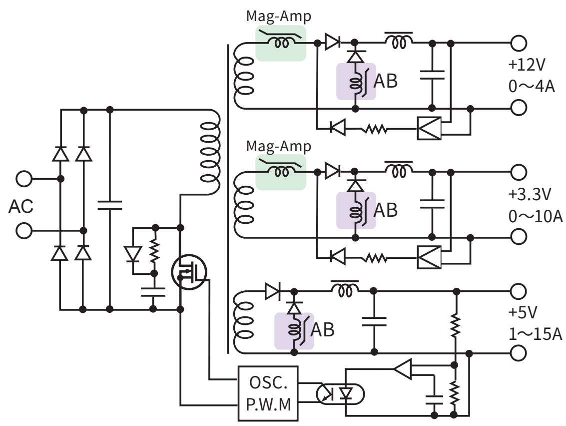
As seen above, when the Mag-amp method is used in regulating output voltage of switching power supplies, excellent characteristics can be achieved in size, efficiency, noise, reliability, and precision. Advantages in cost performance are especially realized in low voltage / high current circuits (example: 3.3V-5A).

Full Mag-Amp Method

The simple Mag-amp method is used mainly for voltage control of the post circuit in power supplies, called the cross-regulation (master-slave) method. This cross-regulation method stabilizes the output voltage by feedback of the main circuit to the primary side. Therefore, the post circuit output is affected by the situation of the load in the main circuit (cross regulation error). There is also the problem that power supplies do not operate unless some current (minimum current) is sent through the main circuit.
The Full Mag-amp method is a way to solve this problem.
The Full Mag-amp method controls each output at the secondary side. Therefore, there is no need for feedback to the primary side, and each output can be controlled from no-load conditions. Also, since each output operates independently, the optimization of the winding ratio for the main transformer and high efficiency can be realized compared to the cross-regulation method.
Furthermore, since each output is independent in the Full Mag-amp method, it is only necessary to adjust the circuit where the specification was changed. Therefore, time can be saved in the process of a design change.



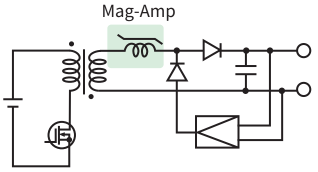
Full Mag-Amp Method



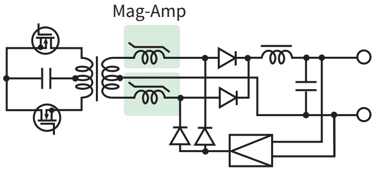
Cross-Regulation (Master-Slave) Method

3.4 Examples of application circuits and characteristic diagrams

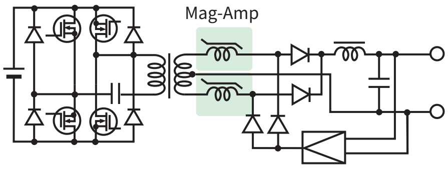
Examples of Circuit



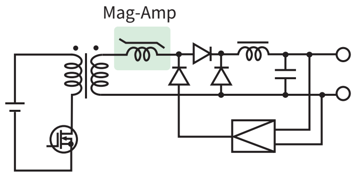
Flyback converter (ON-OFF Type)
Ringing choke converte (RCC)



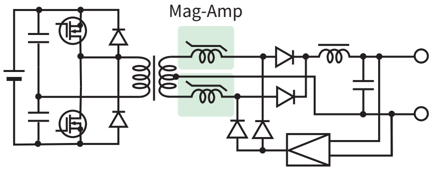
Push-pull converte (Center tap type)



Full bridge converter

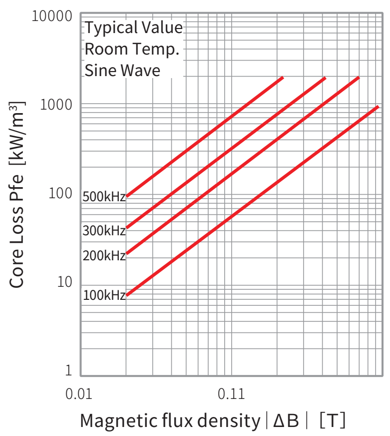


Forward Converter (ON-ON Type)

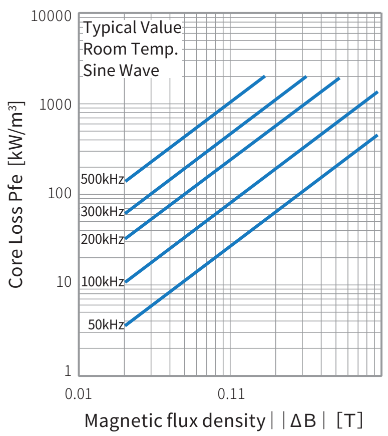


Half Bridge Converter

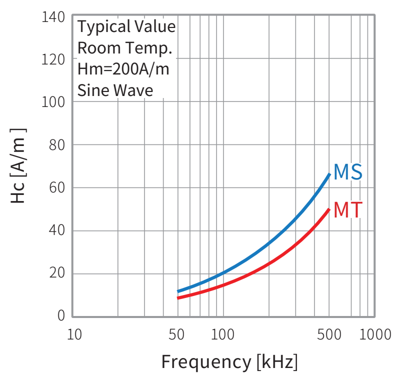
Characteristics (Typical Value)



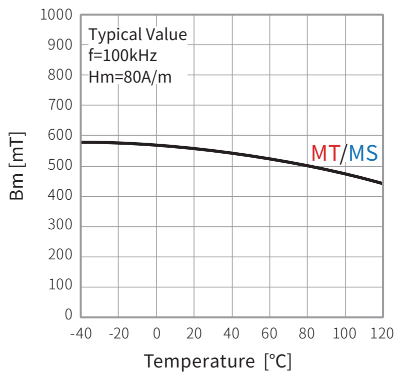
Saturable Core MT Core Loss



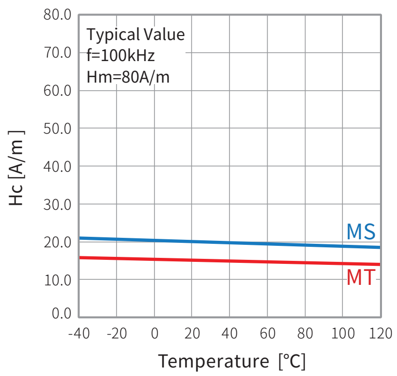
Saturable Core MS Core Loss



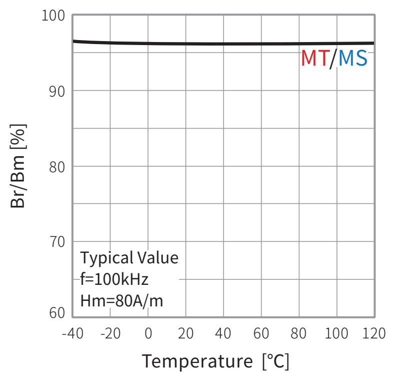
Hc vs. Frequency
(MT／MS series)



Bm vs. Temperature
(MT／MS series)



Hc vs. Temperature
(MT／MS series)



Br/Bm vs. Temperature
(MT／MS series)

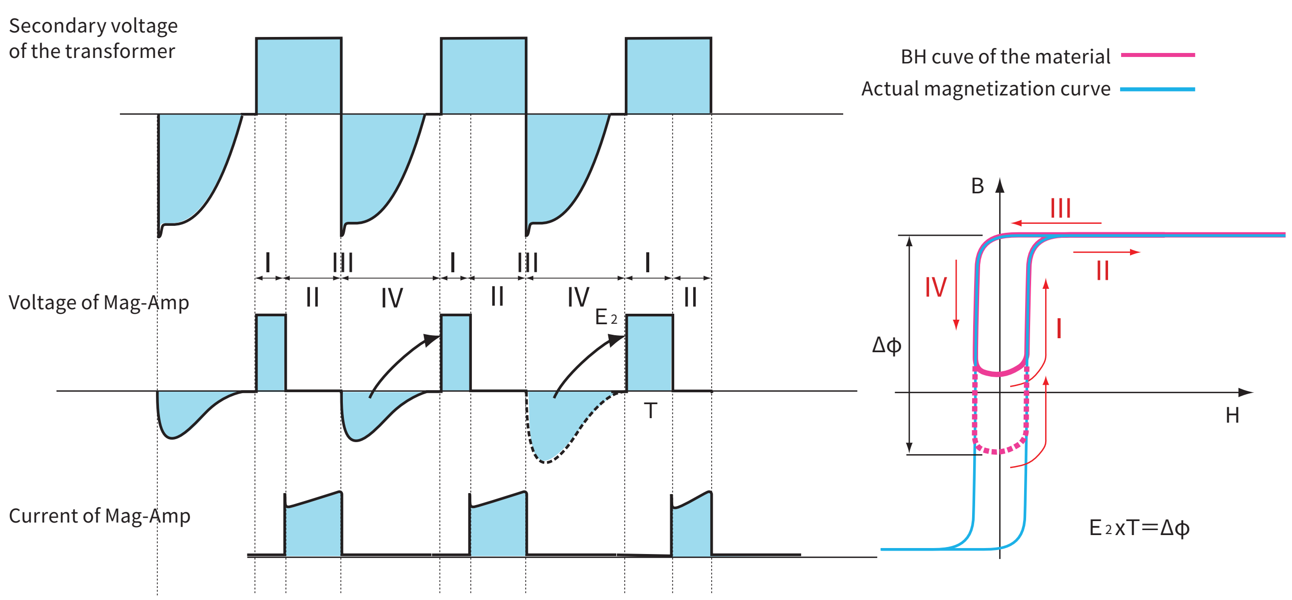
Examples of a use other than Mag-Amp	Resonancer for Switching Power Supply (Partial Resonace Element), CT Magnetic Sensor, Transformer Core for Self-Invertor Oscillator, High Frequency Saturable Core for Current Delay or Timing Control

3.5 Mag-amp operation principle

The Mag-Amp method is a switching regulation method for D.C power supply in which the magnetic switch is created through using saturated area and unsaturated area of the saturable core. Voltage regulation at the secondary side of the switching supply is realized by P.W.M. (Pulse Width Modulation).

Period I [Pulse is on]	When the "ON" pulse is from the main transformer, the flux changes as "I" on the actual magnetization curve. At this time, the saturable core has very high inductance because the core's magnetization is in an unsaturated area. When voltage is added, it is handled at both ends of the coil and the current does not flow toward the side with the current load. During Period "I" , the voltage is blocked with the switch OFF, and the pulse width modulation is done.
Period II [Mag-amp is saturation]	After some time at Period I, the saturable core becomes saturated "II" and the inductance rapidly decreases to a minimum and the current is supplied toward the load side. The switch is ON in Period II.
Period III [Pulse is off]	When the pulse from the main transformer is OFF (Period III), the magnetic curve of the saturable core changes as in III. It rises over the magnetization axis from the effects of the reverse recovery current and leaked current of the output diode.
Period IV [Reset]	While the polarity of the pulse voltage is reversed (Period IV), there is voltage control which corresponds with the preset output voltage by the Mag-amp control circuit. The saturable core's magnetization changes (resets) itself as in "IV".
Period Ⅰ ～Period IV is operated repeatedly through the operated frequency and the voltage is regulated.	

The reset area at Period IV and the area at Period I is equal. Therefore, by changing the reset amount at Period IV , the blocked area at Period I can be changed, and it becomes possible to regulate voltage by magnetic P.W.M.



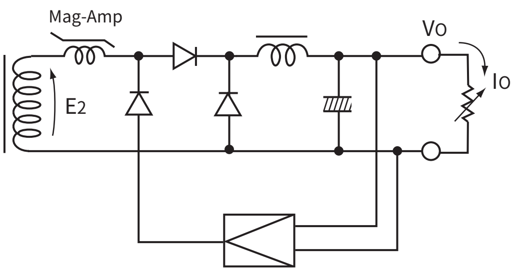
3.6 Simple design method for mag-amps (forward converter)

The standard methodology for designing and selecting the proper size mag-amp is to first determine the product of the secondary voltage of the transformer and the "on duty" time, measured in seconds. The proper size mag-amp can then be selected by determining which mag-amp core can adequately handle the highest product of this secondary voltage and "on duty" time, otherwise known as core flux. All calculations must be made on the condition that this on-pulse product of voltage and time is at its maximum.

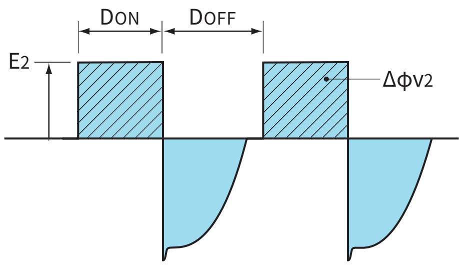
On-pulse maximum product of time

The on-pulse maximum product of time $\triangle\phi V2$ is calculated from the secondary voltage of the transformer (=E2) [V] and the maximum on time duty period (=Don) and operating frequency (=f)[Hz]. For cross-regulation type circuits, the on-duty values for the main circuit at maximum load current are usually used.

$$\Delta\phi_{v2}\ [\mathrm{Wb}] = E_2 \times D_{ON}/f\ [\mathrm{V \times Sec}]$$



Mag-Amp circuit of the secondary side



Transformer voltage of the secondary side

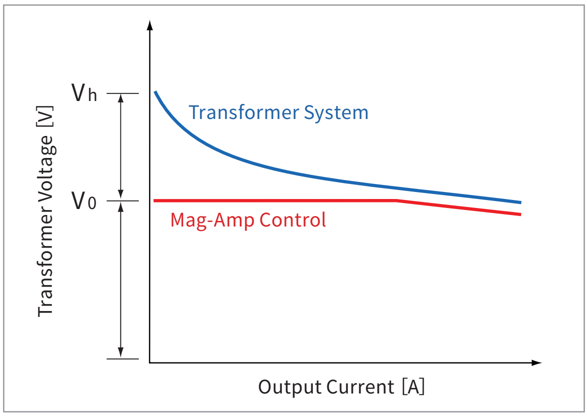
Flux needed for mag-amp control

The calculation of the Voltage-time product (=Magnetic Flux) $\Delta\phi mag$ differs between when the mag-amp is used for voltage regulation only and when the mag-amp is also used to protect against over currents.

(1) Voltage regulation

The mag-amp is designed with the standard of no load, because the flux deviation is usually largest when there is no load. The coefficient for the incremental increase in voltage at no load (Kv) is used. (Kv=<1)

$$\Delta\phi_{mag} = \Delta\phi_{v2} \times K_v\ [\mathrm{Wb}]\ (K_v = \frac{V_h}{V_o}\ \text{see right figure})$$



Output Current vs. Transformer Voltage

(2) Protection of over currents

When the mag-amp is also used to protect against over-currents, the on-pulse maximum voltage-time product$\Delta\phi v2$ must be handled by the mag-amp. Therefore, the following calculation is applied.

$$\Delta\phi mag = \Delta\phi v_2 \ [Wb]$$

Selection of core size

The core size is selected based on the flux needed to control the mag-amp, $\Delta\phi mag$. The following simplified calculation is used to select core size.

$$\phi cAw \geqq \Delta\phi mag \times Io/(Kf \times J)\ /Kt\ [Wb \cdot mm^2]$$

Here, ϕC is the total flux of the core and AW is the core winding area. The values for $\phi C \cdot Aw$ are found in the standard specification chart. Kt is the design safety coefficient; Kf is the coefficient for wire winding, and J is the current density.

Calculation of Number of Turn

The number of turns (N) is calculated by the following equation, where N is an integer

$$N \geqq \Delta\phi mag\ /\ \phi c\ min\ /\ Kt\ [turn]$$

Calculation of Diameter of the Wire

From the equation for current density J [A/mm²], wire diameter d [mm], output current Io[A],

$$Io = (d/2)^2 \times \pi \times J\ [A] \quad \rightarrow \quad d = 2 \times \sqrt{Io/(\pi \times J)}\ [mm]$$

Please always confirm operation on the actual circuit after design.

3.7 Specific design examples

Here, we show a design example when regulating a 5V-10A circuit using a forward converter with an operating frequency of 150kHz.

On-pulse maximum voltage-time product

The E2 on the secondary side of the main transformer and the maximum on duty cycle are assumed to be E2=15[V] and Don=0.4.

$\Delta\phi v2 = E2 \times Don / f$ [V x Sec] = [Wb]

$= 15 \times 0.4/150000$

$= 40$ [μWb]

When using a Mag-amp to also protect against over currents, $\Delta\phi mag = \Delta\phi V2$. Here, we assume that the mag-amp only regulates voltage and set the incremental increase at the time of no current load as KV=0.6.

$\Delta\phi mag = \Delta\phi v2 \times Kv = 40 \times 0.6 = 24$ [μWb]

Choice of core size

The wire winding coefficient, Kf, is the coefficient that it is possible to wind on the inside of a toroidal core. Usually, Kf=0.4 is used. The current density J is usually set as J=5〜10[A/mm2]. Here, we assume J =8[A/mm2].

If the mag-amp's maximum operating temperature is assumed to be 120℃, we assume that the flux density of the core decreases to 80%. We also allow flux design space to be 70%.

$\phi c\ Aw \geqq \Delta\phi mag \times Io/(Kf \times J)/Kt$

$\geqq 24\times10/(0.4 \times 8)/(0.8 \times 0.7)$

$\geqq 133.9$ [$\mu Wb \cdot mm^2$]

From the standard specification table, MT12X8X4.5W is chosen.

Number of wire winding

$N \geqq \Delta\phi mag/\phi cmin/Kt$ [turn]

$\geqq 24/6.31/(0.8 \times 0.7) = 6.8$

$= 7$ [turn]

Wire diameter

When the wire diameter is over ϕ1.0mm, there is difficulty in the actual wire winding of the toroidal cores. Therefore, when the output current Io is over 5[A], parallel winding is used. Here, since Io = 10[A], two parallel wires are used.

$d = 2 \times \sqrt{Io/2/(\pi \times J)}$ [mm]

$= 2 \times \sqrt{10/2/(\pi \times 8)} = 0.89$ [mm]

As a result, 2 parallel ϕ0.9mm wires are wound.

Results of design (Operating Frequency 150kHz, 5V-10A, Voltage Regulation)

MT12 x 8 x 4.5W, ϕ0.9mm, 2 parallel windings, 7[turn]

Please always confirm operation on the actual circuit after design. Since the mag-amp is a passive part,it becomes susceptible to effects from the waves of the transformer, and actual operating tests are necessary.

Design Example (Forward Converter, 150kHz operating)

Voltage [V]	Voltage Control(at Kv=0.6)			Over Current Protection (at E2×DON =1.2Vo)		
	Current [A]			電流 [A]		
	6 (Φ1.0mm)	10 (Φ0.9mmx2p.)	15 (Φ0.9mmx3p.)	6 (Φ1.0mm)	10 (Φ0.9mmx2p.)	15 (Φ0.9mmx3p.)
3.3	MT12S208	MT12S208	MT12:5turn	MT12S208	MT12S208	MT15:7turn
5	MT12S208	MT12S208	MT15:6turn	MT12S115	MT15S214	MT16:6turn
12	MT15S214	MT15S214	MT18S311	MT15S125	MT18S222	MT21:16turn
15	MT15S125	MT18S222	MT18:14turn	MT18S130	MT21S222	MT21:20turn
24	MT18S222	MT18S222	MT21:19turn	MT21S134	MT21:32turn	MS26:18turn

Note) Operating flux is influenced by the main transformer of the circuit, and the value shown in the table is not necessarily applied as it is.

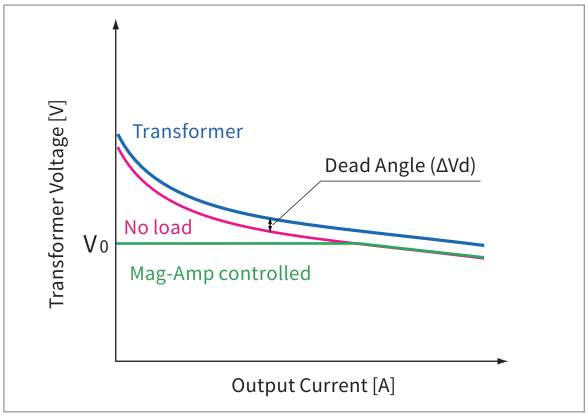
3.8 Evaluation of mag-amp performance

(1) At no-Load

Generally, the range of the flux becomes large at no, or small current load. There is a possibility that the mag-amp may not be able to control the output voltage because there is a shortage of core flux. This problem occurs because the large range of the flux density causes saturating on the other side and there is not enough ability to control the voltage-time product. In order to set the allowances for design, the wire winding for the Mag-amp is reduced and the operating range is confirmed.
However, the core flux necessary at the time of no current load is largely influenced by such factors as the dummy current value. Therefore, when the core flux is large at no current load, such factors as the dummy current value must be adjusted, taking efficiency into account.

(2) Temperature Rise

Generally, the mag-amp's flux range becomes small at the full current load. There is the possibility that output voltage cannot be regulated because it is not possible to make the range any smaller. This problem is called the dead angle.
The allowances for design at full current load are confirmed by increasing the number of wire windings.
However, the dead angle value is influenced not only by the core characteristics, but also by the reverse recovery current of the output diode and leaked currents. Please select output diodes with fast ecovery times. Also, when using SBD (Schottky Barrier Diode), please use one with small current leaks and stable temperature characteristics.



Output voltage-current characteristics

(3) Temperature Rise

The temperature rise from no current load to full current load should be confirmed. Since the upper limit temperature for continuous use of our mag-amp saturable cores is 120°C, the mag-amp should be designed so that the sum of the surrounding temperature and core temperature rise does not exceed 120°C. Please measure core temperature rise under the condition of natural air-cooling (Without cooling fan). Generally, the mag-amp is designed calculating the temperature rise at $\Delta T = 30°C$ to 40°C.
With forward converters, the temperature rise at no current load is especially high. When this occurs, the wire winding should be increased and the operating flux density reduced. When the temperature rise is too high at full current load, the wire winding should be reduced and the operating magnetic field reduced.

(4) Output voltage precision

It is necessary to confirm the voltage regulation characteristics (specifications) from no current load to full current load conditions. When there is a mismatch between the gain of the mag-amp and the gain of the regulated circuit, the circuit vibrates abnormally. Especially when there are sounds from the mag-amp circuit, there is a high possibility that the regulated circuit is abnormally vibrating.

(5) Protection from Over currents

When protecting for over currents, the range of operating flux for the mag-amp becomes large. Please set the maximum flux range to be 70% of the core flux, similar to when there is no current load.

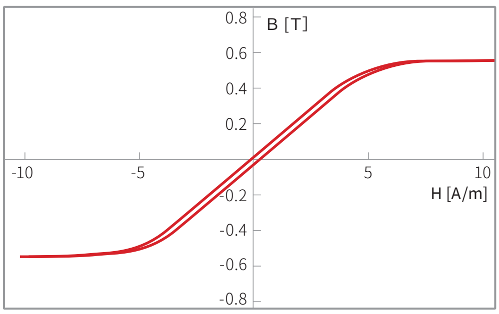
4 High permeability cores

4.1 High permeability cores

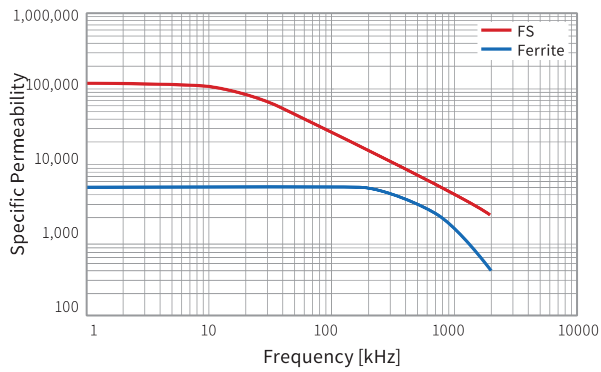
After suitable heat treatment has been done, cobalt base amorphous material shows excellent magnetic properties. Niterra Materials has developed new high permeability core 'FS Series' with this material.
FS series maintain high initial permeability μi especially at the high frequency zone, and are suitable for Pulse Transformers, Noise Filter and Cores for Sensors. High permeability enables electronic parts to be smaller and have higher performance.

High Permeability	μi at 10kHz is 100,000 it changes inductance module smaller and higher performance.
Low Loss	Smaller core loss, higher exchange efficiency, lower self heat of core can be obtained.
Constant Permeability	Small permeability change depending on magnetic field.
Thin and Small Core	Small miniature core enables to mount in a PC-card.

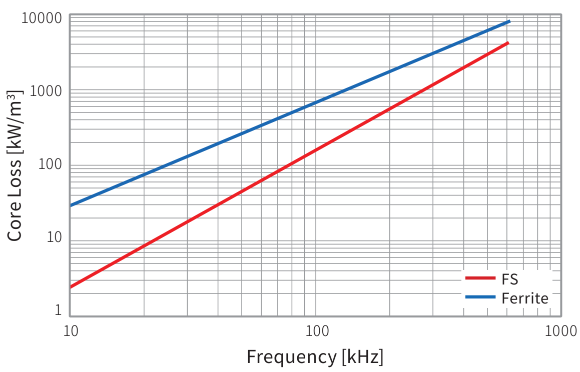
4.2 Characteristic diagrams



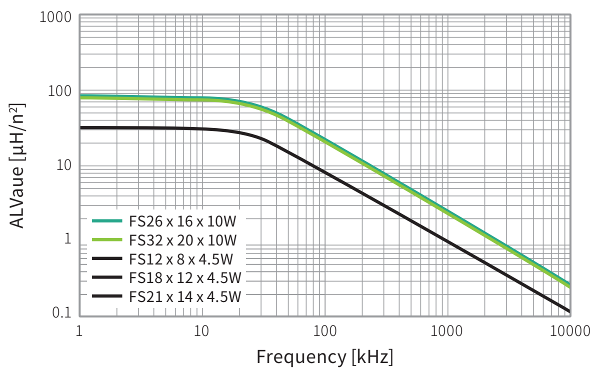
DC BH Curve



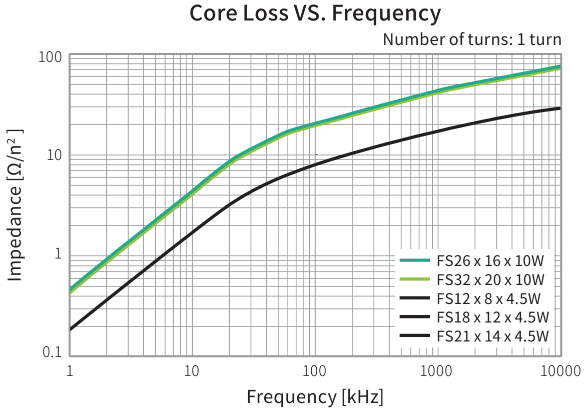
Frequency vs. Permeability



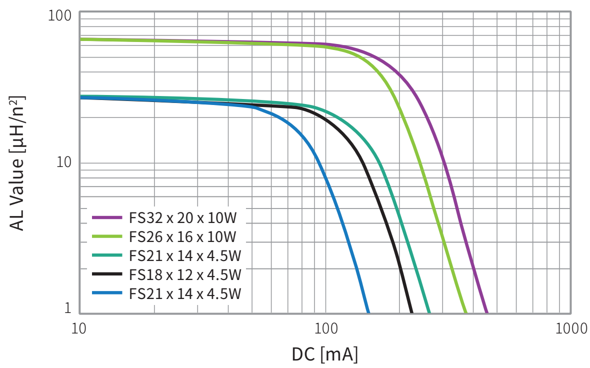
Core Loss VS. Frequency



AL Value VS. Frequency



Impedance VS. Frequency



DC Bias Characteristic

RoHS compliant products

4 High permeability cores

4.3 FS series standard specifications

Product name symbol	Finished dimensions [mm] Outer diameter max	Finished dimensions [mm] Inner diameter min	Finished dimensions [mm] Height max	Core Size*1 [mm] Outer diameter	Core Size*1 [mm] Inner diameter	Core Size*1 [mm] Height	Effective core cross section*1 Ae [mm²]	Mean Flux Path Length*1 Lm [mm]	AL value*2*3 [μH/n²]	Insulating Cover*4
FS12x8x4.5W	14.0	6.6		12	8		6.75	31.4		
FS18x12x4.5W	20.0	10.6	6.8	18	12	4.5	10.1	47.1	27.0	A
FS21x14x4.5W	23.0	12.6		21	14		11.8	55.0		
FS26x16x10W	29.5	13.0	13.0	26	16	9.5	35.6	66.0	67.8	B
FS32x20X10W	35.5	17.0		32	20		42.8	81.7	65.7	

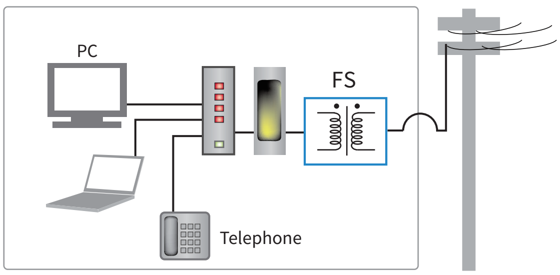
Operating temperature has to be less than 85°C (include self rise up)

*1 Reference value
*2 Tolerance±30%
*3 Measuring Condition : 10kHz,10mA, 1turn, R.T.
*4 UL standard 94V-0 certified material. A:Black PET, B:Black PBT

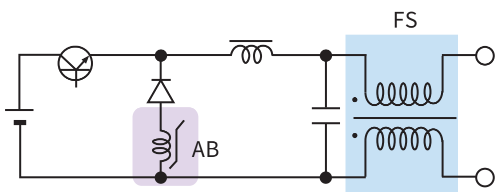
- Don't hesitate to ask our sales section about other size items.
- The values in the table are reference values and are not guaranteed values.

4.4 Application examples

Magnetic core of pulse transformer:
Communication instrument (ADSL etc.), Small size, high density assemble
Magnetic core for common mode noise filter:
Switching power supply, Communication and measuring instrument
Magnetic core for current transformer



ADSL modem, or
pulse transformer for terminal adapter



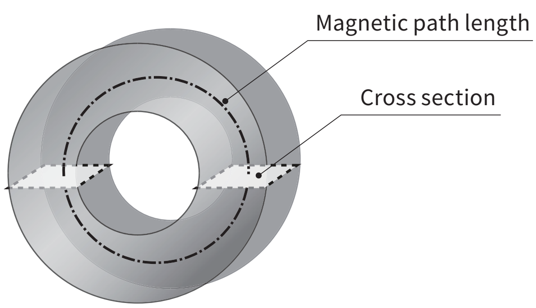
Common mode noize filter
for switching power supply

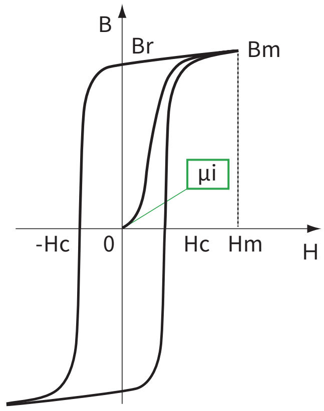
5 Explanatory section

5.1 Glossary of amorphous-related terms

Saturable Core	A magnetic core can be able to saturate. These cores have a high square shape ratio, and it can use magnetic saturation and magnetic being un-saturated.
Toroidal Core	Magnetic core which has doughnut shape.
Cross Section	Effective core cross section area :Ae, Ae [m^2] = ((OD[m] - ID[m]) x height HT[m] / 2) x pf
Packing Factor pf	The ratio of the absolute area of magnetic material to its geometrical area.
Magnetic Path Length Lm	Length of the magnetic circuit. In the case of the toroidal core, magnetic mean path length Lm is adopted. Lm [m] = (OD[m] + ID[m]) x π/2
Magnetic Flux Density B	Magnetic flux strength of the material, which is perpendicular magnetic flux of the unit area. B[T] = ϕ[Wb] / Ae [m^2]
Magnetic Flux ϕ	ϕ[Wb = V·sec] = B [T] x Ae [m^2]
Magnetic Field Strength H	H [A/m] = I [A] / Lm [m]
Permeability μ	μ = B / H. Inductance L is proportional to permeability .
Initial Permeability μi *1	First inclination of the initial growth of magnetic flux density B (see the illustration below)
Maximum Flux Density Bm	In this booklet, Bm is defined as the flux density at the magnetic field Hm. (see the illustration below)
Residual Magnetic Fux Density Br	Br is the flux density at the time the magnetic field return to H = 0 (see the illustration below)
Total Magnetic Flux ϕc	Total magnetic flux of the core. In this booklet, total magnetic flux ϕc is defined as the following equation. ϕc [Wb] = 2 x Bm [T] x Ae [m^2]
Rectangular Ratio Br / Bm	The ratio of the Bm and Br. Greater the rectangular ratio, the more superior the magnetic saturability. Br / Bm = Br [T] / Bm [T]
Coercive Force Hc	Hc is the cross point of the BH curve and X axis. Smaller the Hc, the less the loss and the more superior the Hc. (see the illustration below)

*1 Initial permeability is out of control in the case of saturable cores, because it is unrelated to the Mag-Amp.





5.2 Handling precautions

Notices of the amorphous magnetic parts on handle Detail information are described on the technical data sheet or the specification for supply.	
Maximum Operating Temperature	120°C (include temperature rising by self-heating, under natural air cooling) (except FS series which is 85°C)
Wire Winding	Be careful at wire winding or lead insertion. Damage or deformation of the core or insulating cover has a harmful influence. Be careful to the rare short circuit.
Mounting	Make sure not to apply any stresses which will lead to deformation of the core exterior. If the product is to be impregnated, bonded, cleaned or otherwise treated, confirm that such treatment will not adversely affect the magnetic characteristics. When impregnating the core, be sure that the magnetic properties will not be influenced. Prevent radiation and conduction from high temperature components from reaching the core. Be sure to consider vibration and shock when installing these parts.
Soldering	When soldering be sure that the core exterior will not be deformed by heat conducted through the lead wire. Do not subject parts to re-flow or flow soldering. (Except the surface mounting type)
Circuit Design	Be careful, of imput voltage, rated current, ambient temperature and temperature rise. When revising the circuit, please recheck the core temperature rise. Recheck the maximum temperature or maximum loads.
Transport and Storage	Do not drop the parts. Protect the parts from water.

5.3 List of discontinued products

Discontinued Type No.	Substitution (recommend)	Discontinued Type No.	Substitution (recommend)
FS10x4x1	(FS12x8x4.5W)	MB15x10x4.5	MS15x10x4.5W
MA7x6x4.5x	(MS10x7x4.5W)	MB18x12x4.5	MS18x12x4.5W
MA8x6x4.5x	(MS10x7x4.5W)	MB21x14x4.5	MS21x14x4.5W
MA10x6x4.5x	(MS10x7x4.5W)	MS8x7x4.5W	(MS10x7x4.5W)
MA14x8x4.5x	MS14x8x4.5W	MS9x7x4.5W	(MS10x7x4.5W)
MA18x12x4.5x	MS18x12x4.5W	MS10x6x4.5W	(MS10x7x4.5W)
MA22x14x4.5W	(MS26x16x4.5W)	MT10x6.5W	MT10x7x4.5W
MA26x16x4.5W	MS26x16x4.5W	SA4.5x4x3	AB5x4x3DY
MB8x7x4.5	(MS10x7x4.5W)	SA5x4x3	AB5x4x3DY
MB9x7x4.5	(MS10x7x4.5W)	SA7x6x4.5	(SS7x4x3W)
MB10x7x4.5	MS10x7x4.5W	SA8x6x4.5	(SS10x7x4.5W)
MB12x8x4.5	MS12x8x4.5W	SA10x6x4.5	(SS10x7x4.5W)
MB14x8x4.5	MS14x8x4.5W	SA14x8x4.5	SS14x8x4.5W
		AB3x2x6W	(AB4x2x4.5W)

Attention :
Same or similar core size items are listed up for substitution. Magnetic or electric characterisitcs are changeable.
Please test substitution parts before replacing to ensure performance.
Wired parts made by these cores are also discontinued items.

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