2021 KOREA MURATA WEBINAR

EMI part

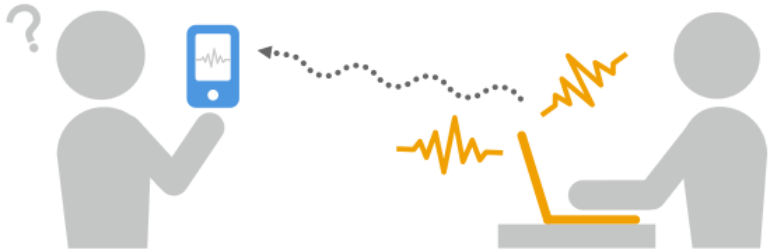
노이즈 제거에 적합한 EMI 제품

1. Noise Source
2. Noise Investigation
3. Noise Countermeasure
4. Noise Example
5. Murata Product Recommendation & Summary

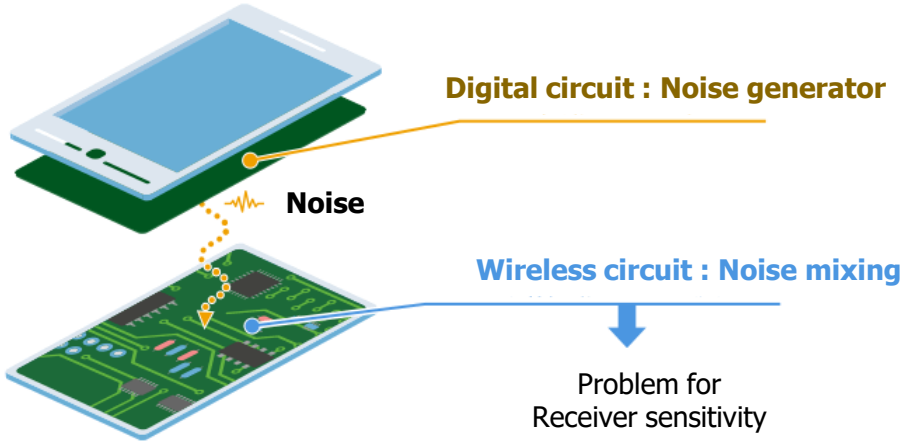
1. Noise Source

Emission or Immunity

EMC
(Electromagnetic Compatibility)



Immunity **Emission**

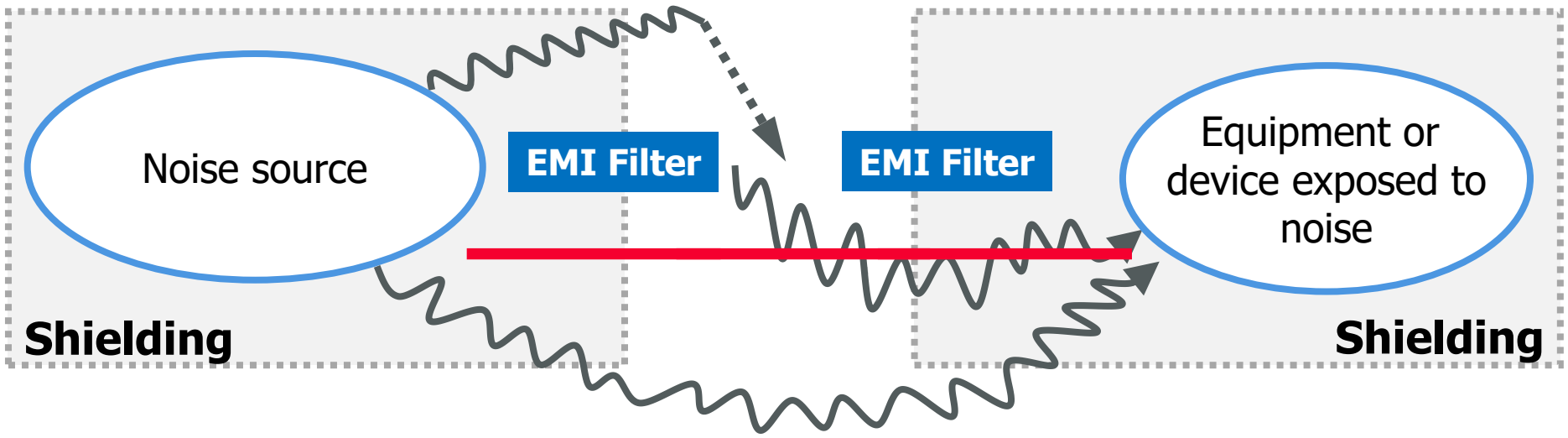


Noise problem between 2 different products
(Traditional Problem)

Noise problem in a product
(Recent Problem)

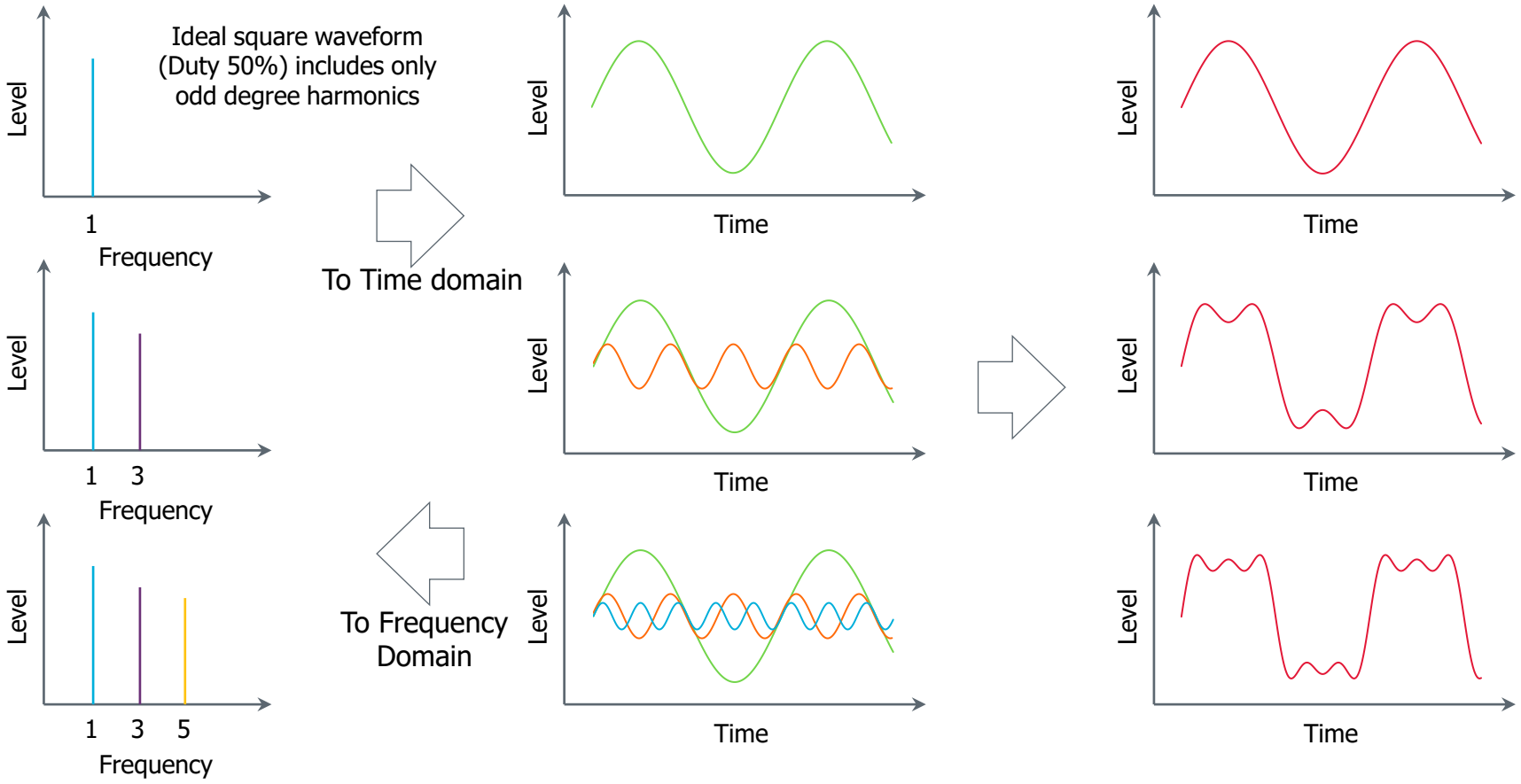
There are the cases have failure, performance degradation or broken when strong electromagnetic waves from outside (**Emission**) to an electric product (**Immunity**).

Radiation or Conduction



	Noise source side	Noise receiver side
Conduction	EMI Filter	EMI Filter
Radiation	Shielding	Shielding
Conduction ➡ Radiation	EMI Filter	Shielding
Radiation ➡ Conduction	Shielding	EMI Filter

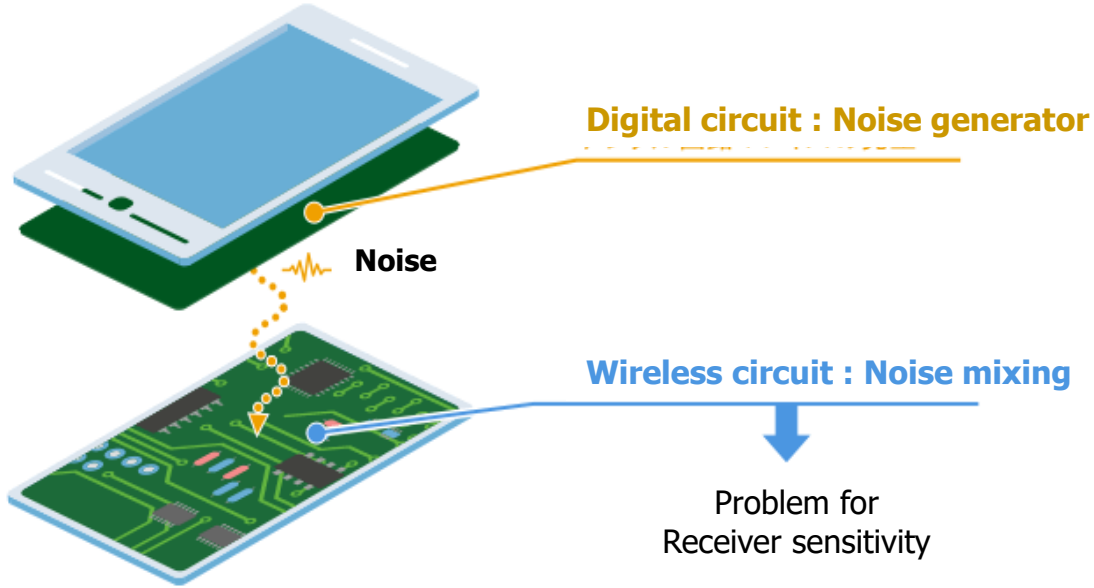
Radiation or Conduction



Digital signal waveform is consist of basic waveform and the harmonics. Noise could be reduced by harmonics cutting, but need to be careful of signal quality in the case.

Analog Circuit (Audio, Video or RF)

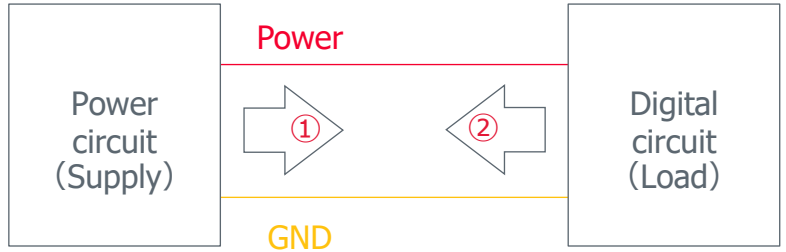
Noise problem example



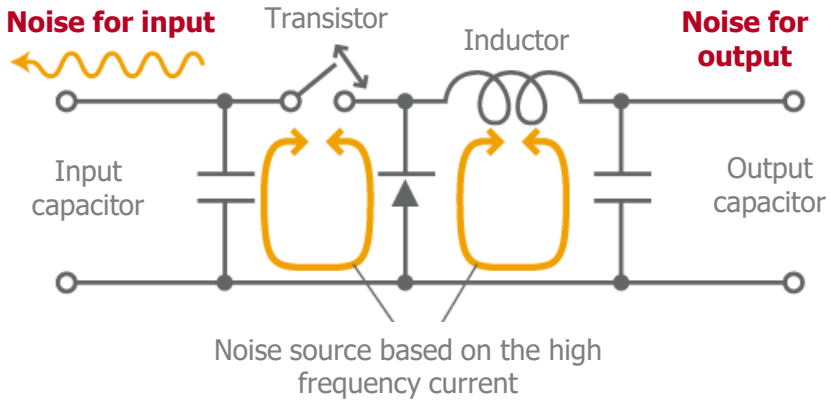
Receiver sensitivity for RF circuit, or audio/video quality degradation are main problem for analog circuit. We guess the problem is increasing in the future based on the RF circuit increasing.

Power Circuit (DCDC or ACDC)

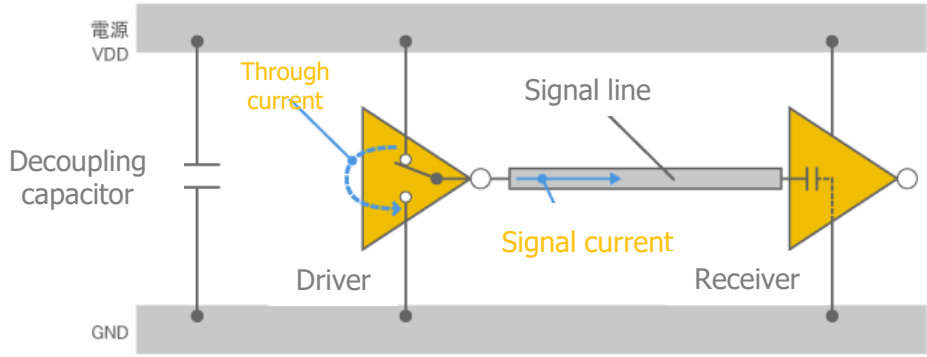
Noise problem example



①Noise problem at power circuit

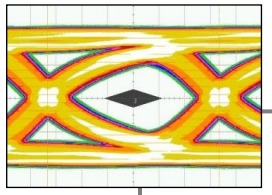


②Noise problem at digital circuit

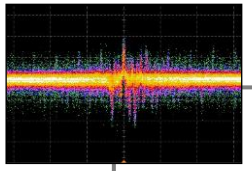


Main noise sources based on power lines are power circuit and digital circuit, and both are related to switching frequencies for each.

Total Optimized Design

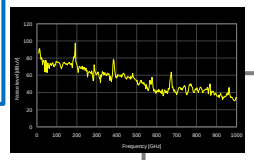


SI
(Signal Integrity)
信号波形品質



PI
(Power Integrity)
電源電圧品質

Worse SI makes
better EMI（Trade off）



EMI
(Electromagnetic Interference)
放射ノイズ

Better PI makes
better EMI (Synergy)

But, power efficiency might be worse
(Trade off)

EMI is highly related to SI and PI, and important point is total optimized design.

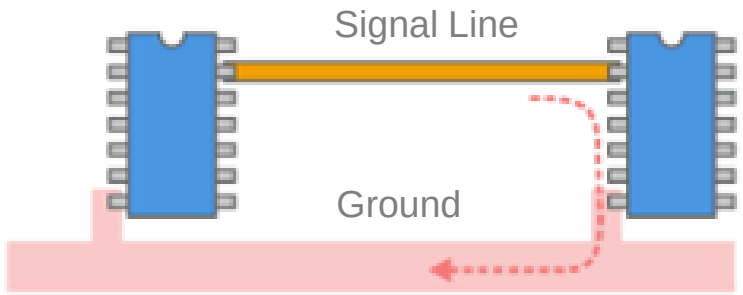
Noise loop (Return pass)

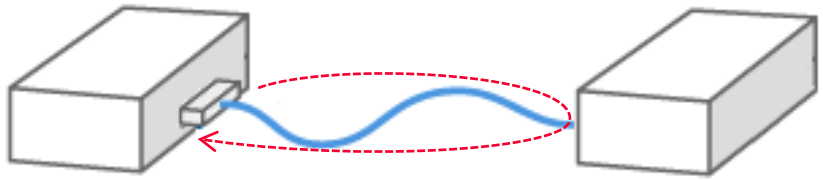
Current

- Current goes back to the source with making the loop.
- Current goes to “low impedance lines (Return pass) ”

Noise problem

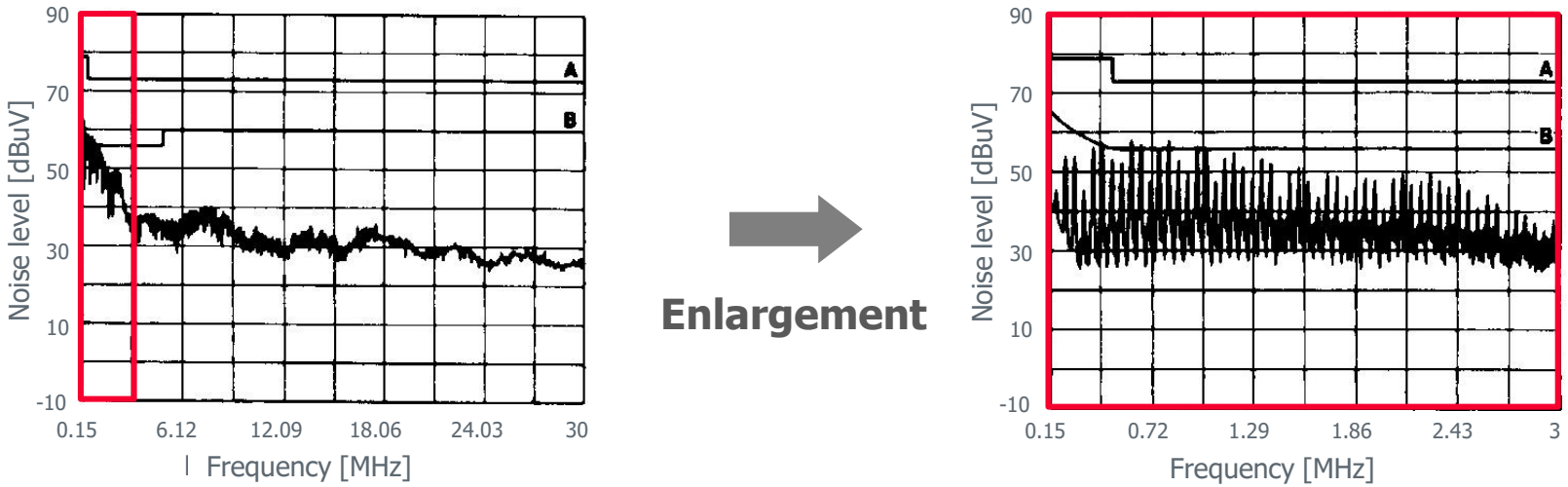
- If the current loop is long, the noise might be generated.





2. Noise Investigation

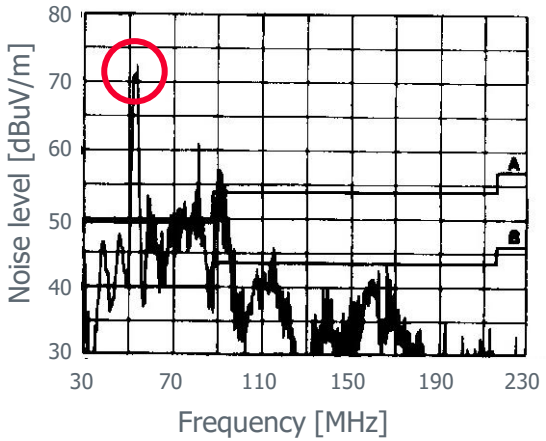
Frequency



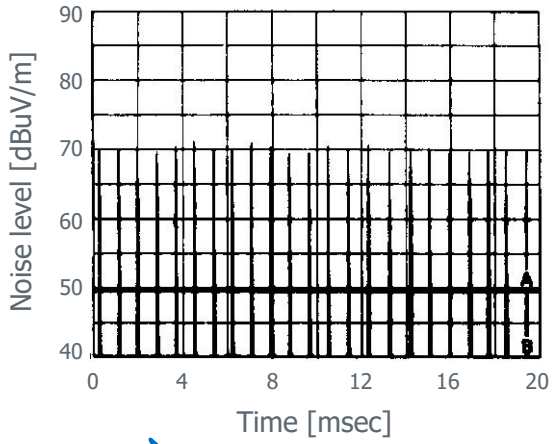
If it is hard to see the range, we can change the frequency span, RBW, etc.

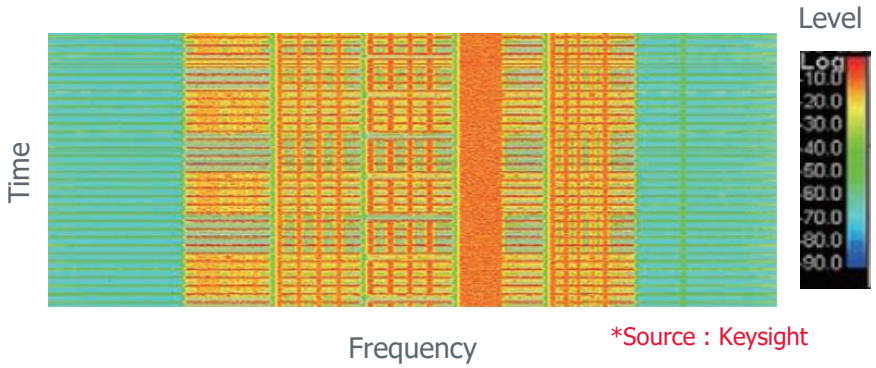
Checking the frequency range by EMI receiver (Spectrum Analyzer). Operating frequency and harmonics for each circuit (Digital, Analog or Power) could be the hint for the noise source investigation.

Time



Change frequency axis to time





*Source : Keysight

Zero span :

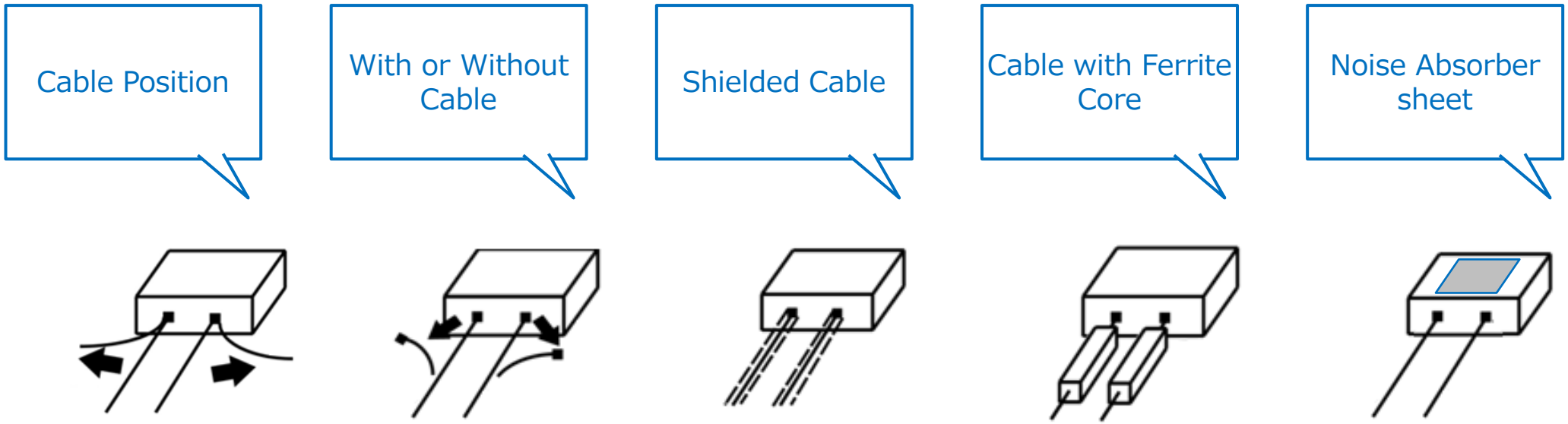
Time axis for specific frequency.

Spectrogram :

Time – Frequency information

We can see the noise situation by time using Zero span or Spectrogram functions for EMI receiver (Spectrum Analyzer)

Simple Countermeasure



Could check noise path and antenna by such simple countermeasure. It is easy to implement them, and change back as well.

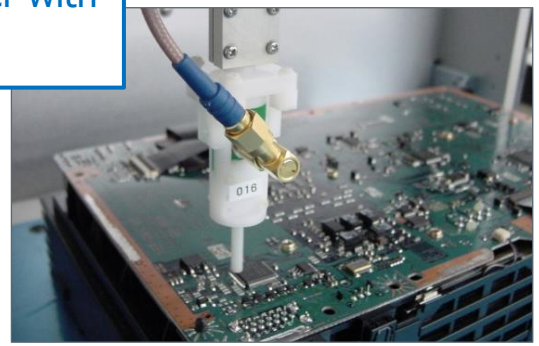
Position

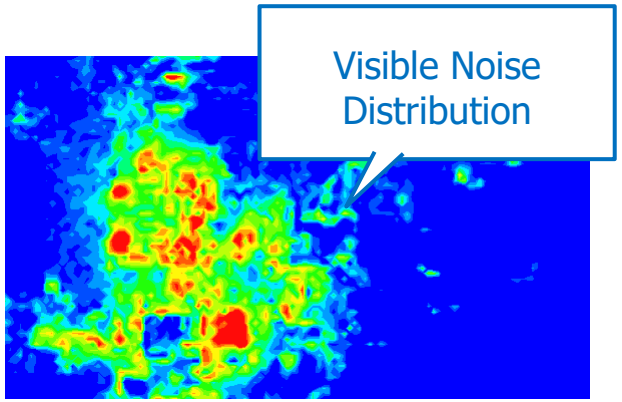
Magnetic Prove

Electric Prove

FET Prove

Current Prove



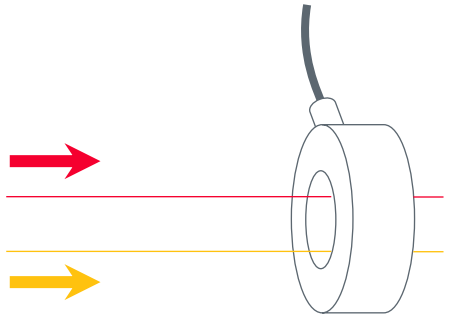


Small proves could measure the noise level for the part of circuit boards or cables. And, it makes easy to check the noise source and path.

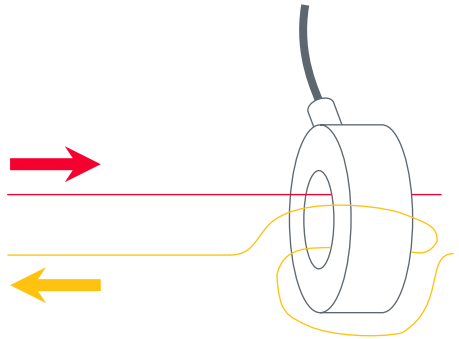
Position

Using Current Prove

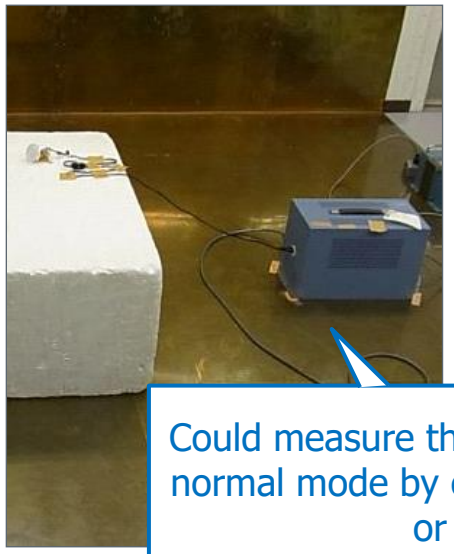
Common Mode



Normal Mode



Using Δ type LISN

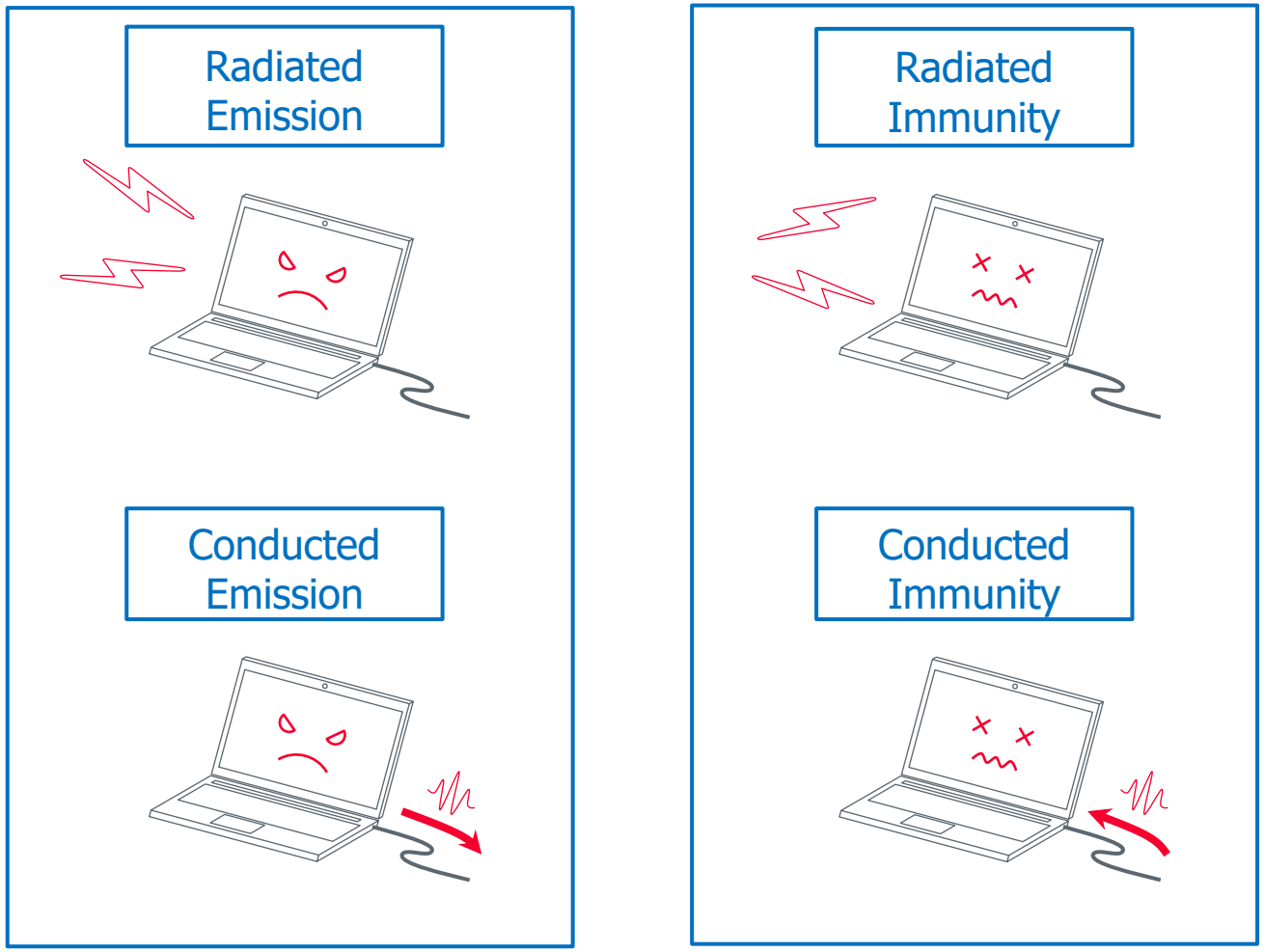


Could measure the common mode or normal mode by changing the switch or LISN

It is important to make clear which noise mode is dominant, common mode or normal mode in order to countermeasure correctly.

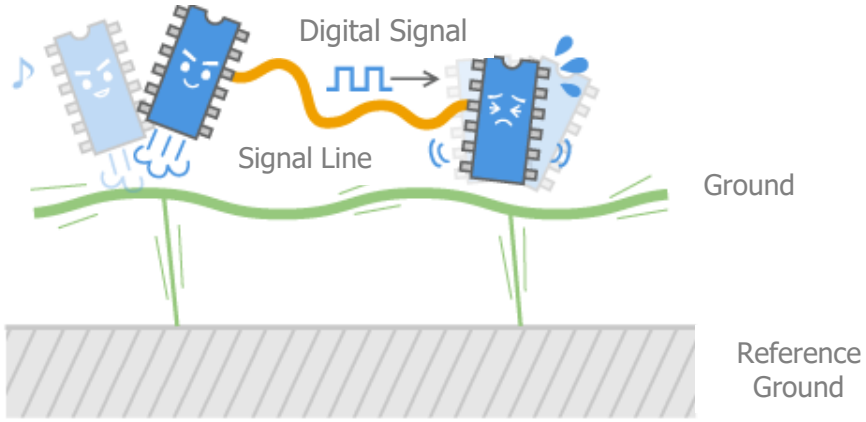
3. Noise Countermeasure

Noise Problem Review

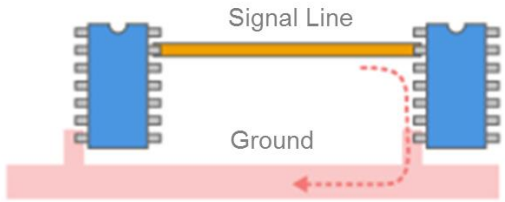


There are 4 main noise phenomenon, and each EMC test is required in the world wide.

For Noise Source - Ground Design



Common mode noise is generated when the ground is unstable



Return Pass is important

- Current goes back to the source with making the loop.
- Current goes to "low impedance lines (Return pass) "
- If the current loop is long, the noise might be generated.

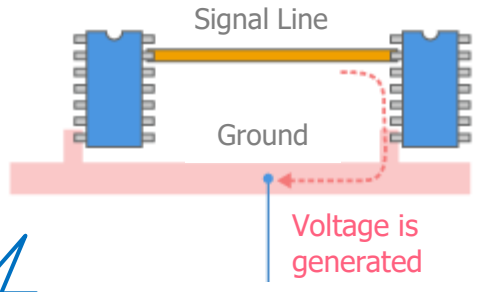
Noise Countermeasure

- Consider where the current going to.
- Design the return pass route to prevent the noise.

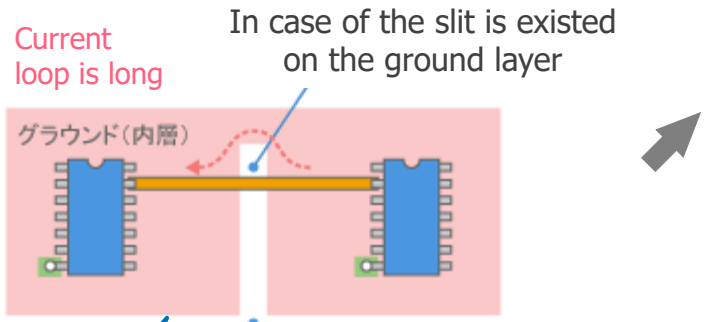
Noise sources are mainly "IC", but they come from mainly ground design. Ground design is important for the countermeasure.

For Noise Source - Ground Design

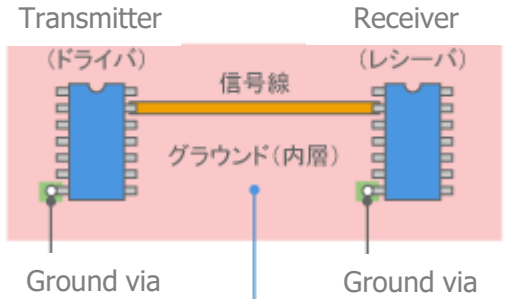
Ground design on the circuit board



Thin Ground



Slit on the ground layer

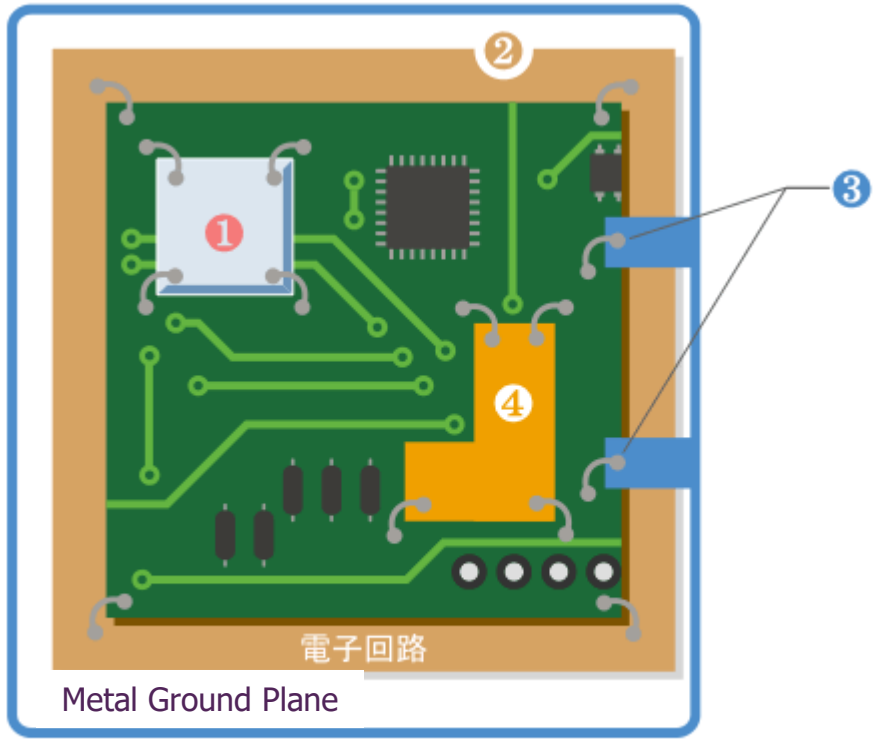


Ideal Ground

The shortest return pass is required for ground design on the circuit board. Thick, short and via position are important. Split ground is always needed to consider the return pass.

For Noise Source - Ground Design

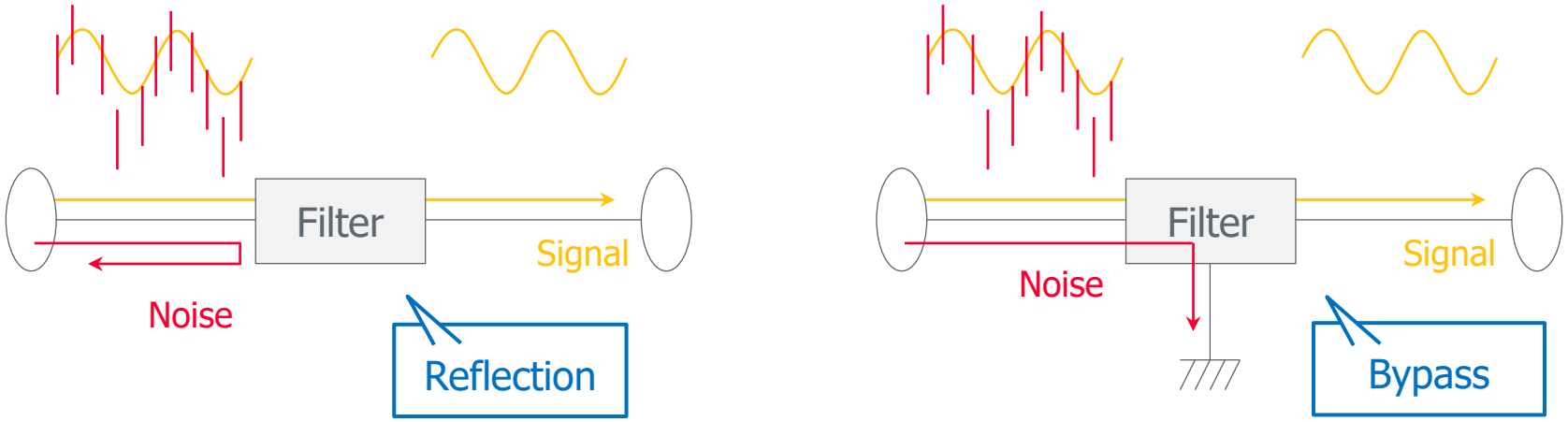
Total Ground Design



1. Covered by shield case, and connecting to board ground
2. Using metal ground plane under the circuit board, and connecting to board ground
3. Connecting between the board ground and shield case as chassis with low impedance method
4. Make lower ground impedance by using thick and short line for each ground.

Using metal ground plane or shield case (Chassis) if only board ground can not be optimized.

For Noise Path – Filter (Solutions)

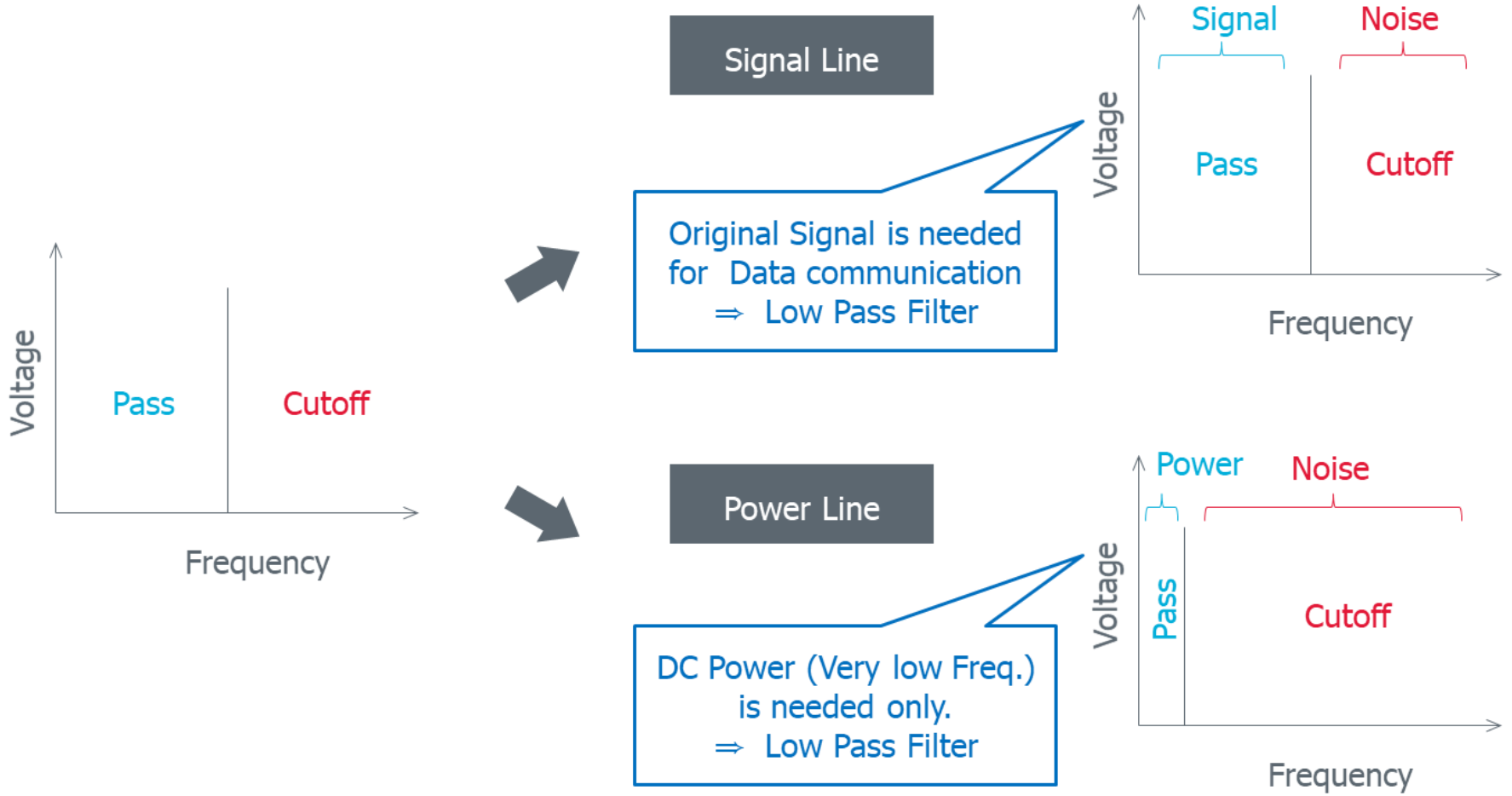


Distribution Method			Target Noise	Main Circuit	Filter Solutions
Frequency	Signal	Low Freq.	All noises	All circuits	Capacitors, Inductors, Low Pass Filters, etc.
	Noise	High Freq.			
Mode	Signal	Normal	Common mode noises	Power Differential Signal	Common mode choke coils
	Noise	Common			
Voltage	Signal	Low Volt.	Surge voltage	All circuits	Surge absorbers
	Noise	High Volt.			

Need to consider not only how to reduce the noise but also how not to affect to other things.

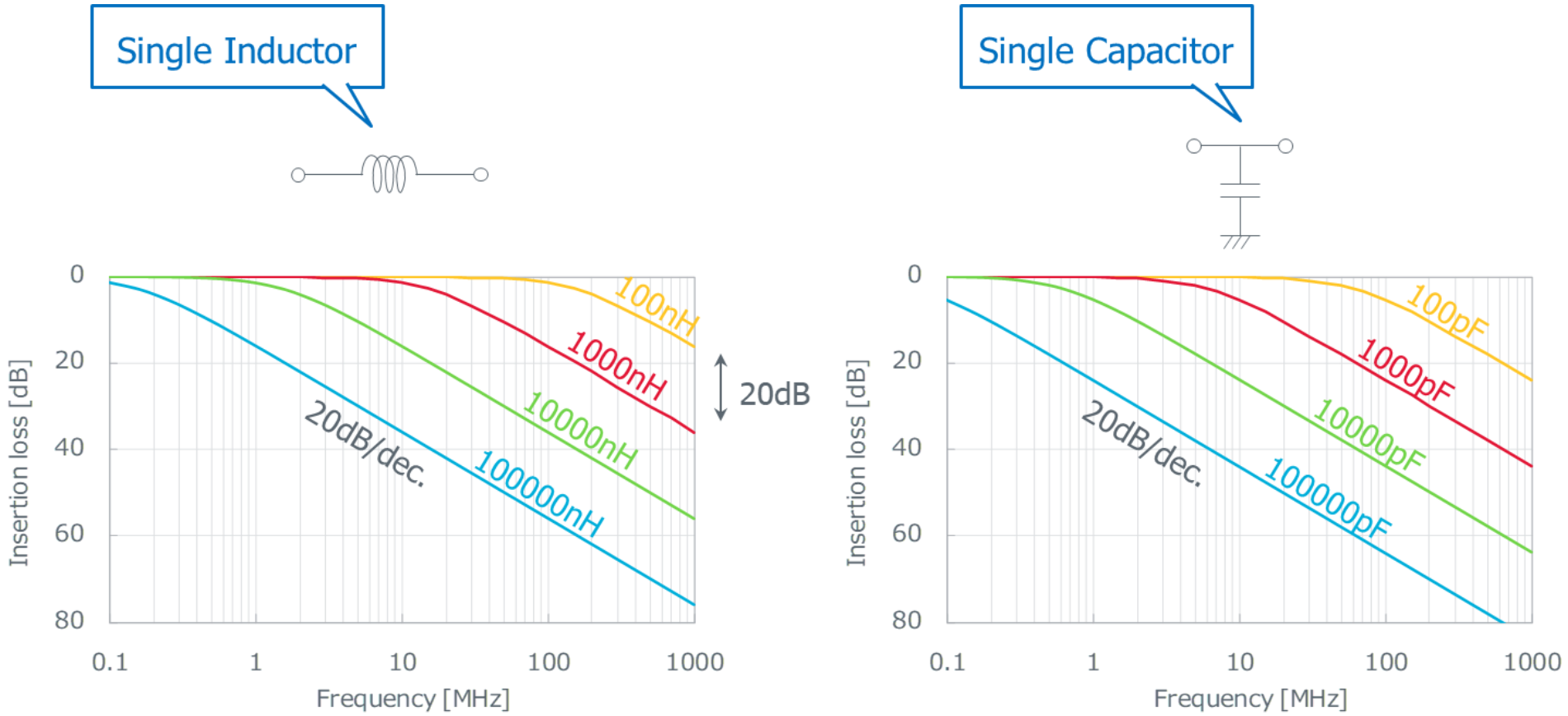
"Pass" and "Cut" factors need to be distributed.

For Noise Path – Filter (Frequency)



Low Pass Filter is very suitable for both signal / power line because high frequency noise exists on both circuits mainly.

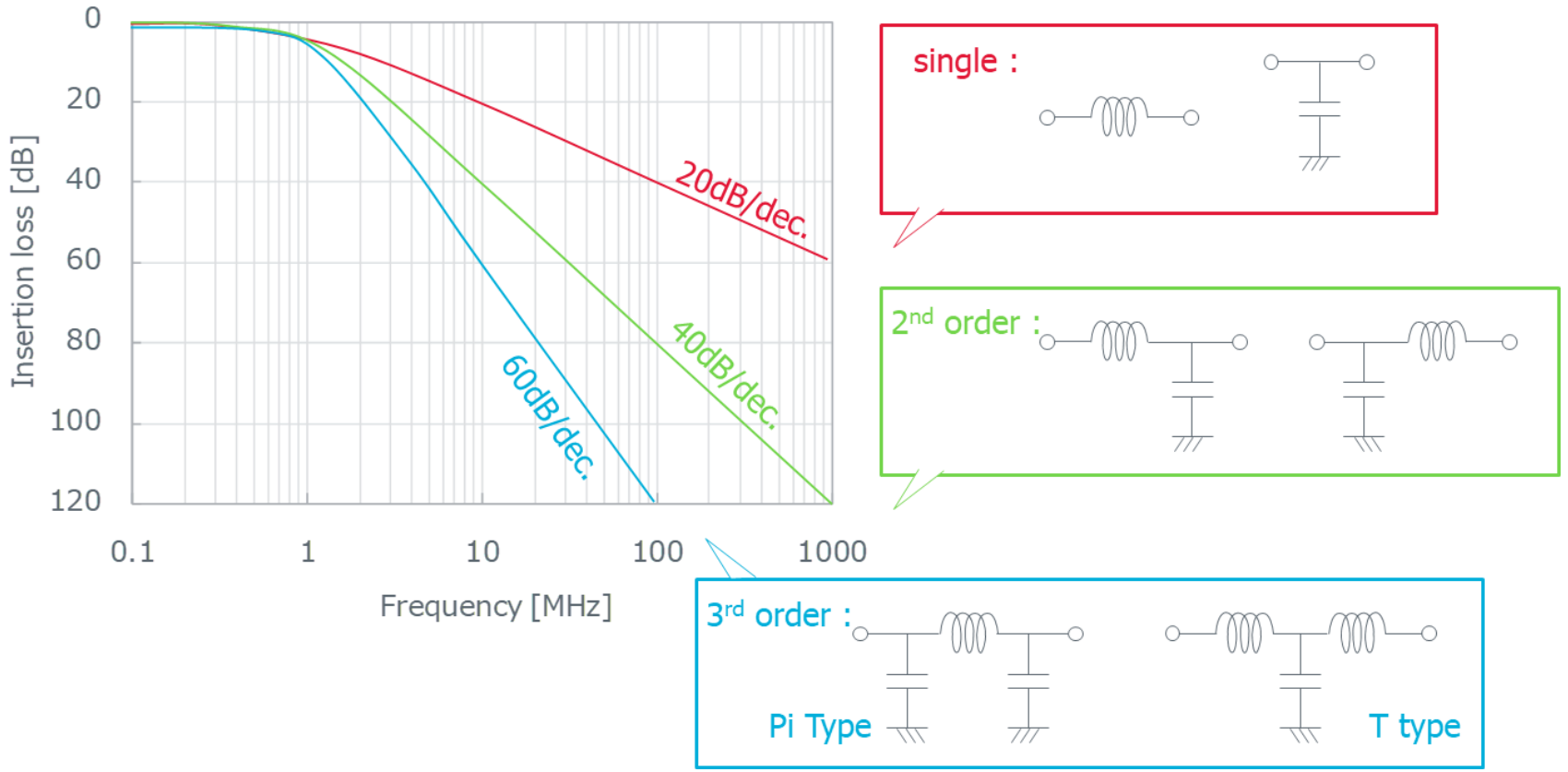
For Noise Path – Filter (Frequency)



Most basic low pass filter is inductor in series connection or capacitor in shunt connection.

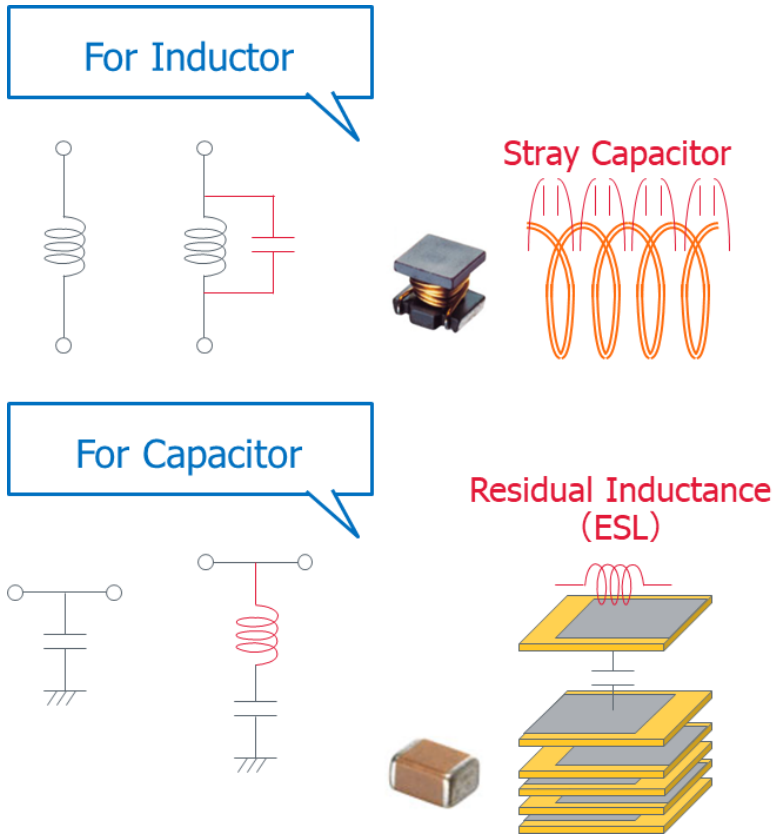
As an ideal characteristic, insertion loss is deeper by increasing inductance or capacitance values.

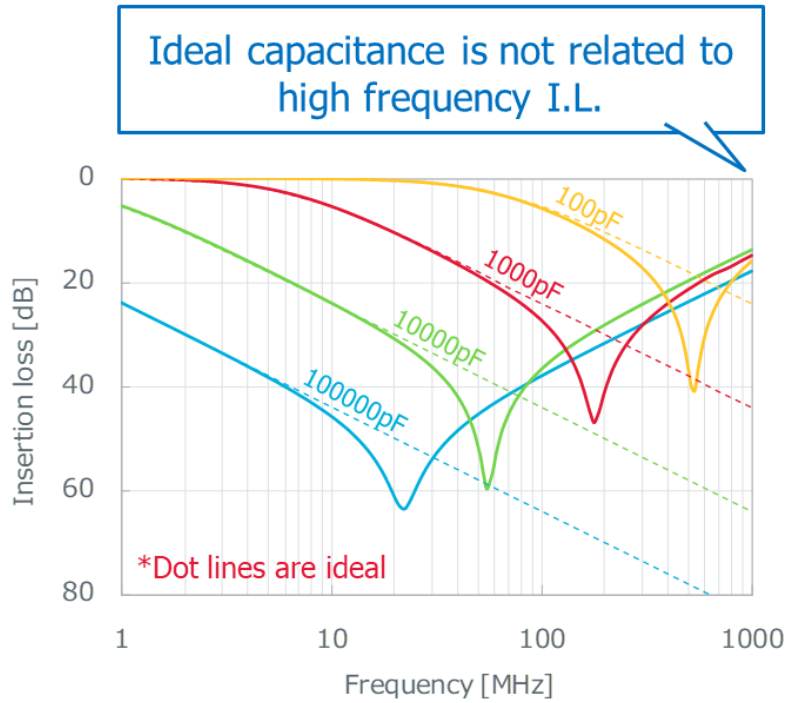
For Noise Path – Filter (Frequency)



More steep insertion loss could be obtained by combining inductor & capacitor, and/or increase the number of components. LC filters have the benefit to get much better noise reduction effect and avoid affecting to signal integrity.

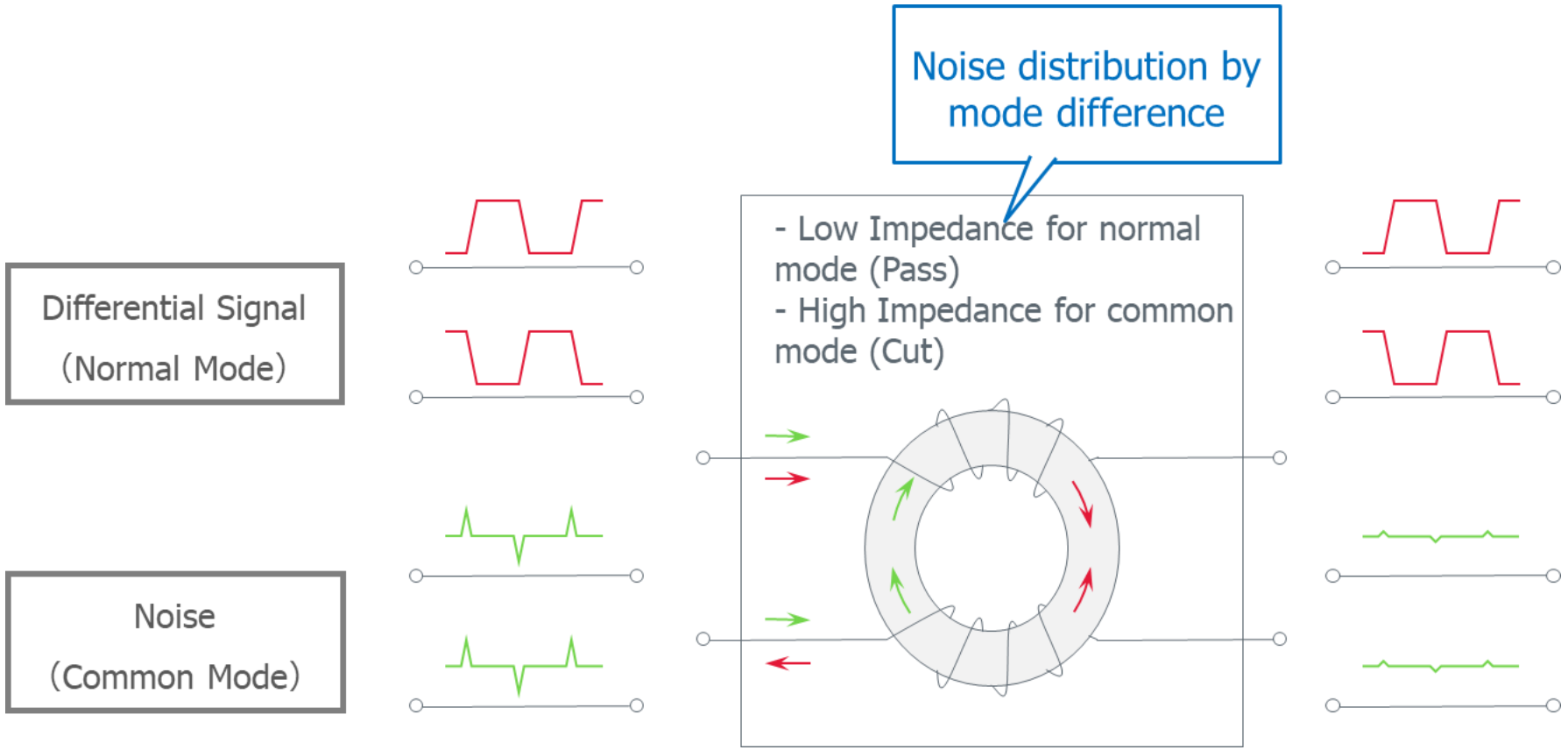
For Noise Path – Filter (Frequency)





Parasitics are dominant at the frequency range for both Inductors and Capacitors. It is important to select small parasitic products.

For Noise Path – Filter (Mode)

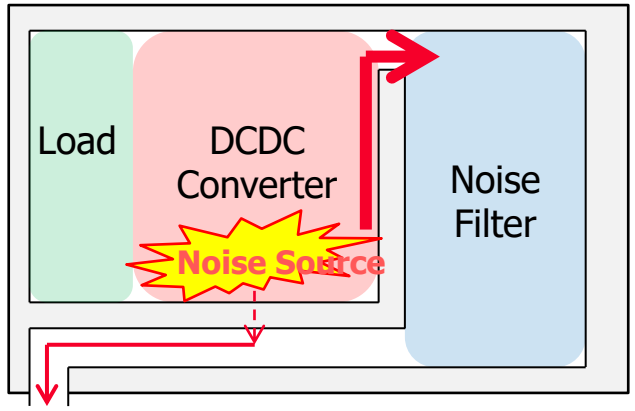


Common mode choke coil is good solution for differential signal, it could cut only noise without signal integrity degradation.

CMCC LAY OUT

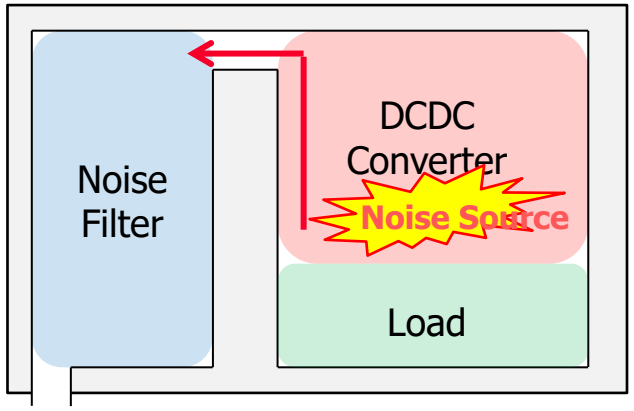
Example 1

Bad



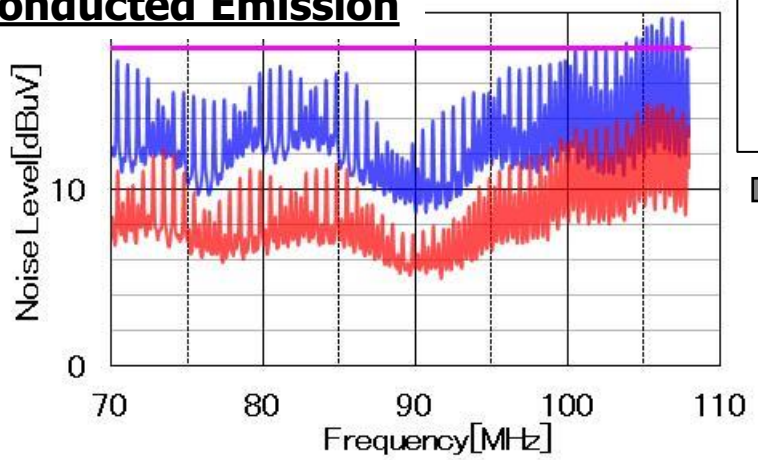
× There is the path of conducted noise to the cable
⇒ Bad Filter Effect

Good



○ Noise should go through noise filter
⇒ Good Filter Effect

Conducted Emission

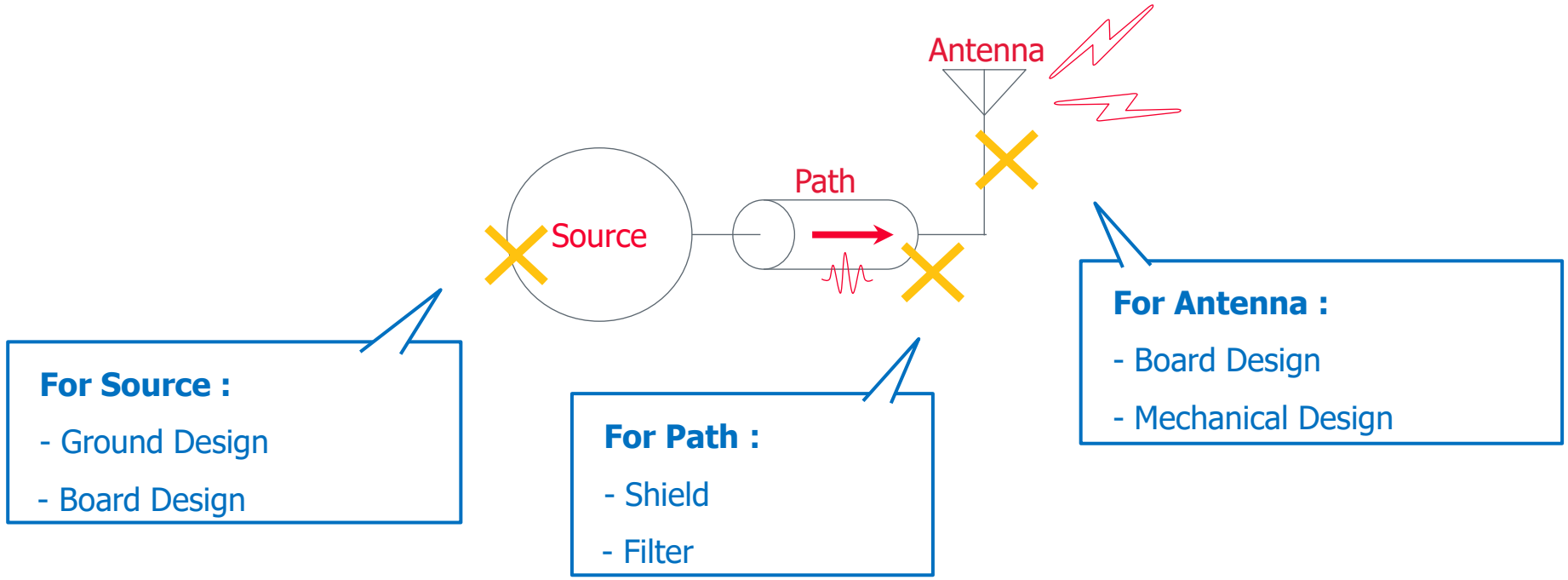


— : Bad Layout
— : Good Layout
— : CISPR25 class5

Over 6dB improvement at FM frequency range based on the board layout optimization.

Point!
Noise filter should be close to cable connectors

Countermeasure Summary



Countermeasure method for radiated emission could be utilized for other noise phenomenon. There are 3 main factors as “Noise Source”, “Noise Path” and “Noise Antenna”.

4. Noise Example

Buck Converter EVM Evaluation

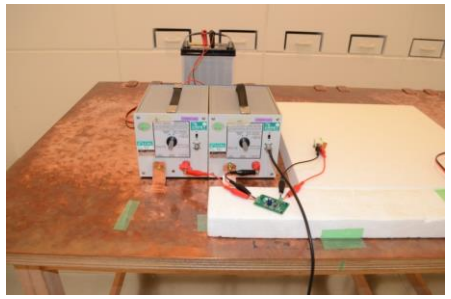
EVM

EVM in the market

: Buck 12V to 5V

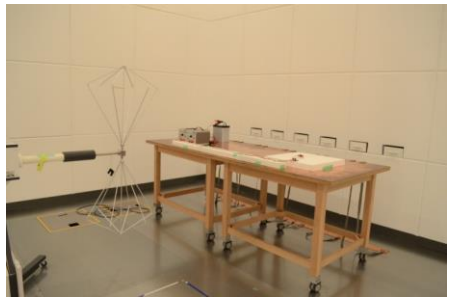
: f_{sw} = 2MHz

Measurement Condition



CISPR25

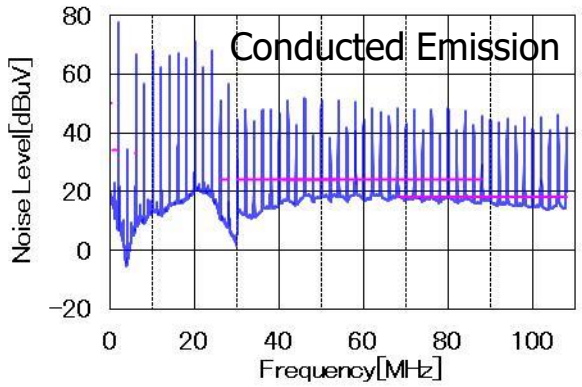
: Conducted Emission (Volt.)

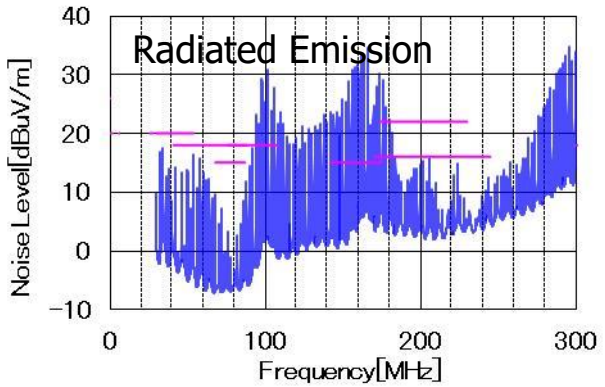


CISPR25

: Radiated Emission

Measurement Result



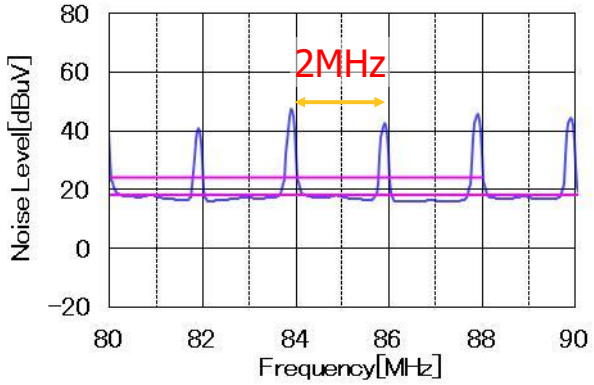


— : Initial
— : Floor Noise
— : CISPR25 class1

➡ CISPR25 class5 NG

Buck Converter EVM Evaluation

Noise Source Analysis

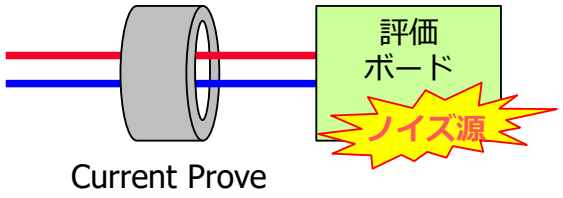


Emission Noise Frequency Range (2MHz)

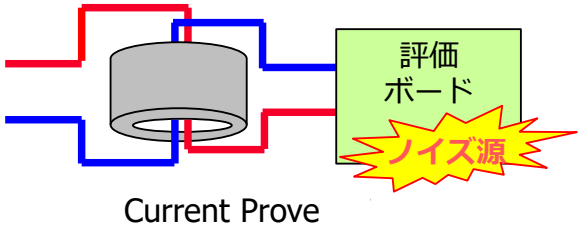
➡ Switching Frequency for Buck Converter

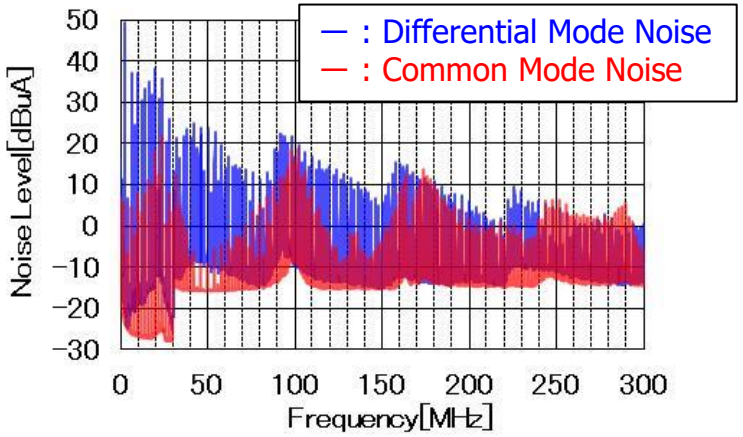
Noise Mode Analysis

Common Mode Measurement



Differential Mode Measurement

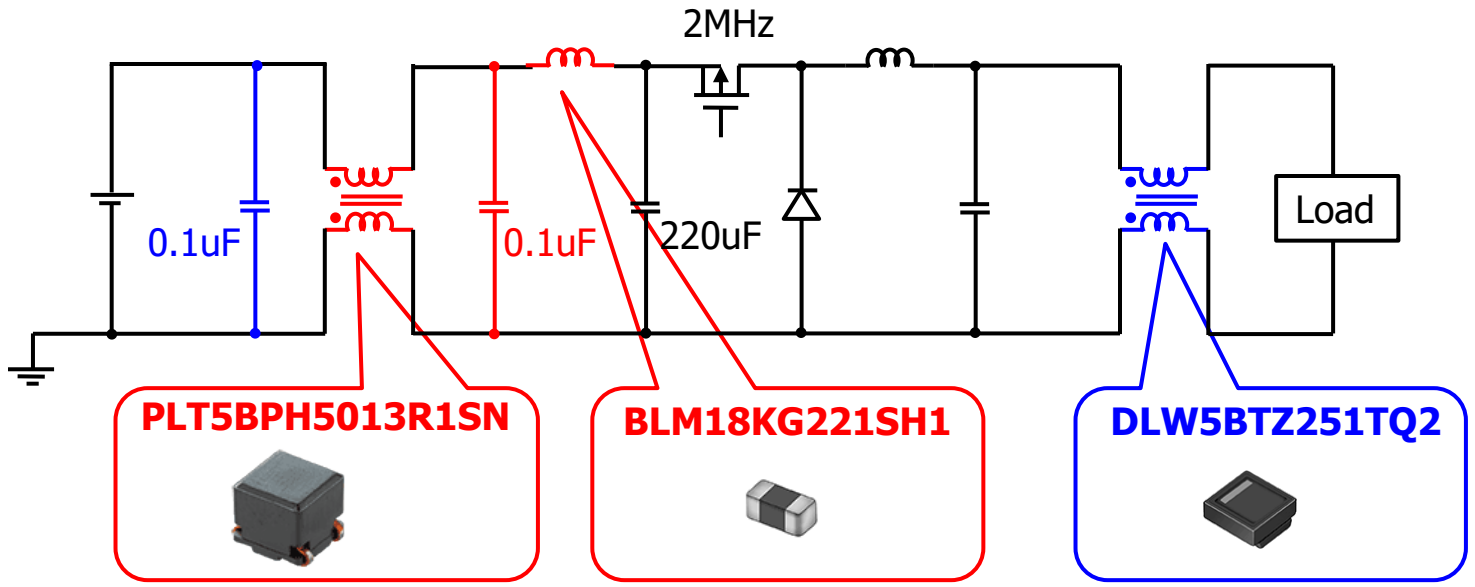




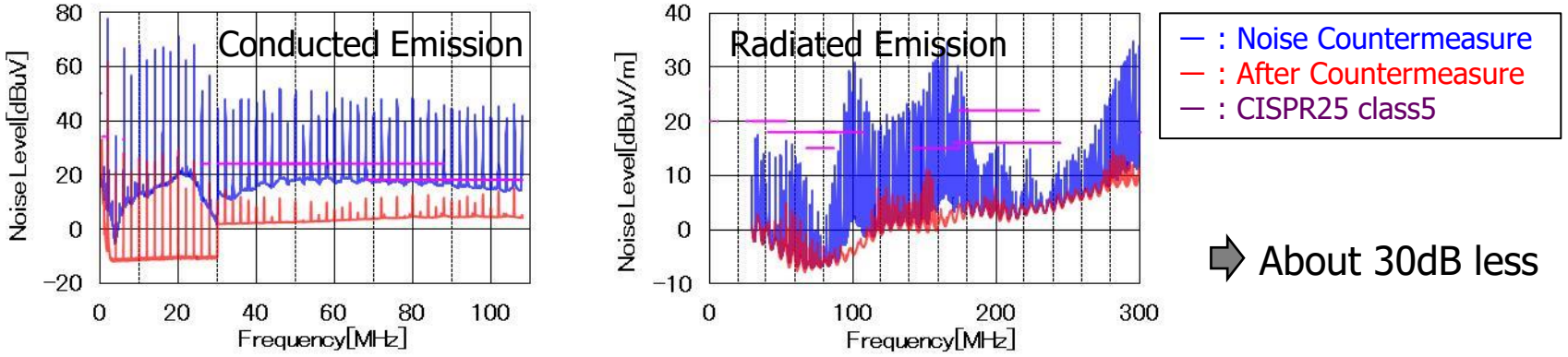
➡ Differential mode noise was dominant for Low Freq.
Both Common and Differential mode noise were existed for High Freq. range

Buck Converter EVM Evaluation

Noise Countermeasure

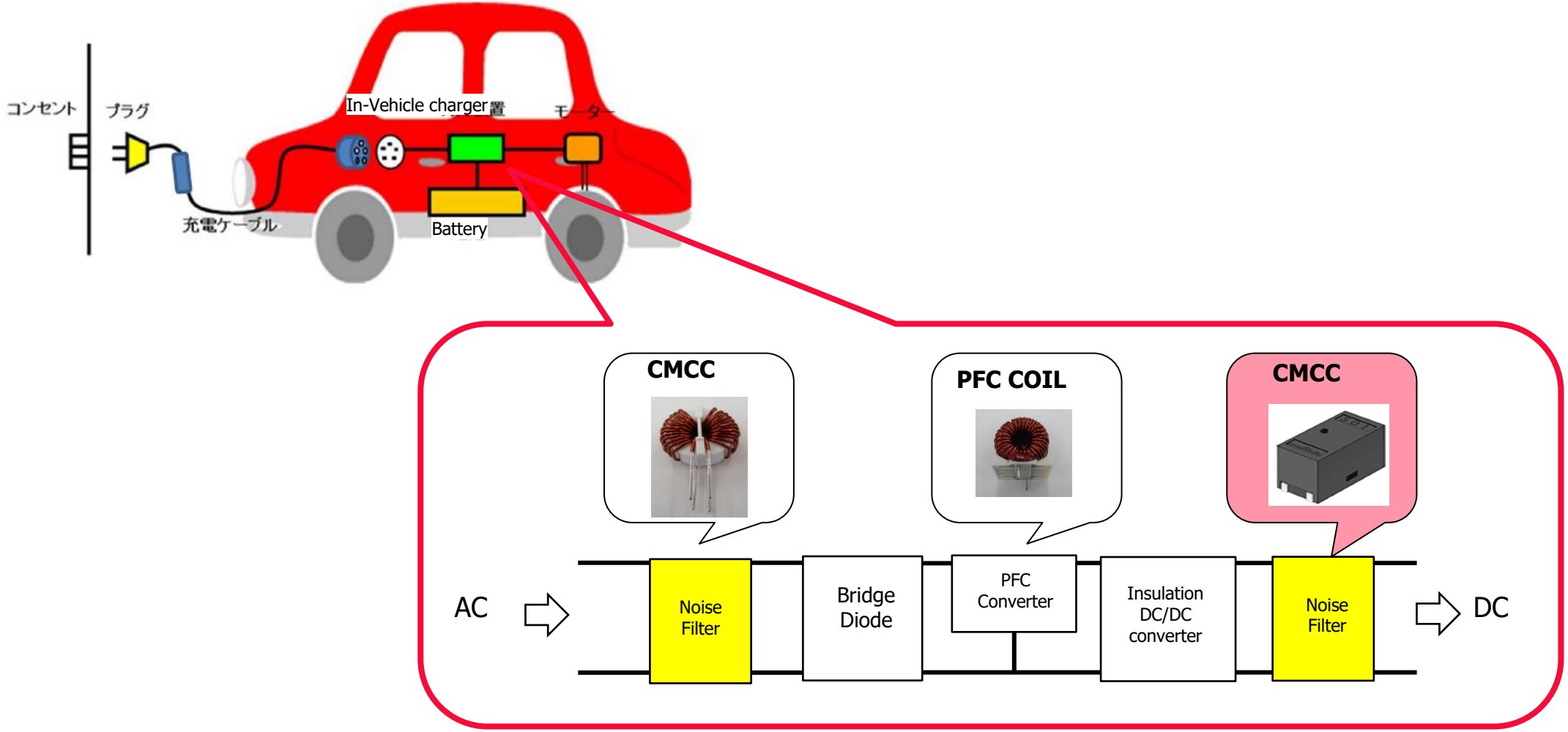


Noise Countermeasure Effect



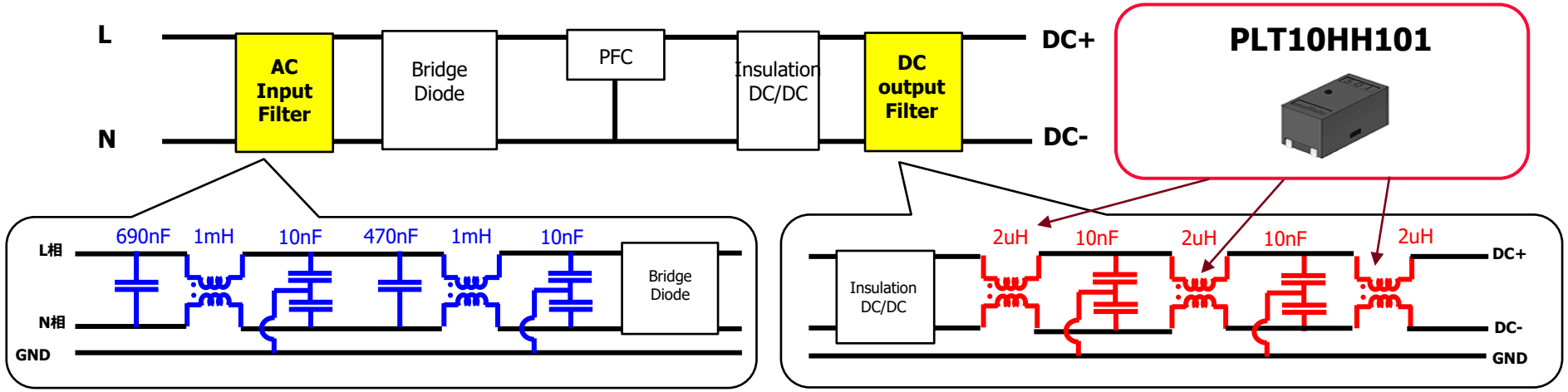
About 30dB less

OBC(On Board Charger)

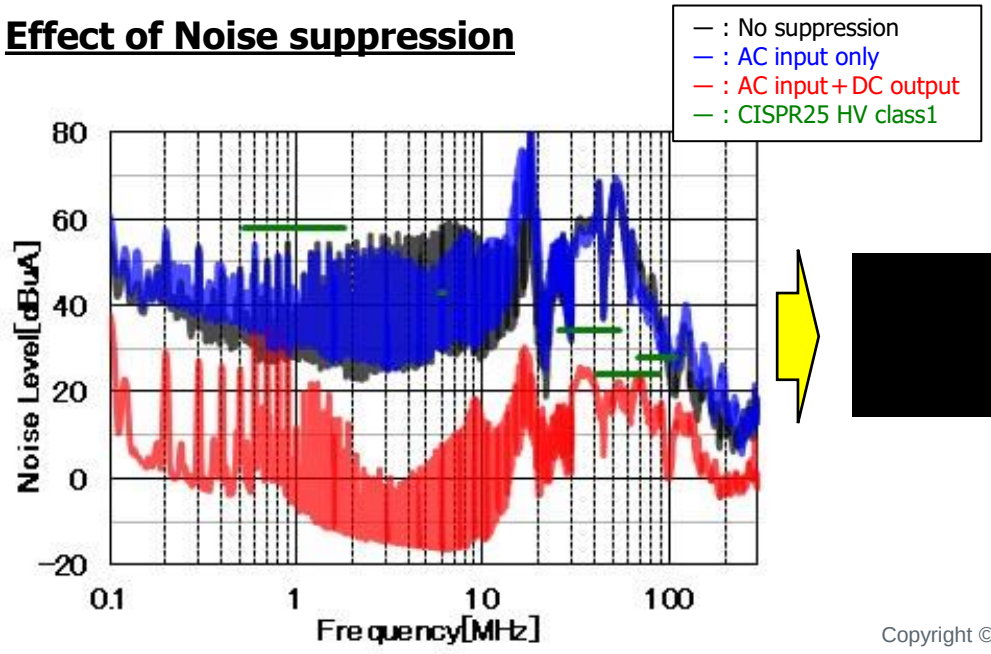


OBC(On Board Charger)

Noise Suppresion - Conducted emission for DC output -



Effect of Noise suppression



Reduction of about 51dB !

CISPR25 HV class1 OK!

Confidential

5. Murata Product Recommendation & Summary

Overall – Noise filter

Capacitor Type

GRM/GCM Series

Multilayer type

NFM series

Low ESL

Ferrite Beads

BLM series

Low cost, Compact

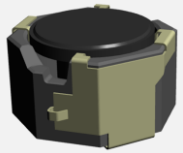
LC filters

NFL/NFE

High current
High attenuating

Inductor Type

MDH series



Wire wound type
High Reliability

DFE series

Metal Composite
High Performance

LQH series

Wire wound type

LQM series

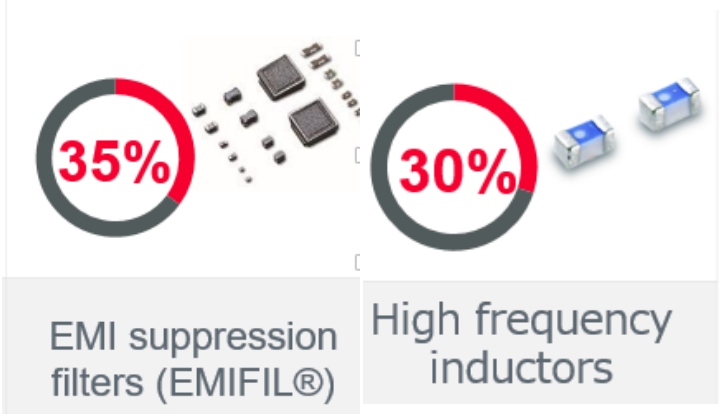
Multilayer type

Common mode choke coils

DLW/PLT series

Excellent attenuation
for signals and power

For better business partner



Continuous Improvement
-Failure analysis
-8D report

New Products Development
- High Electrical performance / Rating
- Down sizing
- Price Competitiveness
- Enough Reliability / Strength

Qualification support
- PPAP, Audit

Win - Win Relationship with Customers

Component information
- Free Samples
- Data like S-Para / SPICE / Leakage
- Tools on Website

Collaboration with Semiconductors
-Reference on Datasheet

Free Charge !

EMC consulting
- EMC improvement
- Receive Sensitivity improvement
- VA proposal
- Technical Delegation / Seminar

Circuit design information
- Recommended EMC components
- Signal integrity
- Efficiency / Ripple on DC/DC conv.

Collaboration

NDA

Thank you

감사합니다.