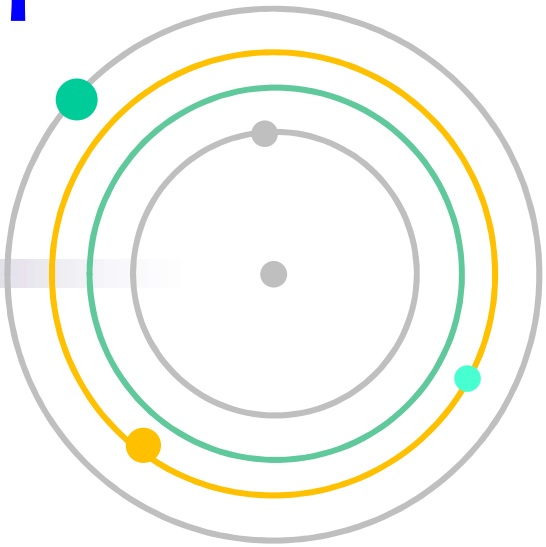
EMC Technical Seminar



All statements, specifications, properties, technical information, and recommendations herein are based on tests; however, the accuracy and completeness are not guaranteed and are subject to change without notice due to product improvement and specification change. This statement is made in lieu of all warranties, expressed or implied, including the implied warranties of marketability, and fitness for purpose. KITAGAWA INDUSTRIES America, Inc. obligation under this warranty shall be limited to replacement of product that proves to be defective. Prior to use, the user shall determine the suitability of the product for its intended use, and the user assumes all risk and liability whatsoever in connection therewith. KITAGAWA INDUSTRIES America, Inc. shall have no liability for any injury, loss, or damage arising out of the use of or the inability to use the products. No statement or recommendation contained herein shall have any force or effect unless in an agreement signed by officers of seller and manufacturer.

Please contact the sales department at KITAGAWA INDUSTIRES America, Inc. for the use of our products prior to selecting the parts for your application.

Rev 7 – 07182023
G2024-004E

Contents

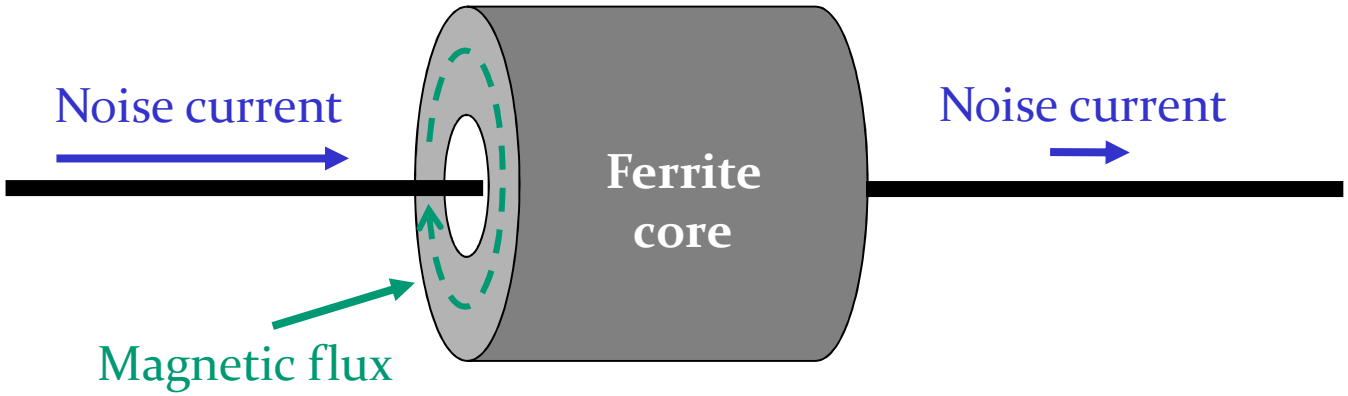
Filtering

Filtering: Separate noise from signal

Filtering Method	Available market solutions
Frequency separation	capacitors, inductors, ferrite cores
Current mode separation (Common mode or normal mode)	common mode chokes, capacitors, inductors, ferrite cores
Voltage separation	varistors

❖ Ferrite cores are the most popular components for EMI suppression.

How a Ferrite Works



Magnetic field generated by electrical current

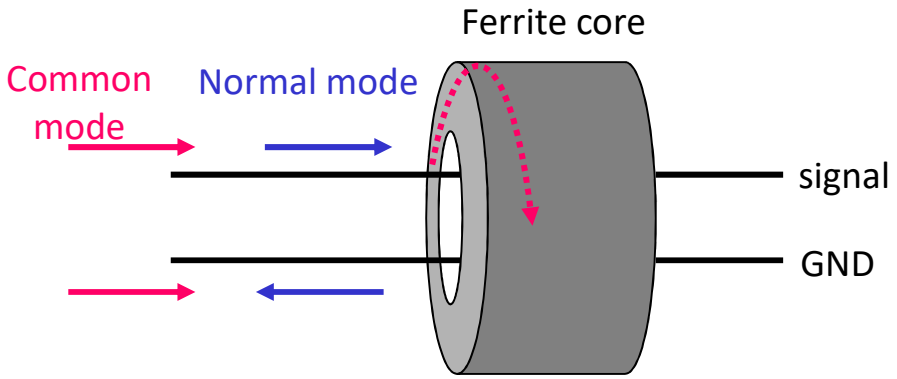
→ Concentrated into magnetic flux by ferrite's magnetic permeability

→ Magnetic field is reduced by ferrite's magnetic loss (converted to heat energy)

→ Noise current is reduced

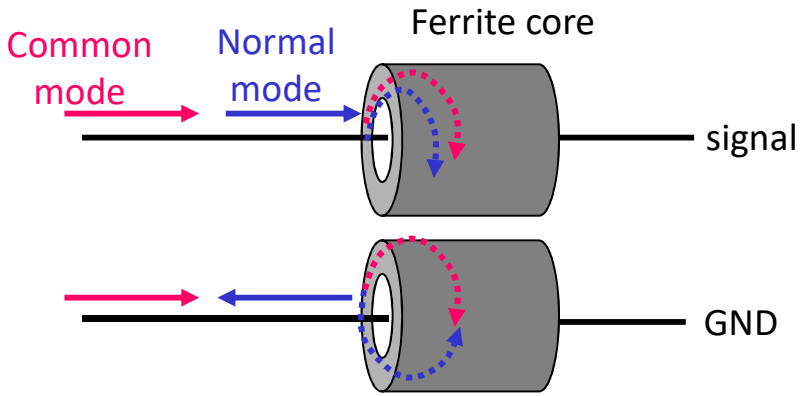
Placement of Ferrite(s) based on Current Mode

For Common Mode Only



Normal mode cancelled out

For Normal (Differential) and Common Mode

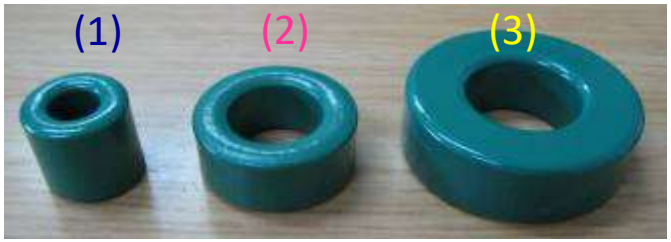


Works for both normal and common mode currents

Caution: Magnetic saturation and/or wave shape distortion could occur when suppressing normal mode noise.

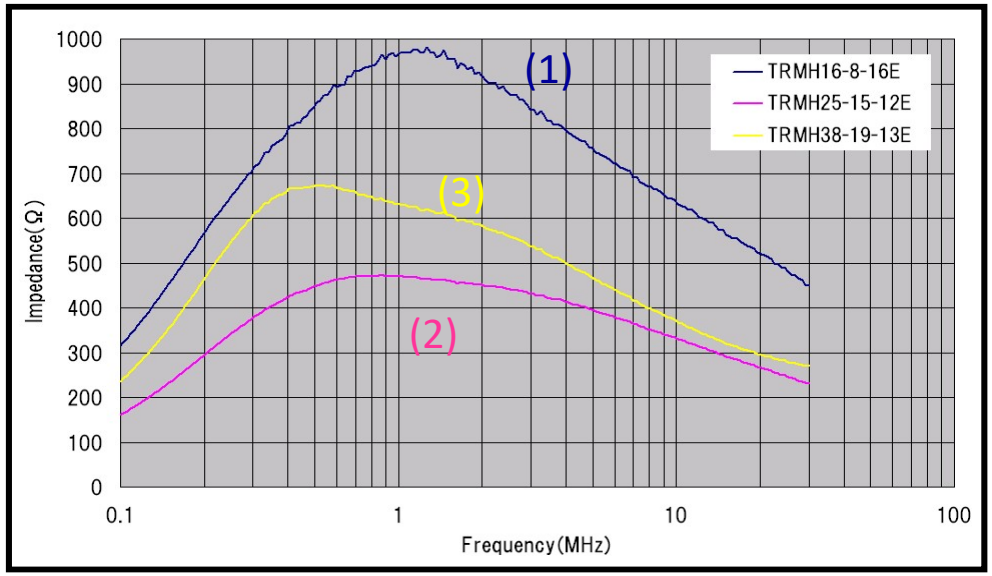
How to Select a Ferrite Core

① Shape factor of ferrite

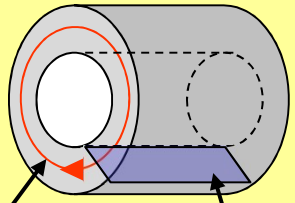


No.	Part number	Shape factor	Magnetic path length (mm)	Cross section (mm^2)
(1)	TRMH-16-8-16E	1.70	75.4	128
(2)	TRMH-25-15-12E	0.96	125.6	120
(3)	TRMH-38-19-13E	1.38	179.0	247

Impedance property (5 turns)



Inductance Calculation



Shape Factor

$$L = N^2 \mu \frac{Ae}{Le}$$

Magnetic path Length: Le

Cross section：Ae

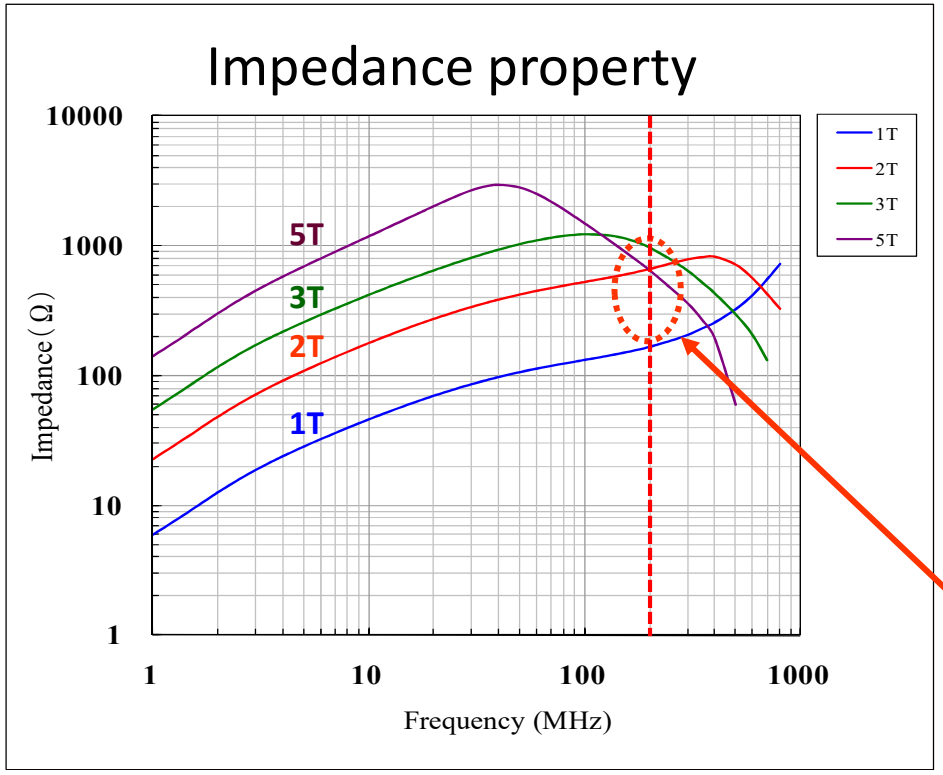
N：number of turns

μ：permeability

How to Select a Ferrite Core

② Turns through a core

Impedance increases with each turn.



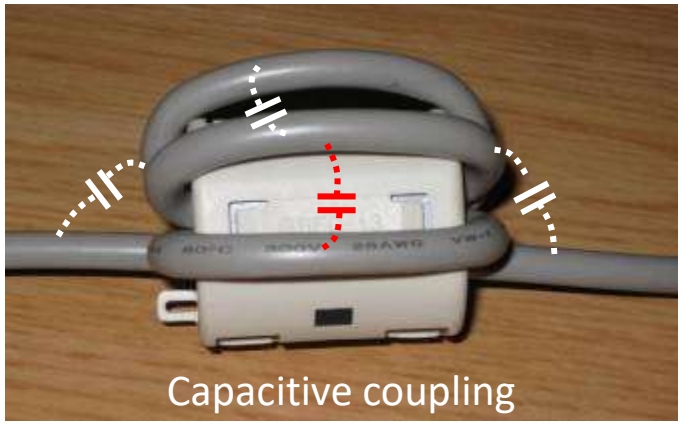
Turn formula: N^2

Example:

2 turns = 2^2 = 4 ferrites

→ Effect of two turns is similar to applying 4 ferrites on a cable

3 turns = 3^2 = 9 ferrites



Stray capacitance between cables reduces impedance performance at higher frequencies (above 200MHz)

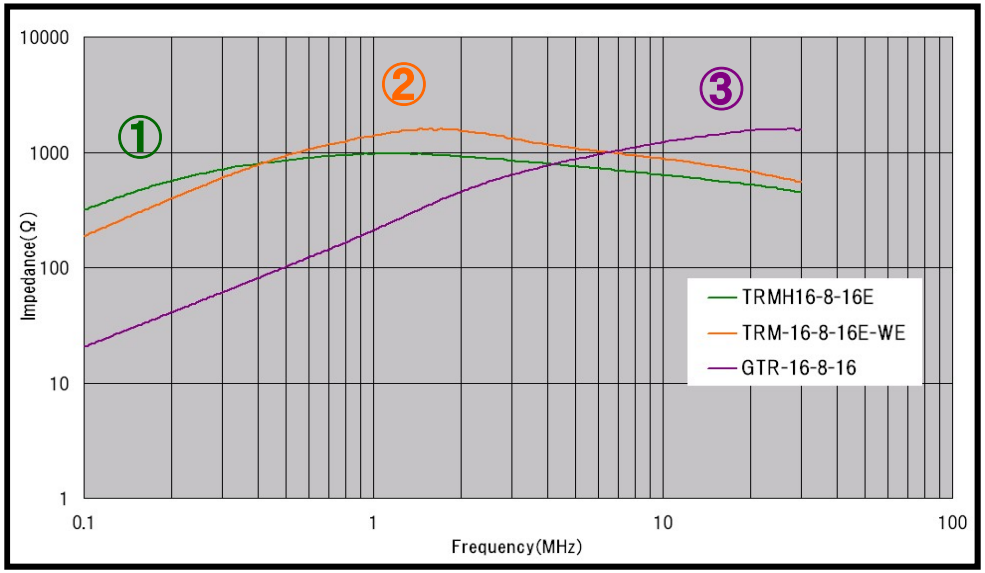
How to Select a Ferrite Core

③ Account for different ferrite materials

① ② ③

No.	Items	Permeability	Product Color
①	TRMH-16-8-16E	10000	Green (epoxy coating)
②	TRM-16-8-16E-WE	5000	Blue-Green (epoxy coating)
③	GTR-16-8-16	700	Black (no coating)

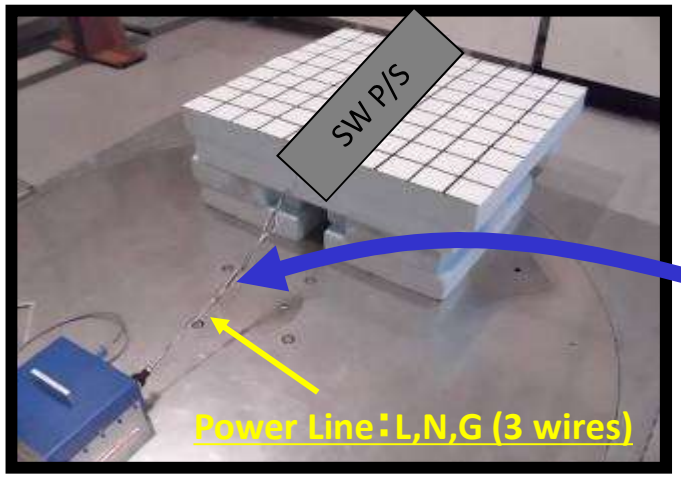
Impedance property (5 turns)



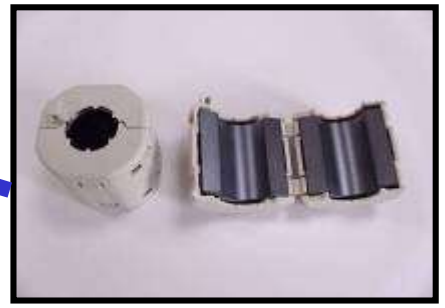
Select the ferrite material formulated to target the problematic frequency range.

Suppression of Conducted Noise

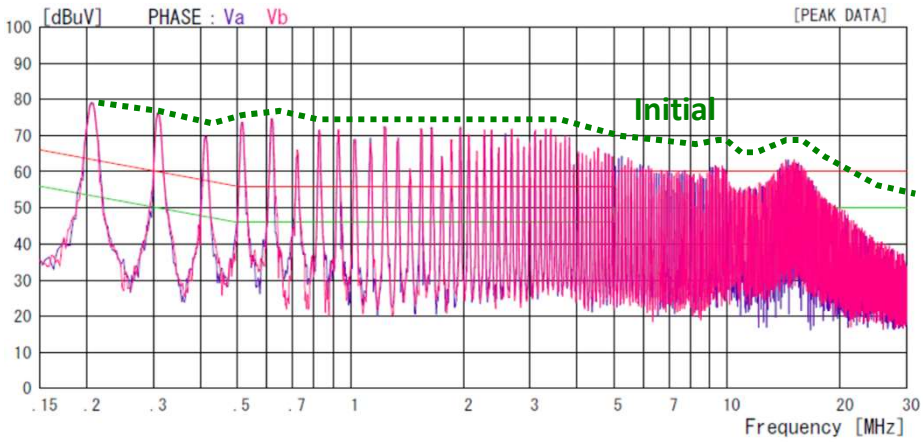
Test setup



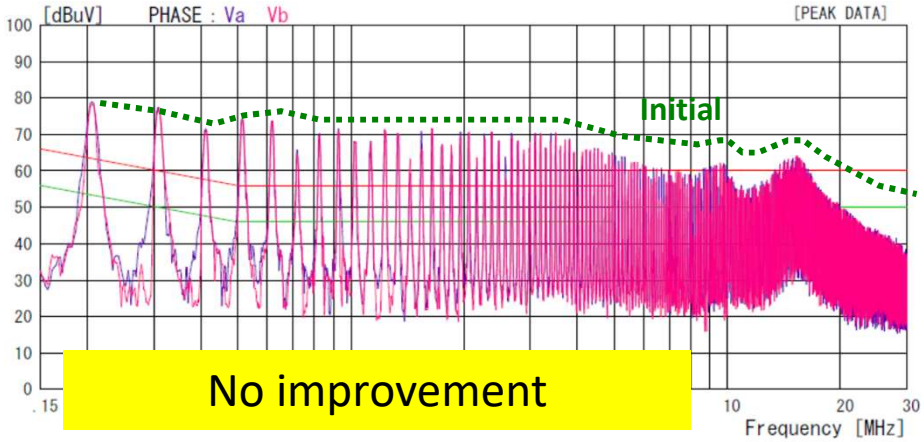
Ferrite core attached to power line (5 turns)



Initial condition

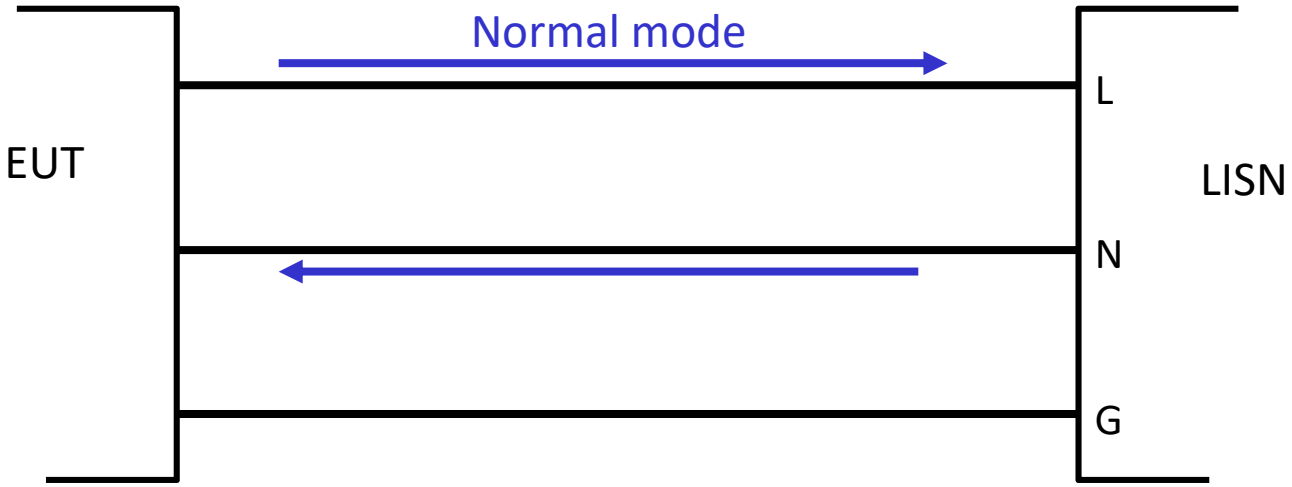


Attached on all wires together (L+N+G)



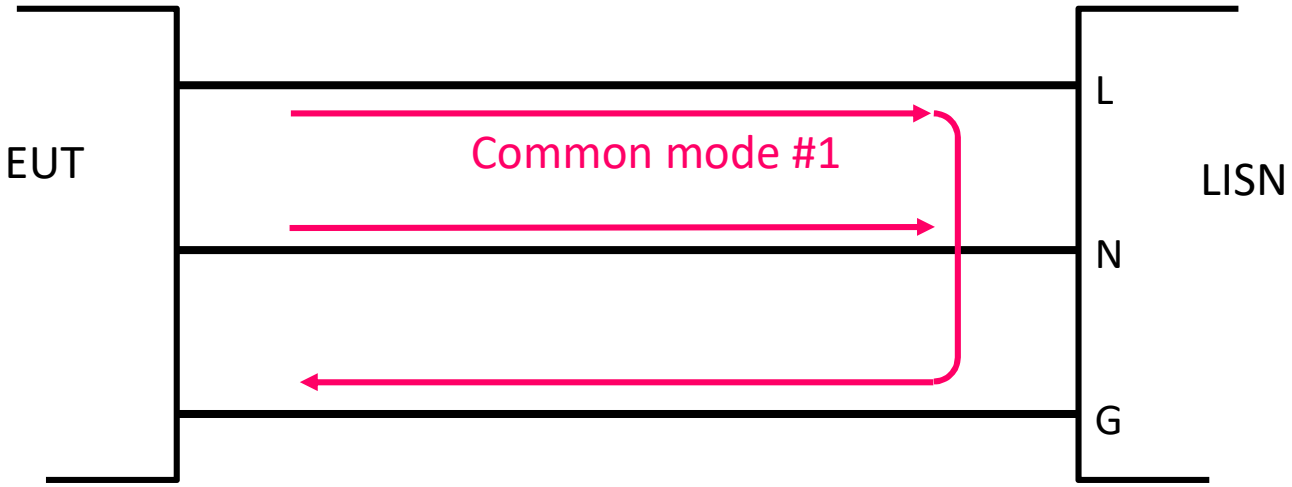
No improvement

Noise Current Paths



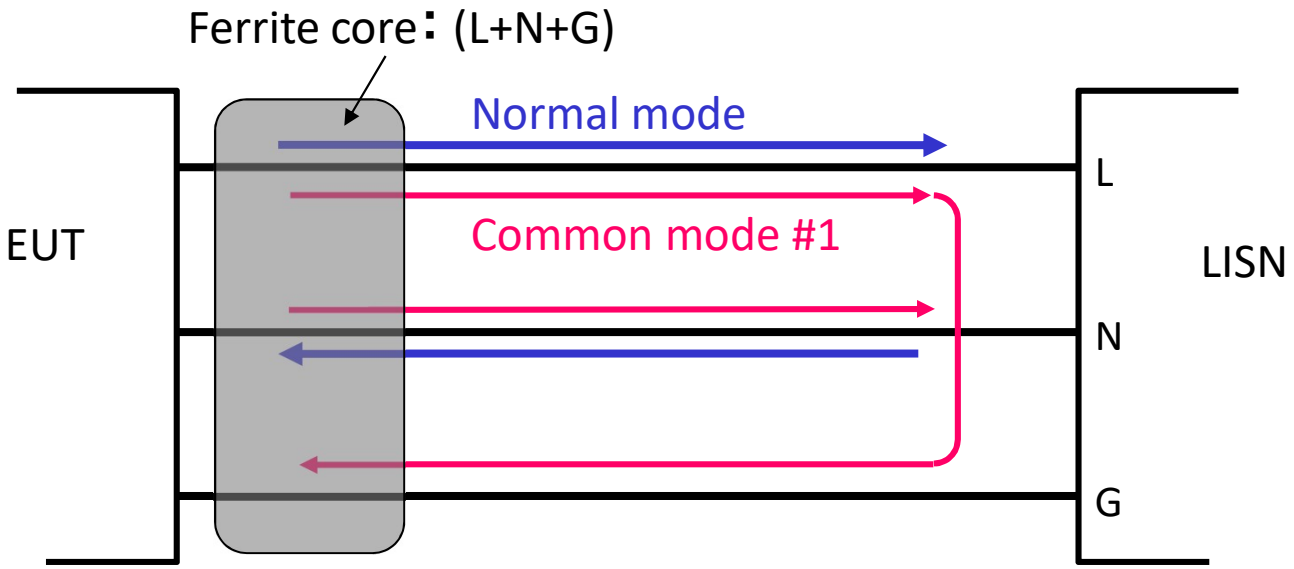
Normal mode crrent is flowing from L to N on the power cable.

Noise Current Paths



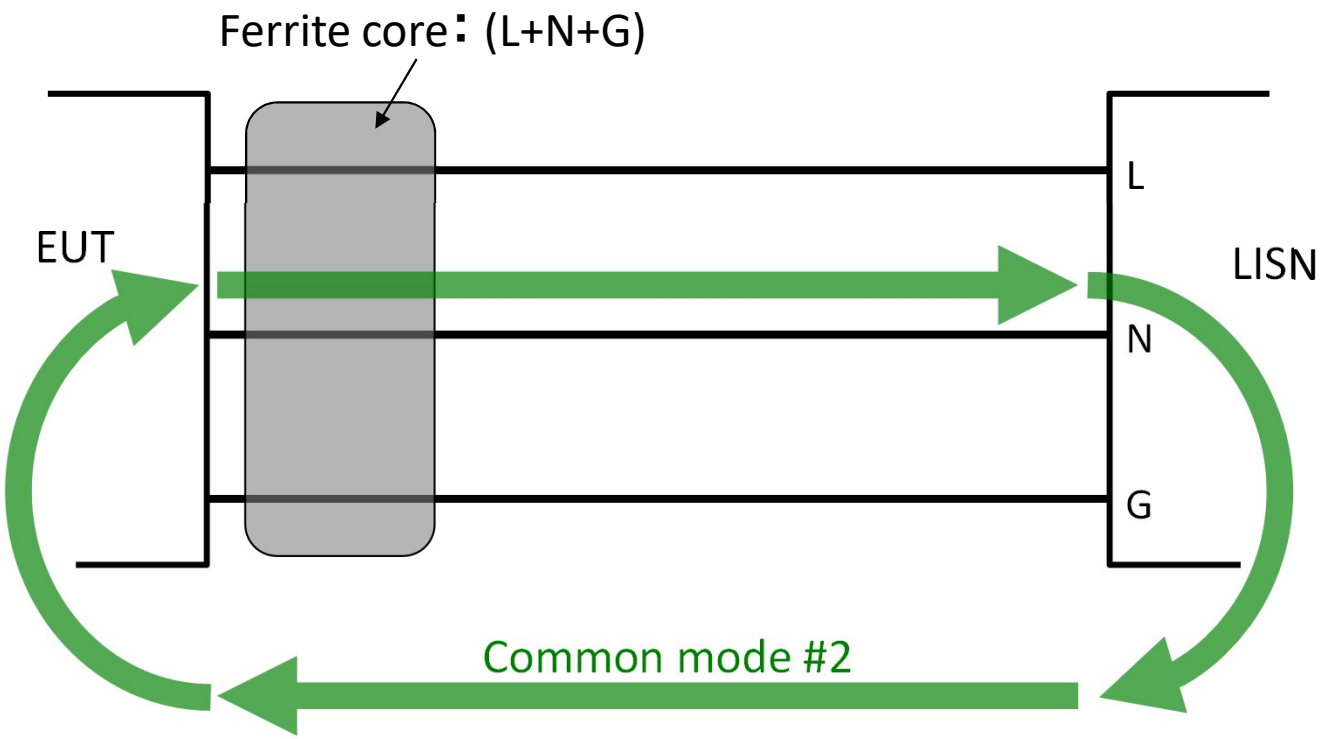
Common mode #1 is flowing from the L ahd returning on the G line.

Noise Current Paths



- **Since there are forward and return currents in the ferrite core for both of normal and common modes, and the magnetic fluxes are canceled out, there is no magnetic flux generated in the ferrite core.**
- **As a result, attached the ferrite core to L+N+G together has no effect for both normal mode and common mode.**

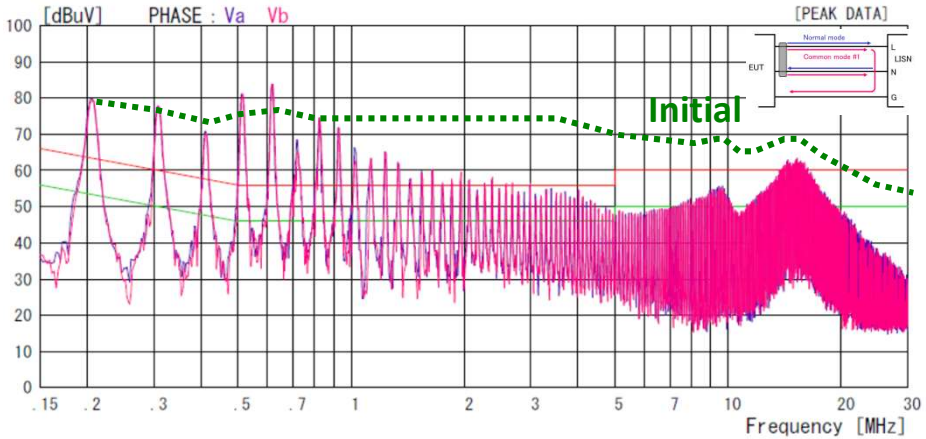
Noise Current Paths

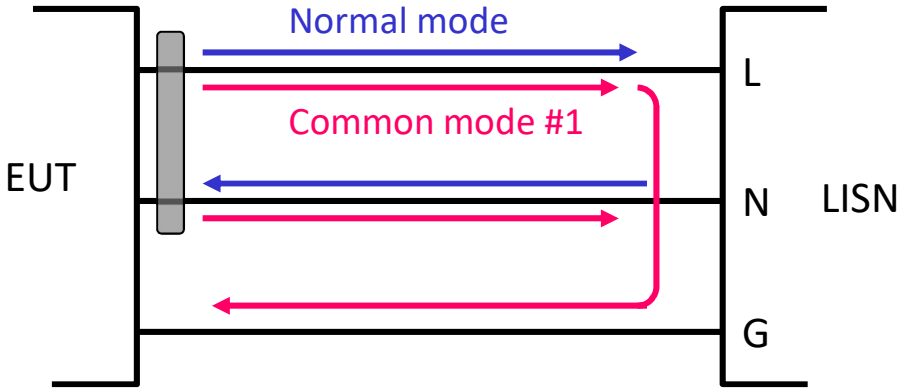


When a ferrite is attached to L+N+G together, it is only effective for treating common mode #2 noise.

Ferrite Core Attached Based on Current Modes

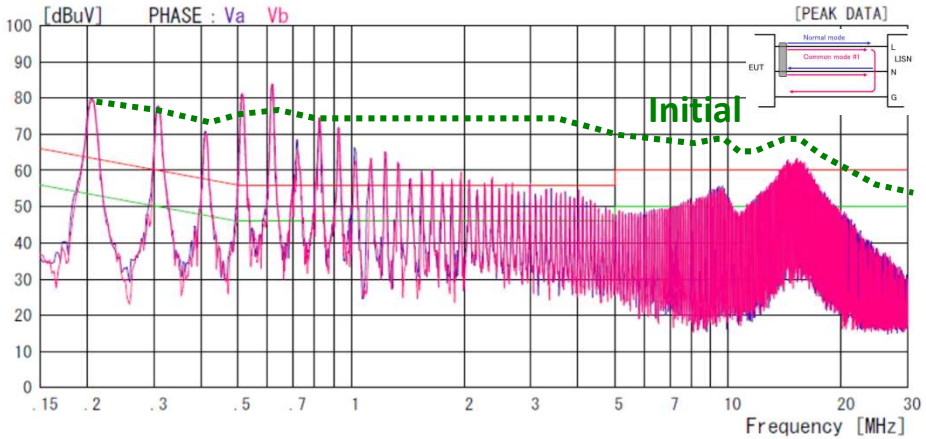
Attached to L+N together



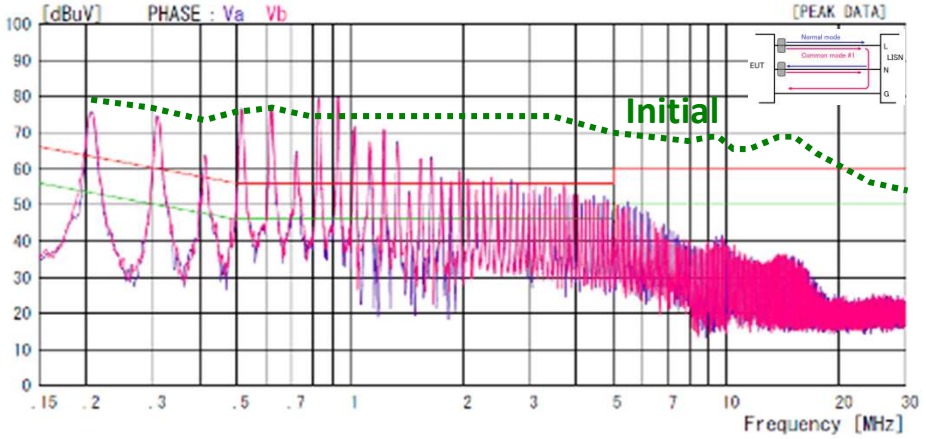


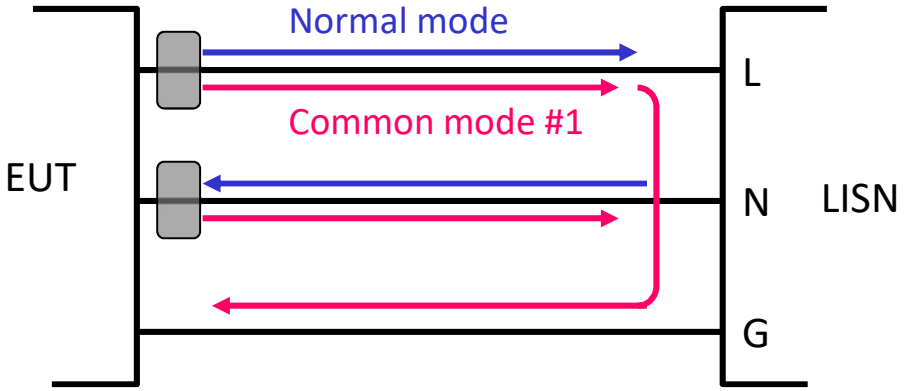
Ferrite Core Attached Based on Current Modes

Attached to L+N together



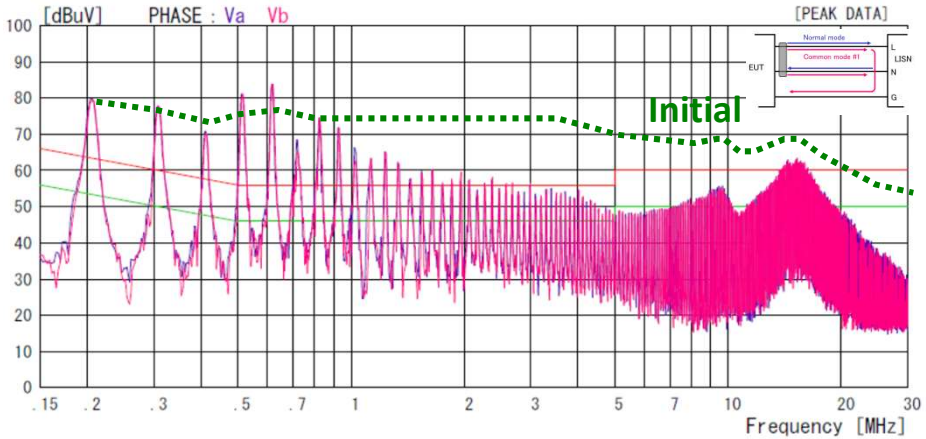
Attached to L and N separately



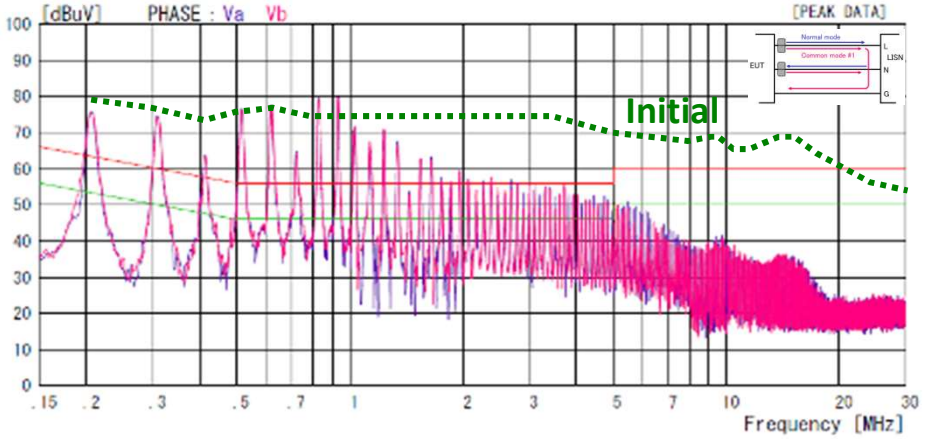


Ferrite Core Attached Based on Current Modes

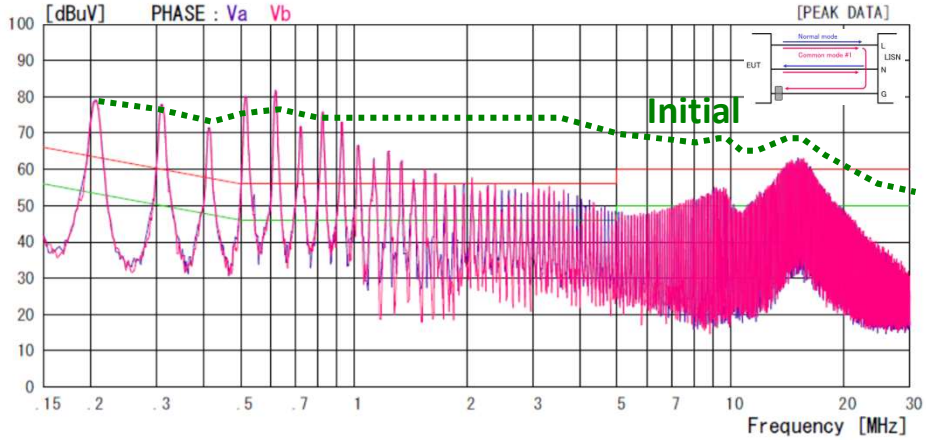
Attached to L+N together

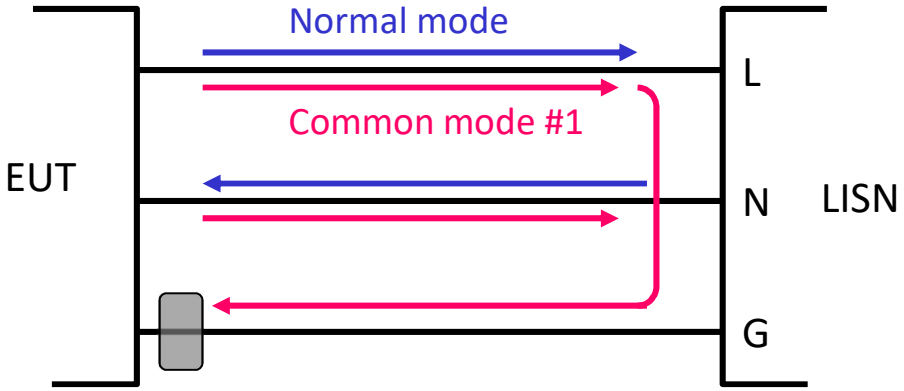


Attached to L and N separately



Attached to G only





Wide Selection of Ferrites Based on Frequency, Cable Dimensions, etc