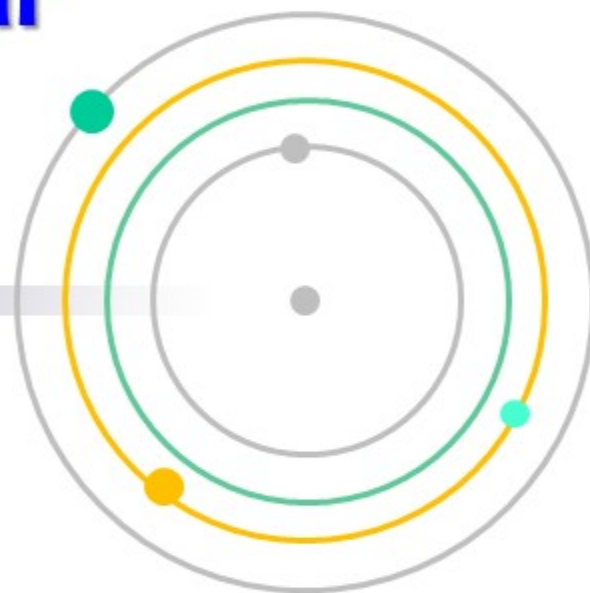


EMC Technical Seminar



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Rev 6-07222019

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1. Fundamentals of EMC
2. Shielding Techniques and Components
3. Grounding Techniques and Components
4. Filtering Techniques with Ferrite Cores

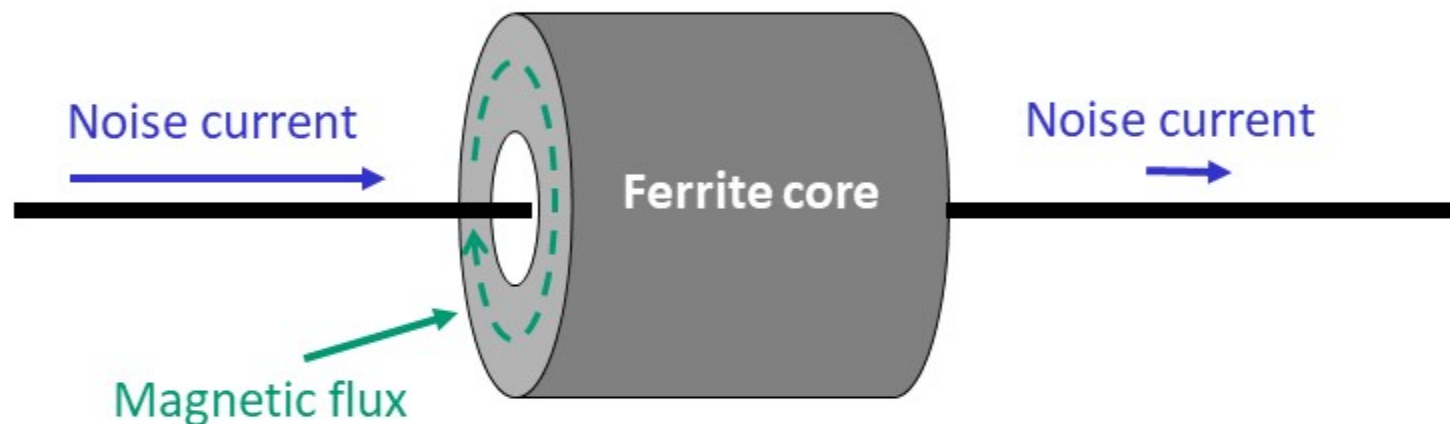
Filtering

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

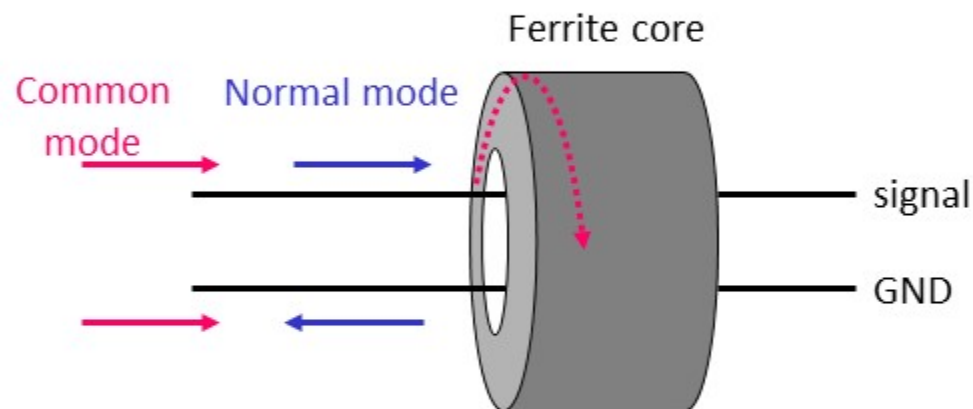


Magnetic field generated by electrical current

- 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

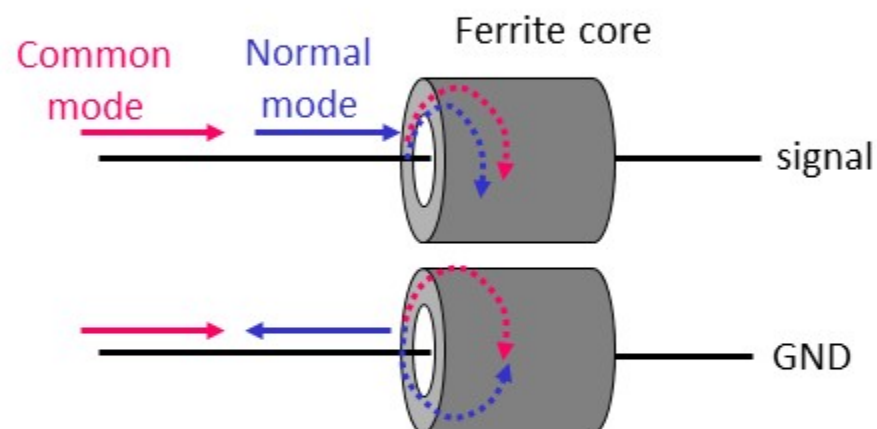
Placement of Ferrite(s) based on Current Mode

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.

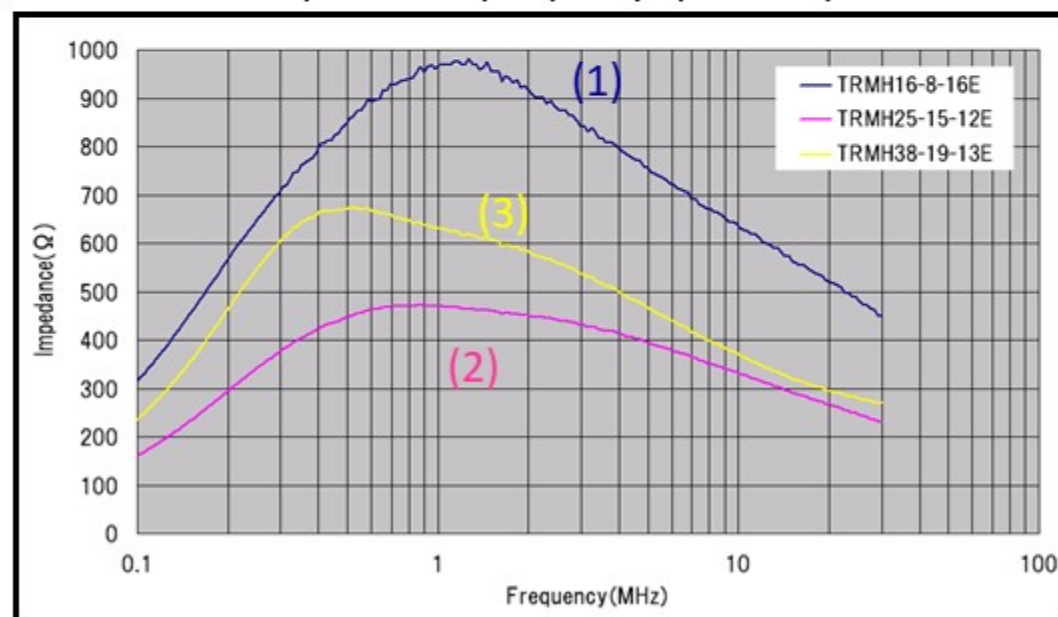
How to Select a Ferrite Core

① Shape factor of ferrite

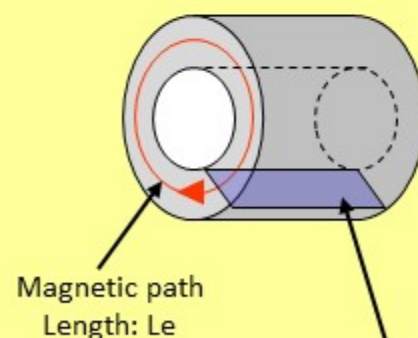


No.	Part number	Shape factor	Magnetic path length (mm)	Cross section (mm ²)
(1)	TRMH-16-8-16E	1.70	75.4	128
(2)	TRMH-25-15-12E	0.96	125.6	120
(3)	TRMH-38-19-13E	1.38	179.0	247

Impedance property (5 turns)



Inductance Calculation



Shape Factor

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

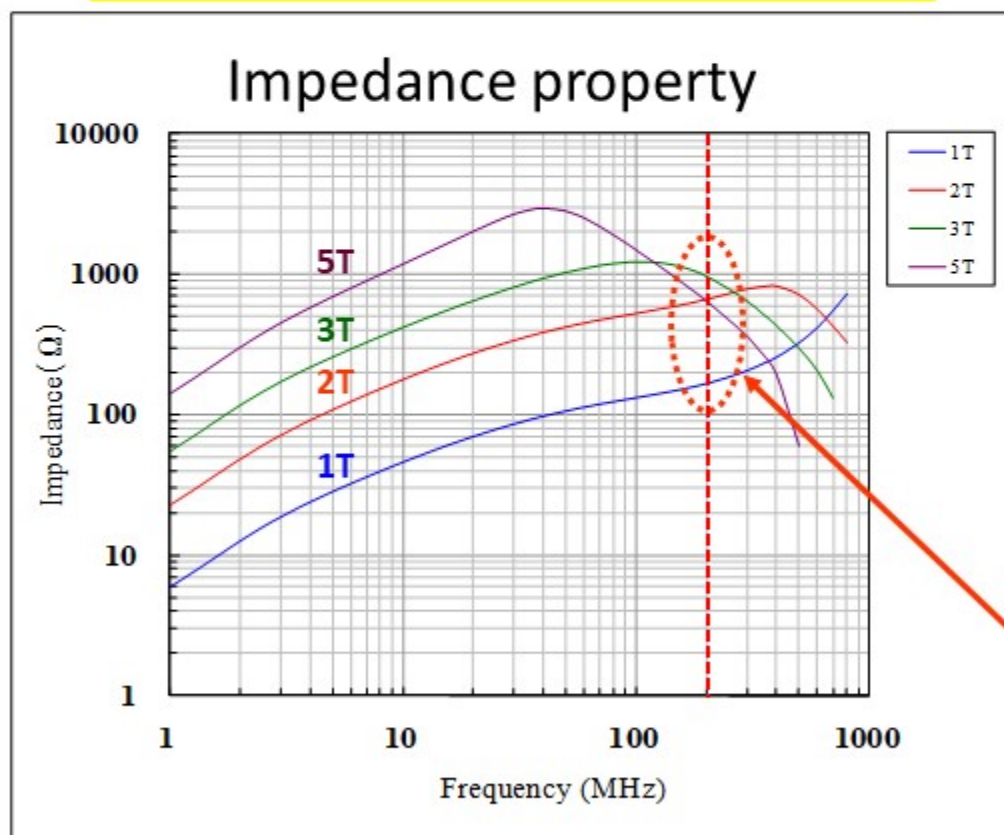
(N: number of turns
μ: permeability)

Cross section: Ae

How to Select a Ferrite Core

② Turns through a core

Impedance increases with each turn.



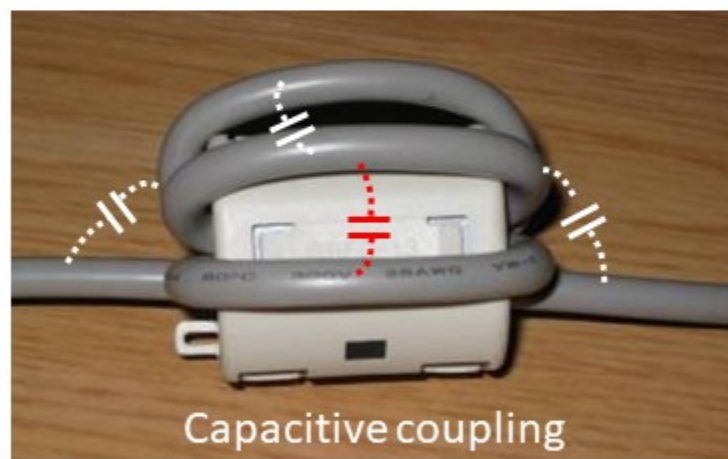
Turn formula: N^2

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



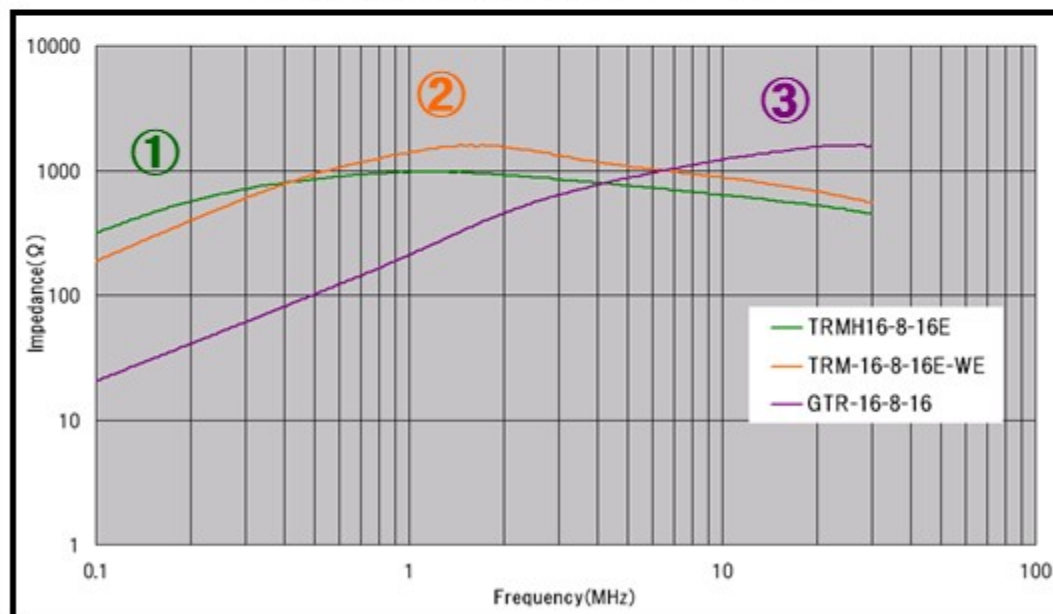
①

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)

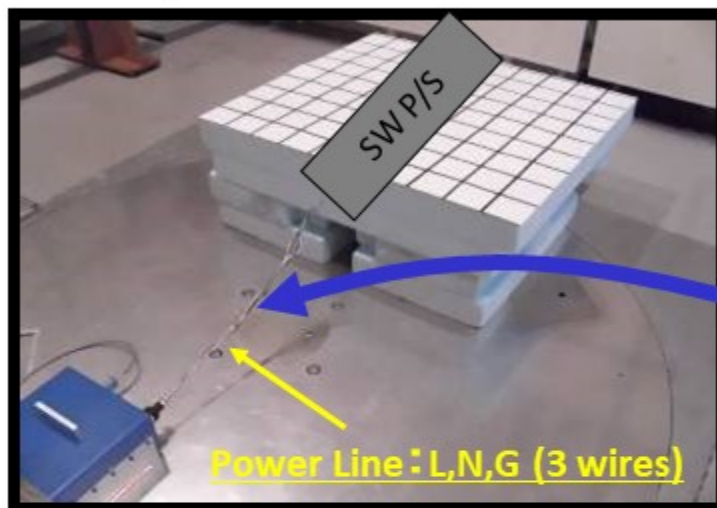
Impedance property (5 turns)



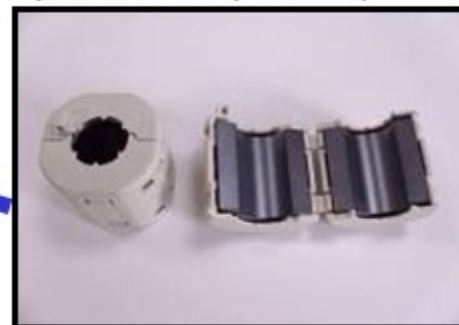
Select the ferrite material formulated to target the problematic frequency range.

Suppression of Conducted Noise

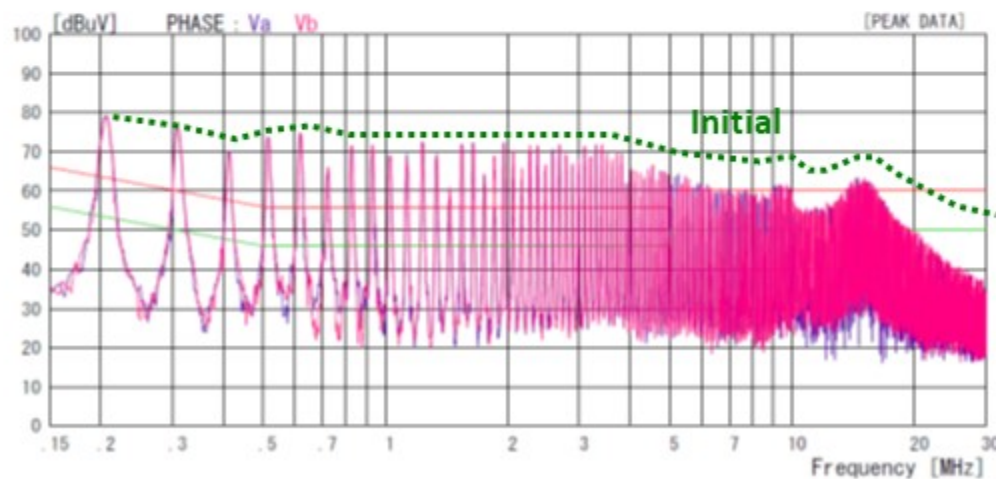
Test setup



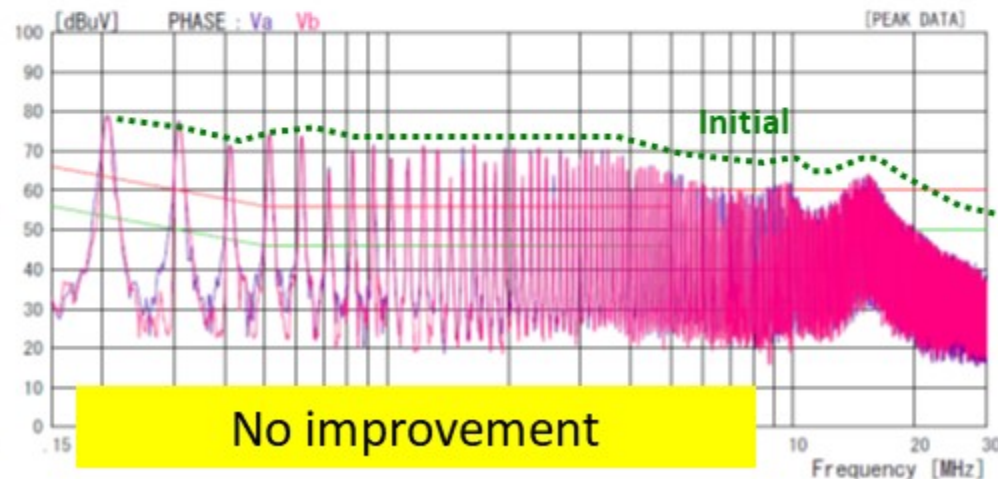
Ferrite core attached to power line (5 turns)



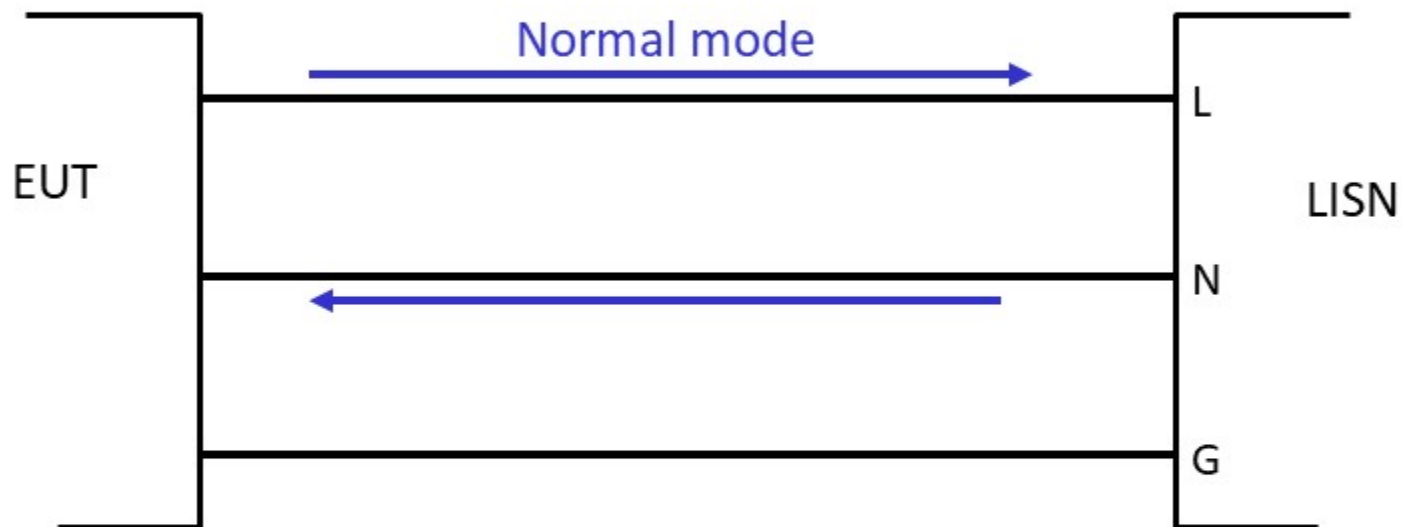
Initial condition



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

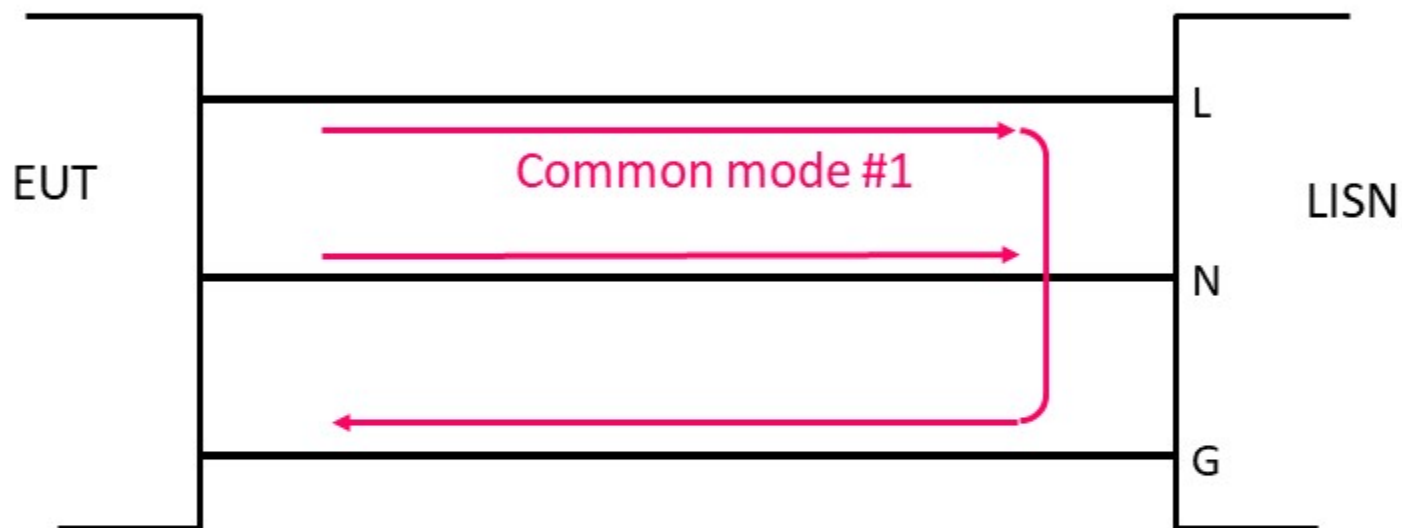


Noise Current Paths



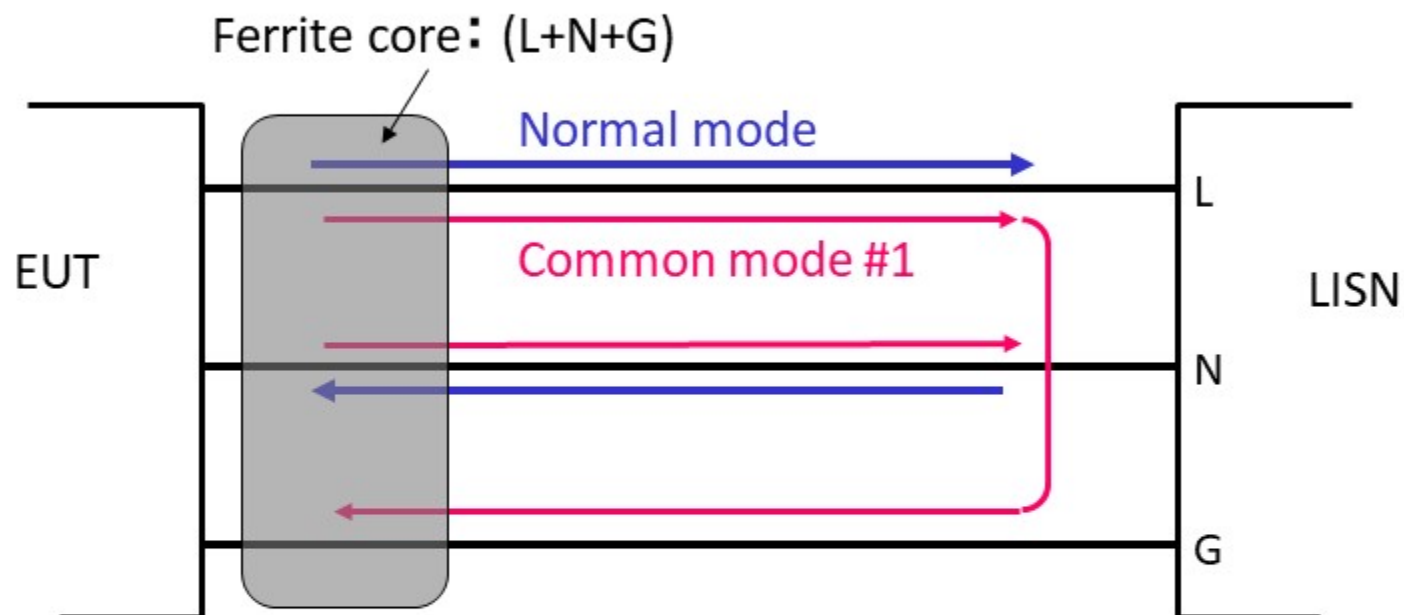
Normal mode current is flowing from L to N on the power cable.

Noise Current Paths



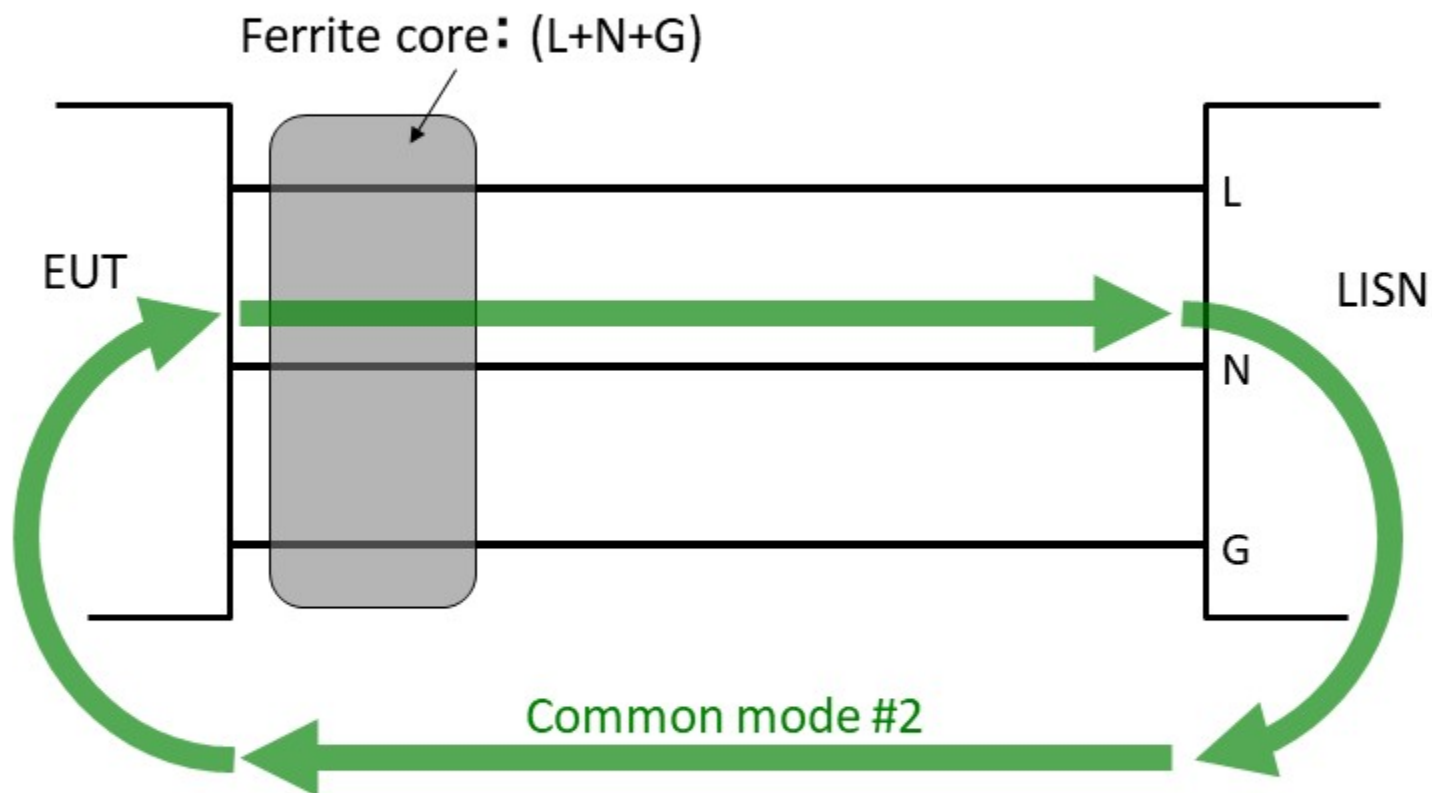
Common mode #1 is flowing from the L and N line and returning on the G line.

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.

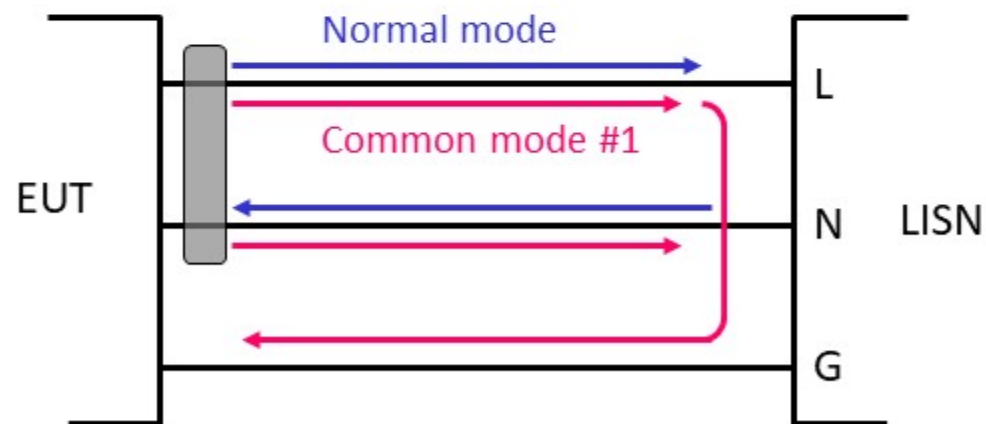
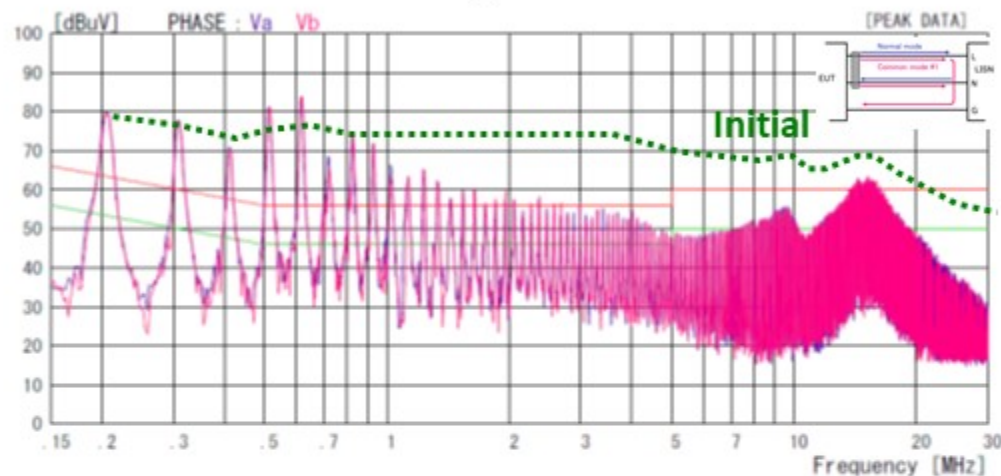
Noise Current Paths



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

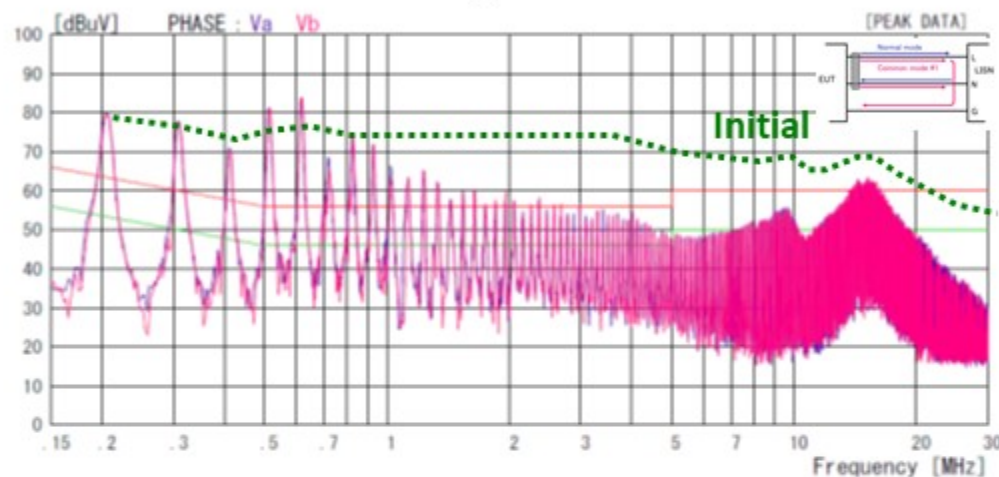
Ferrite Core Attached Based on Current Modes

Attached to L+N together

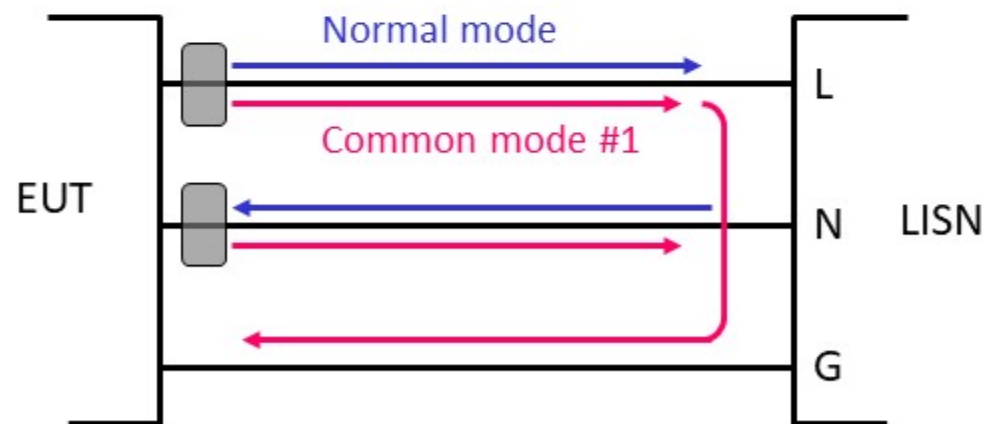
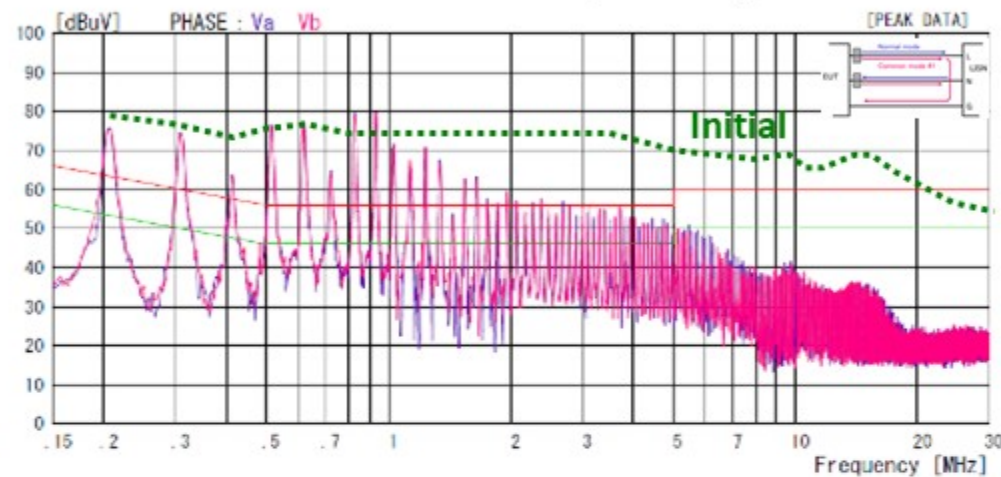


Ferrite Core Attached Based on Current Modes

Attached to L+N together

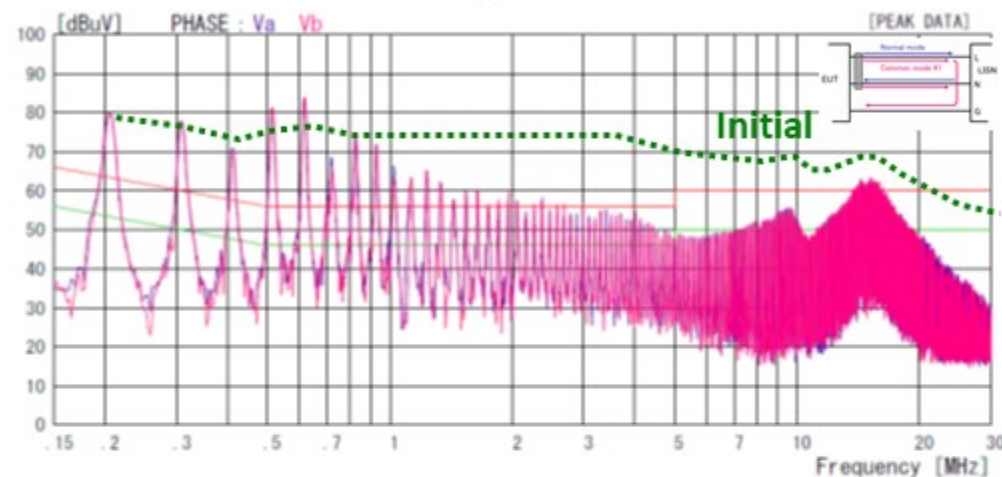


Attached to L and N separately

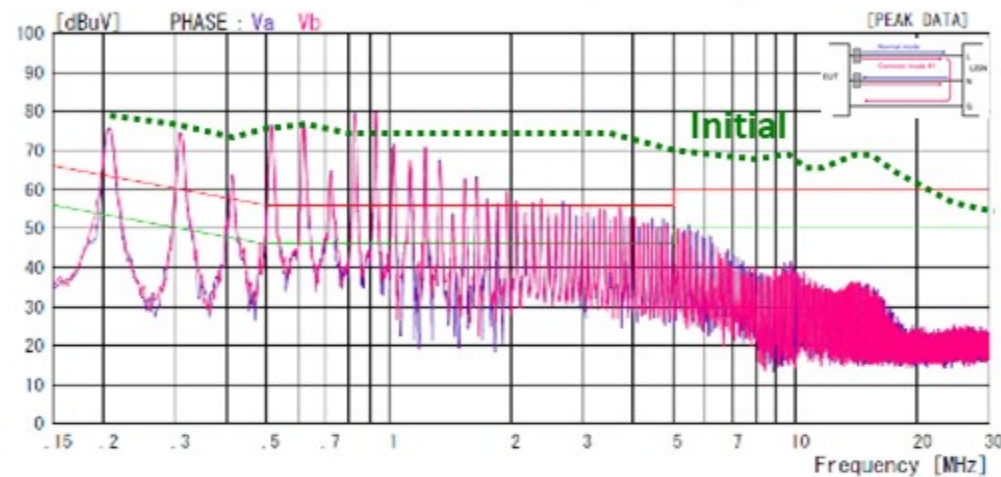


Ferrite Core Attached Based on Current Modes

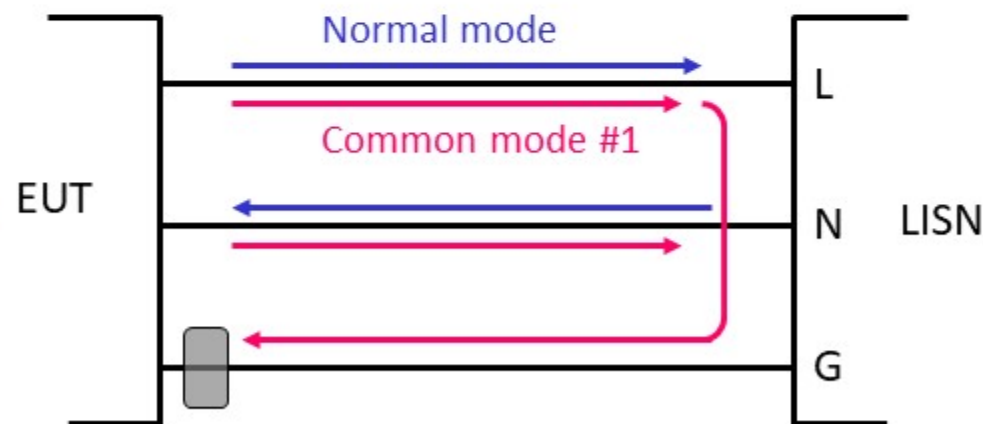
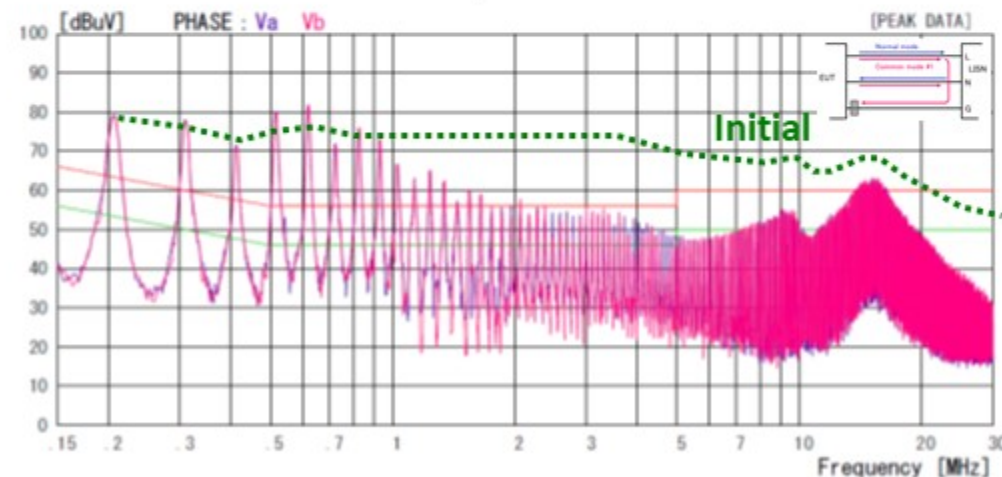
Attached to L+N together



Attached to L and N separately



Attached to G only



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

