POSTER #17

SWTest Asia Conference
Poster Presentation Guide & Template

Wai Kit K
Development & Design Division
Lincstech Co., Ltd.

Understanding the Factors for Power supply characteristics

• Introduction

- Semiconductor devices has been advancing towards low power and high frequency in recent years. Hence the stability of power supply characteristics for PWB(Printed Wiring Board) used to test these devices becomes more important.
- In this presentation, we study the PWB as a part of the PDN(Power Distribution Network) and experimentally determine the factors that improves the impedance of the power plane. The factors experimented is as stated below :-

❖ **Layer Structure**
- ➢ PWB Laminate Material Type
- ➢ Copper Foil Thickness
- ➢ Insulation Layer Thickness

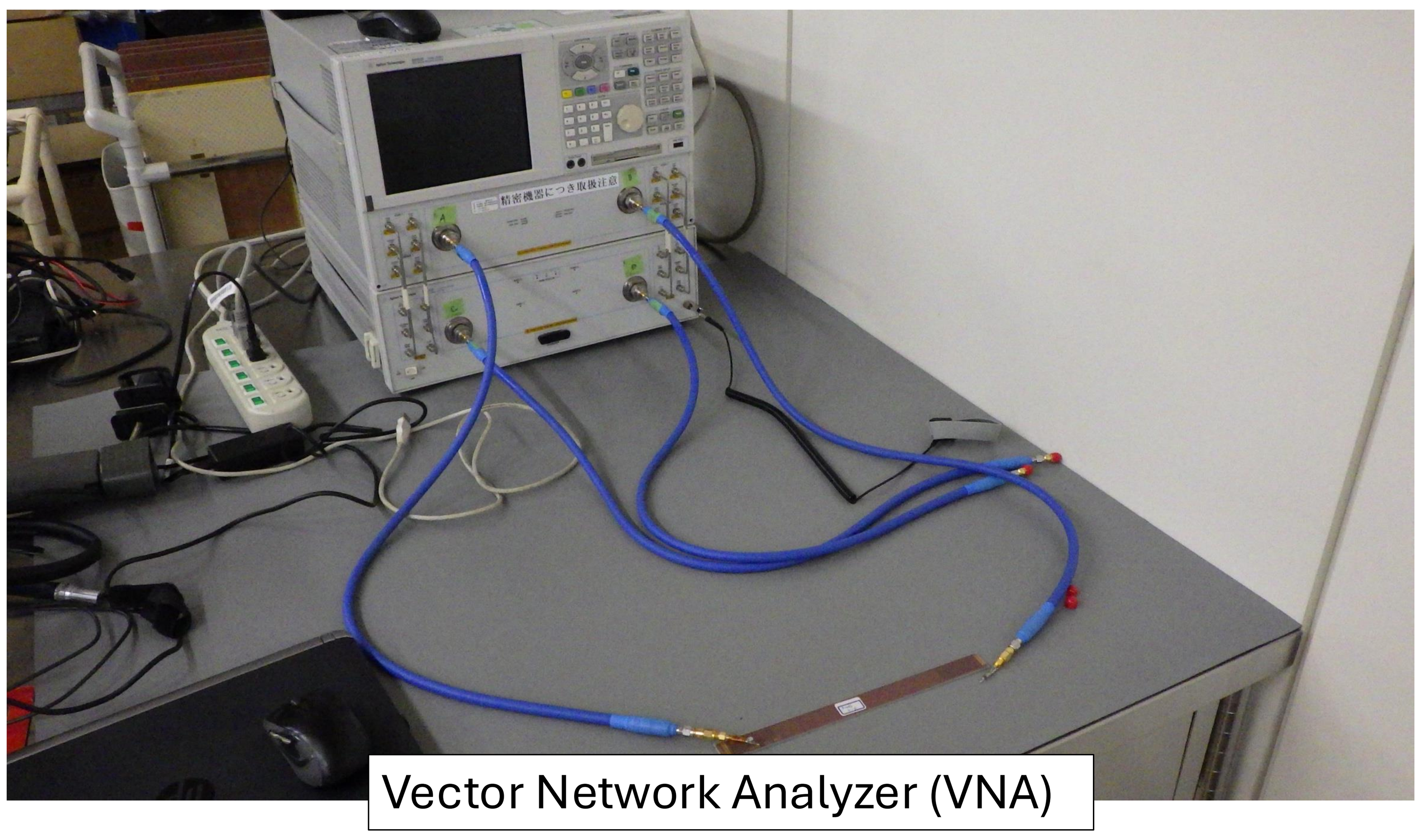
❖ **Power and Ground layer Assignment**
- ➢ Power with close reference to ground.
- ➢ Power with a far reference to ground

❖ **Power Plane Pattern**
- ➢ Power Plane width
- ➢ Power Plane length
- ➢ With & Without Anti-Pad

- The objective of this presentation is to provide adequate advice when designing PWB used for semiconductor testing.

Materials and Methods

- We made PWB with different layer structures, insulation materials, patterns and compared their power characteristic by using Vector Network Analyzer (VNA) measurement.



Vector Network Analyzer (VNA)

Manufacturer : Keysight
Model : E8363B , N4420B
Measurement Range : 10MHz to 1GHz
Measured characteristic : S11

- From the data measured, the PWB power impedance was calculated using "Open-Short Method" in which the equation is stated as below.

$$Z_{open} = \frac{1 + S_{11\,open}}{1 - S_{11\,open}} Z_{Line}$$

Impedance Equation for open condition

$$Z_{short} = \frac{1 + S_{11short}}{1 - S_{11short}} Z_{Line}$$

Impedance Equation for shorted condition

$$|Z| = \sqrt{|Zopen| \times |Zshort|}$$

Impedance Equation

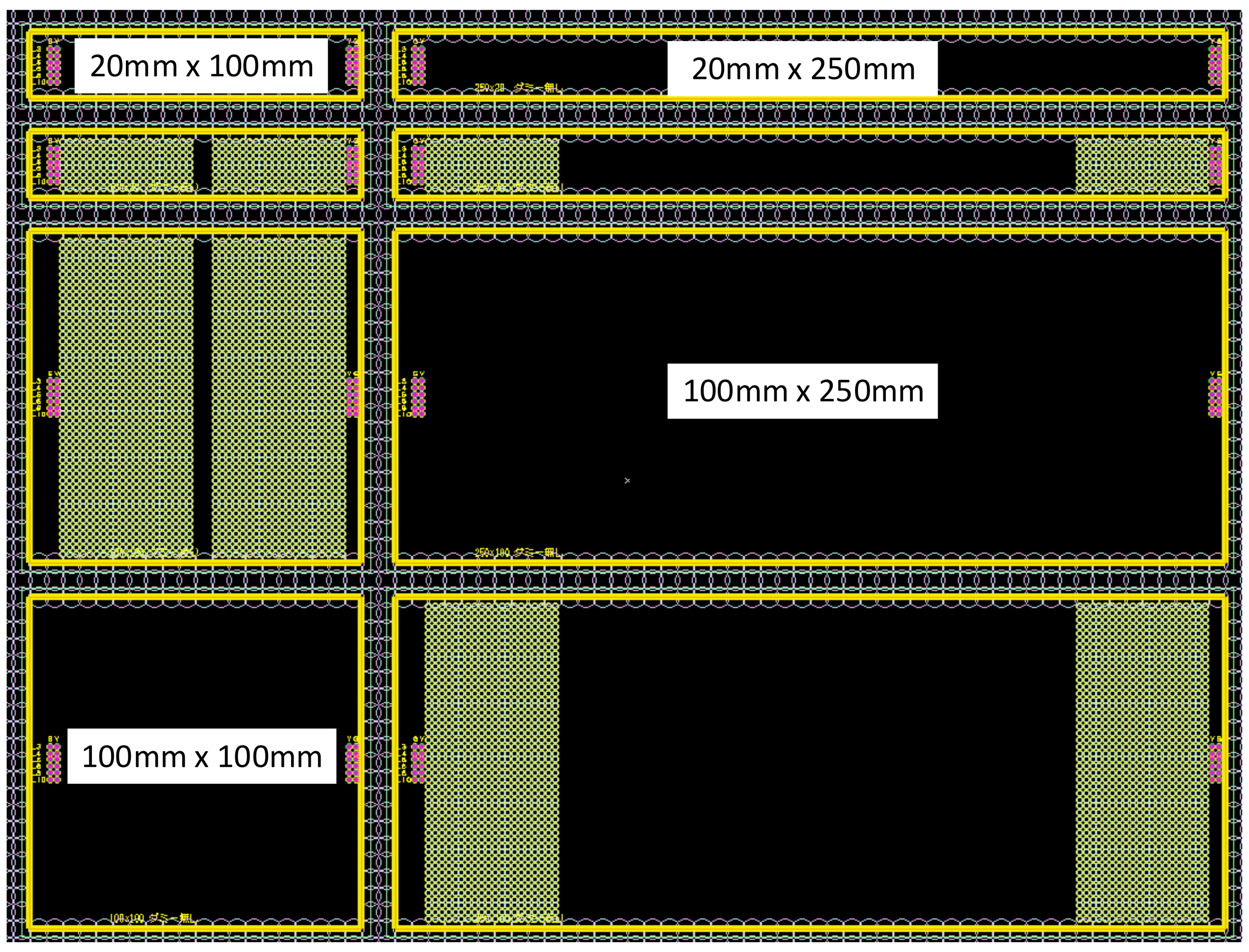
- PWB specification used in this study is shown as below.

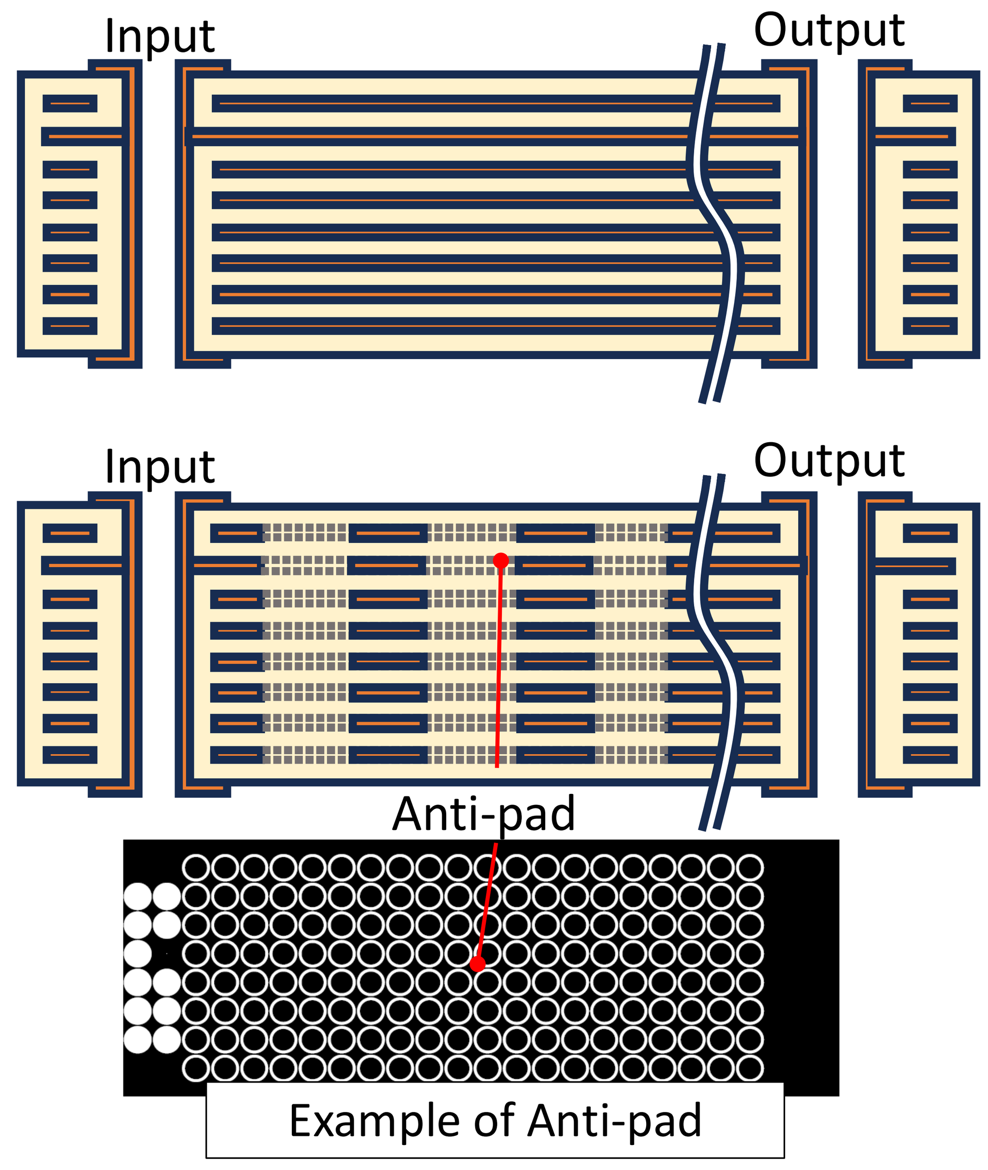
	Product 1 (PN1)	Product 2(PN2)	Product 3(PN3)	Product 4 (PN4)	Product 5(PN5)	Product 6(PN6)
Insulation Thickness	60µm	60µm	100µm	100µm	60µm	100µm
Insulation Material	Mat A : Low loss (Dk : 3.6)	Mat A : Low loss (Dk : 3.6)	Mat A : Low loss (Dk : 3.6)	Mat A : Low loss (Dk : 3.6)	Mat B : High Tg FR4 (Dk : 4.2)	Mat B : High Tg FR4 (Dk : 4.2)
Copper Foil Thickness	18µm	70µm	18µm	70µm	18µm	18µm

Coupon W x L
① 20mm x 100mm
② 20mm x 250mm
③ 100mm x 100mm
④ 100mm x 250mm

a : With Anti-pad
b : Without Anti-pad

Power Plane patterns used in this experiment





Power Plane W x L

1) **20mm x 100mm (Narrow & Short)**
2) **20mm x 250mm (Narrow & Long)**
3) **100mm x 100mm (Wide & Short)**
4) **100mm x 250mm (Wide & Long)**

These 4 types of power plane are further divided by

a. With Anti-pad

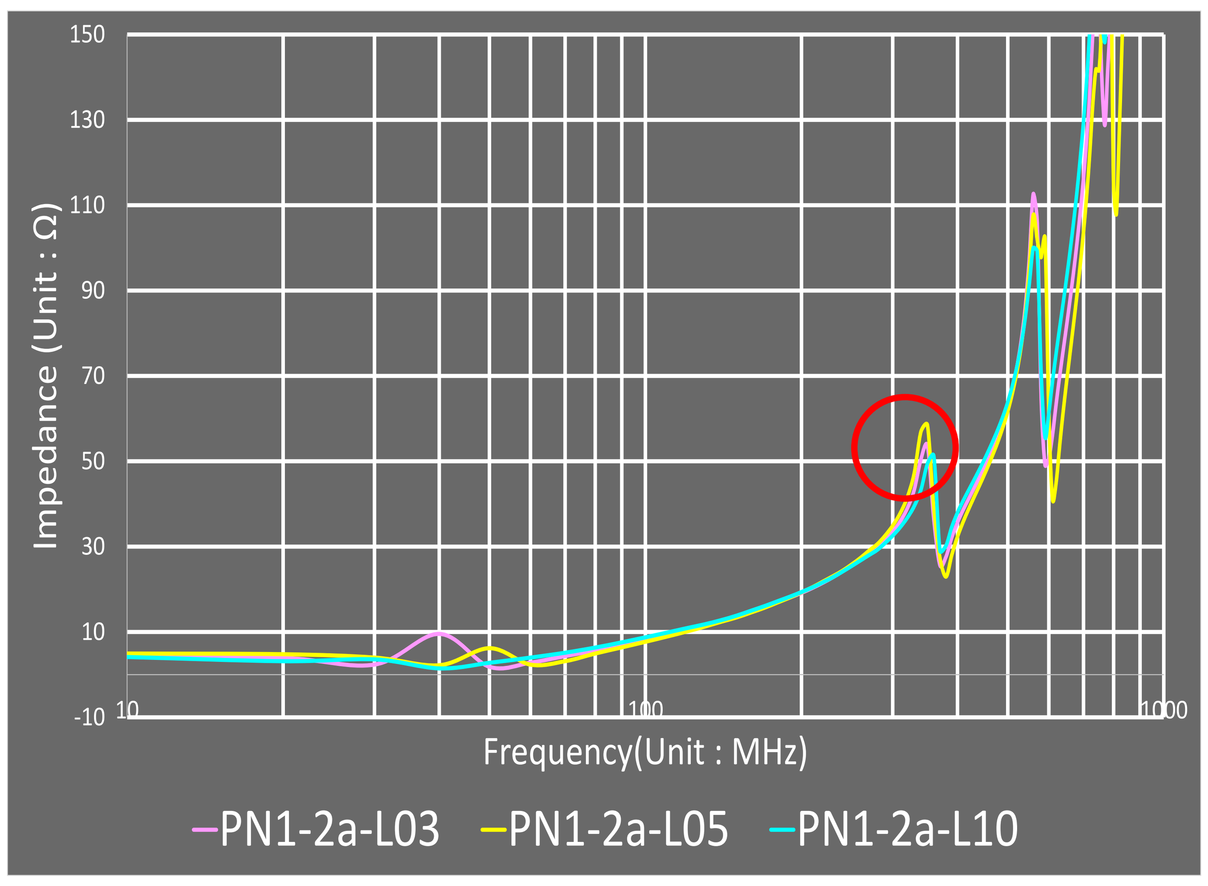
b. Without Anti-pad

Stackup used and their corresponding thickness

Layer	Name	Product 1 (PN1)(μm)		Product 2 (PN2)(μm)		Product 3 (PN3)(μm)		Product 4 (PN4)(μm)		Product 5 (PN5)(μm)		Product 6 (PN6)(μm)	
		Material Thickness	Copper Foil	Material Thickness	Copper Foil	Material Thickness	Copper Foil	Material Thickness	Copper Foil	Material Thickness	Copper Foil	Material Thickness	Copper Foil
L01	TOP		56		56		56		56		56		56
		76		98		103		98		70		119	
L02	GND		15		65		15		65		15		15
		65		65		100		100		70		101	
L03	VCC1		15		65		15		65		15		15
		74		91		101		91		68		89	
L04	VCC2		15		65		15		65		15		15
		65		65		100		100		70		101	
L05	VCC3		15		65		15		65		15		15
		74		91		101		91		68		89	
L06	VCC4		15		65		15		65		15		15
		65		65		100		100		70		101	
L07	GND		15		65		15		65		15		15
		74		91		101		91		68		89	
L08	VCC5		15		65		15		65		15		15
		65		65		100		100		70		101	
L09	GND		15		65		15		65		15		15
		74		91		101		91		68		89	
L10	VCC6		15		65		15		65		15		15
		65		65		100		100		70		101	
L11	GND		15		65		15		65		15		15
		76		98		103		98		70		119	
L12	BOTTOM		56		56		56		56		56		56
	Total Thickness		1034		1646		1371		1821		1023		1362
	Specification	1100 +/-	300	1600+/-	300	1300+/-	300	1800+/-	300	1000+/-	300	1300+/-	300

- **To the left is the stackup used in this experiment, along with the thickness used for each layer**
- **The 3 layers that are compared are :**
  - L03 VCC1 (Close ground reference, one side)
  - L05 VCC3 (Far ground reference)
  - L10 VCC6 (Close ground reference, both sides)

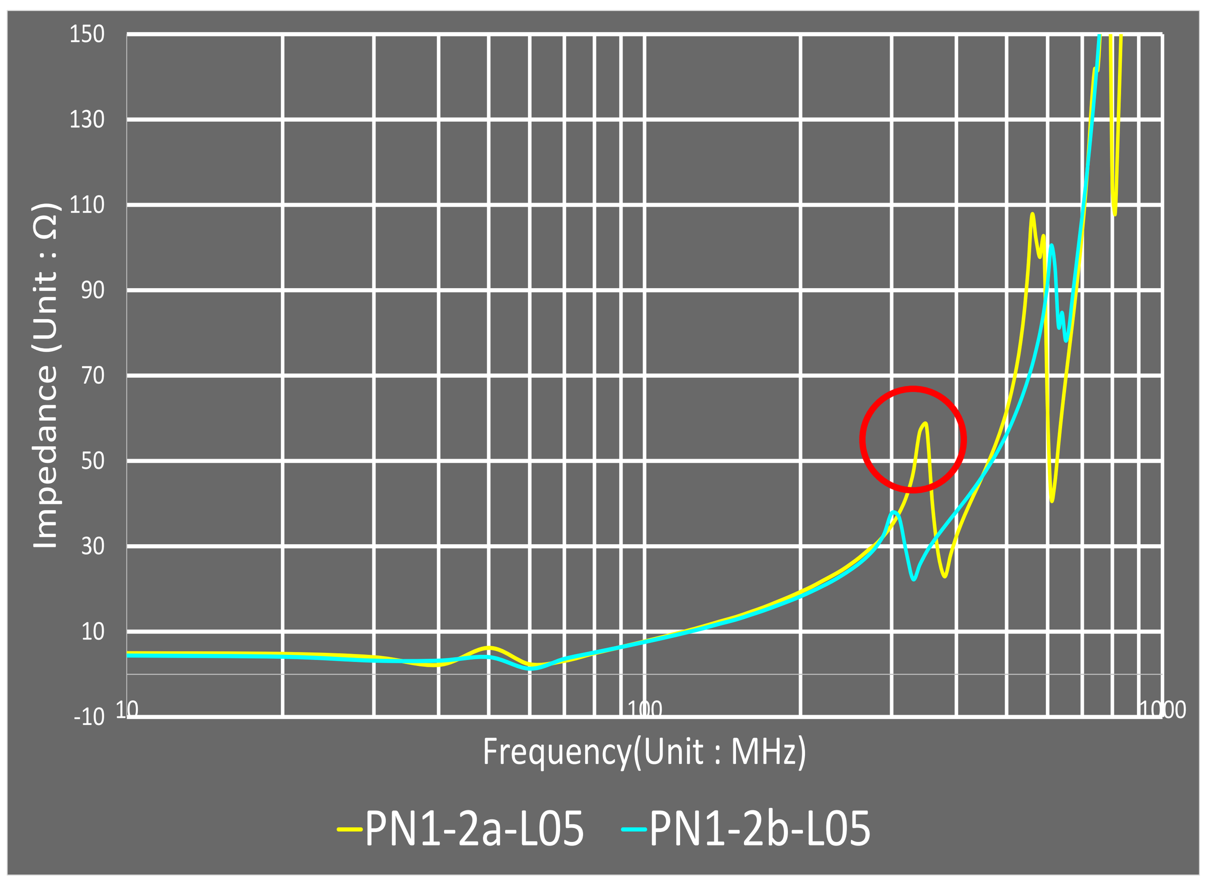
- **Results (Layer assignment and Pattern factors)**
  - To study each factor's effect, we focused the comparison on anti-resonance amplitude and frequency.



Reference to GND

L05 (Far) shows higher anti-resonance when compared to L03 (Close/1 side GND) and/or L10 (Close/both side GND)

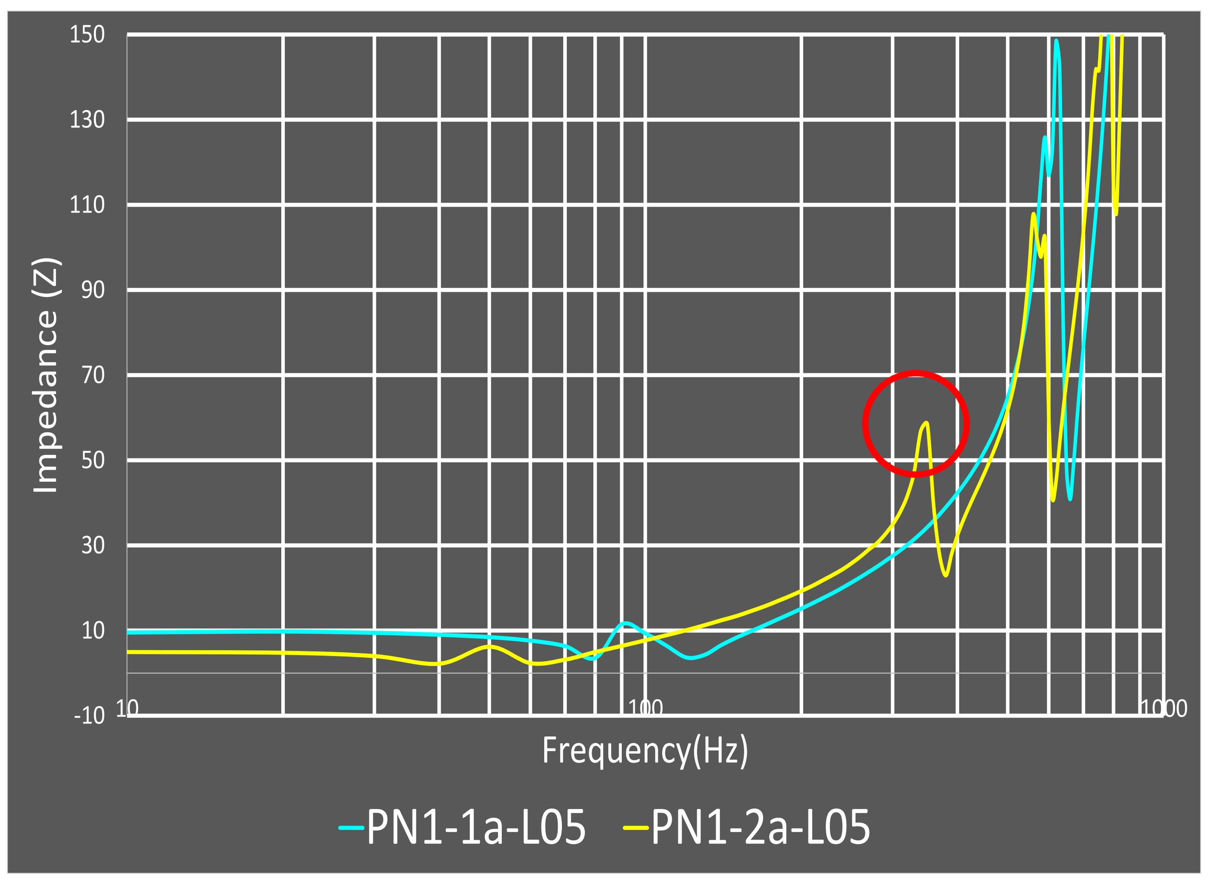
[Closer reference to ground : Better]



Anti-pad

2a (With anti-pad) shows higher anti-resonance when compared to 2b (Without anti-pad)

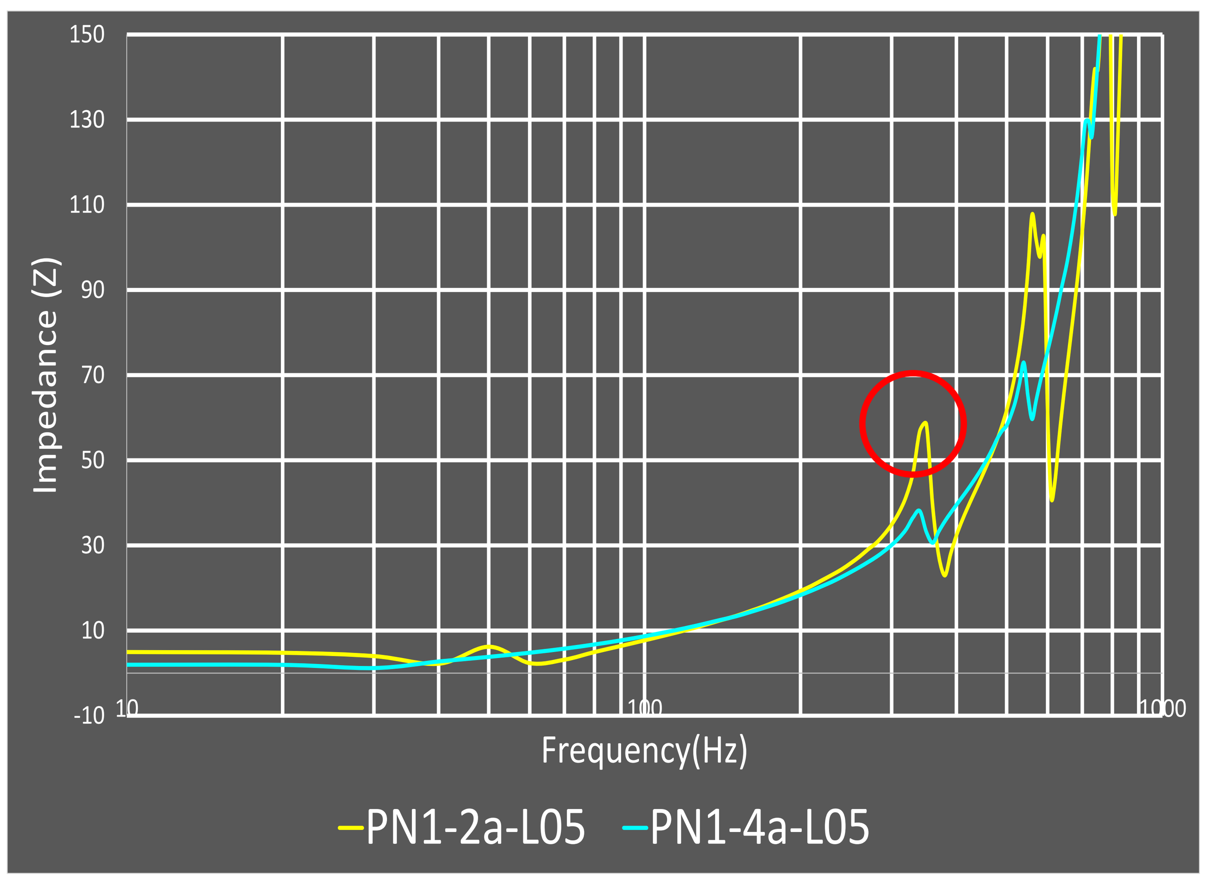
[Without Anti-pad : Better]



Power Plane (Length)

2a (20mmx250mm) shows higher impedance when compared to 1a (20mmx100mm)

[Short : Better]



Power Plane (Width)

2a (20mmx250mm) shows higher impedance when compared to 4a (100mmx250mm)

[Wide : Better]

- From the data obtained, it is seen that power plane that is long and narrow with anti-pad and a far reference to ground layer (2a-L05) yields the worst result.
- From here on out, 2a of L05 will be used for comparison of the layer structure as it is easier to compare.

- **Results (Layer structure factors – Laminate type, Insulation Layer Thickness, Copper thickness)**

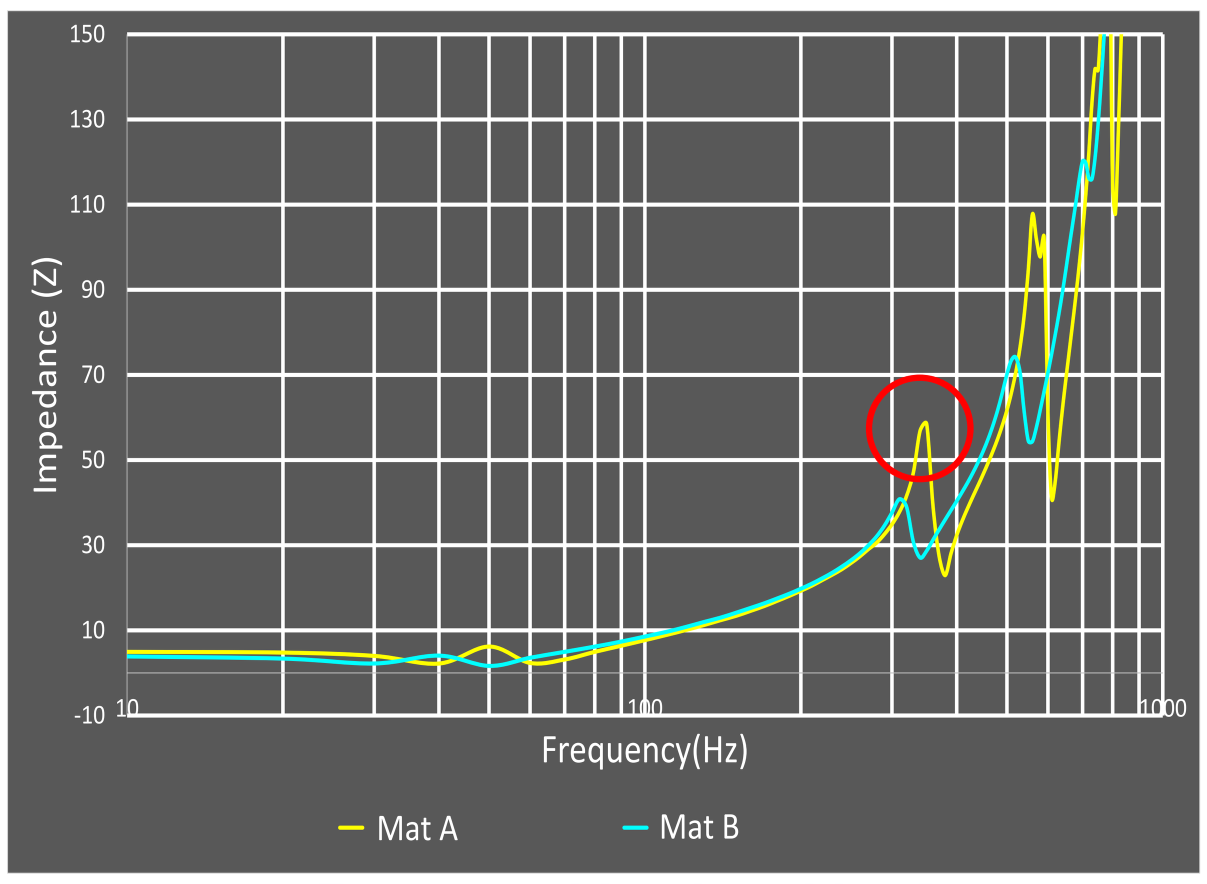


Figure 1 : Mat A vs Mat B (Insulation Layer Thickness 60µm)

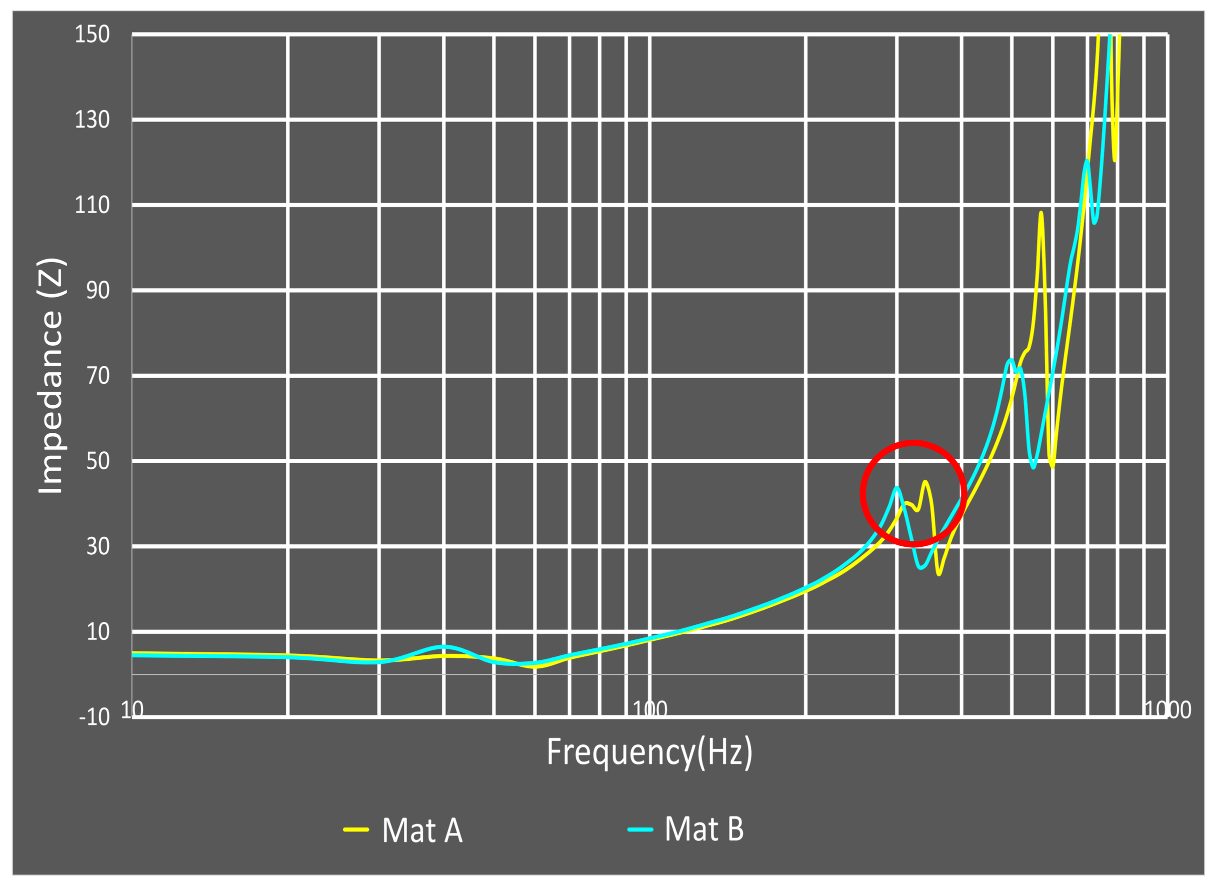


Figure 2: Mat A vs Mat B (Insulation Layer Thickness 100µm)

Laminate type factor

From the graph, low Dk Material (Material A) has a higher impedance when compared to Material B.

[High Dk : Better]

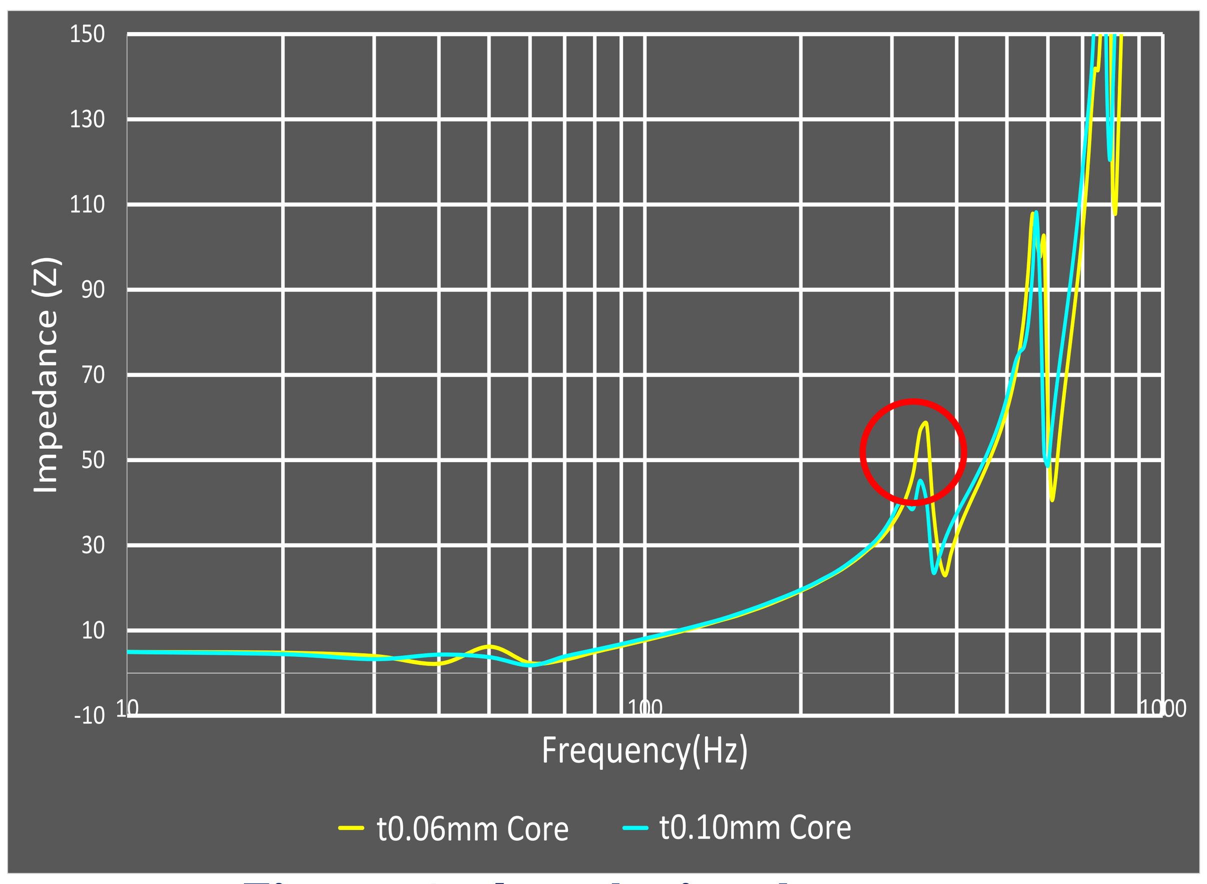


Figure 3 : Insulation Layer Thickness(Mat A)

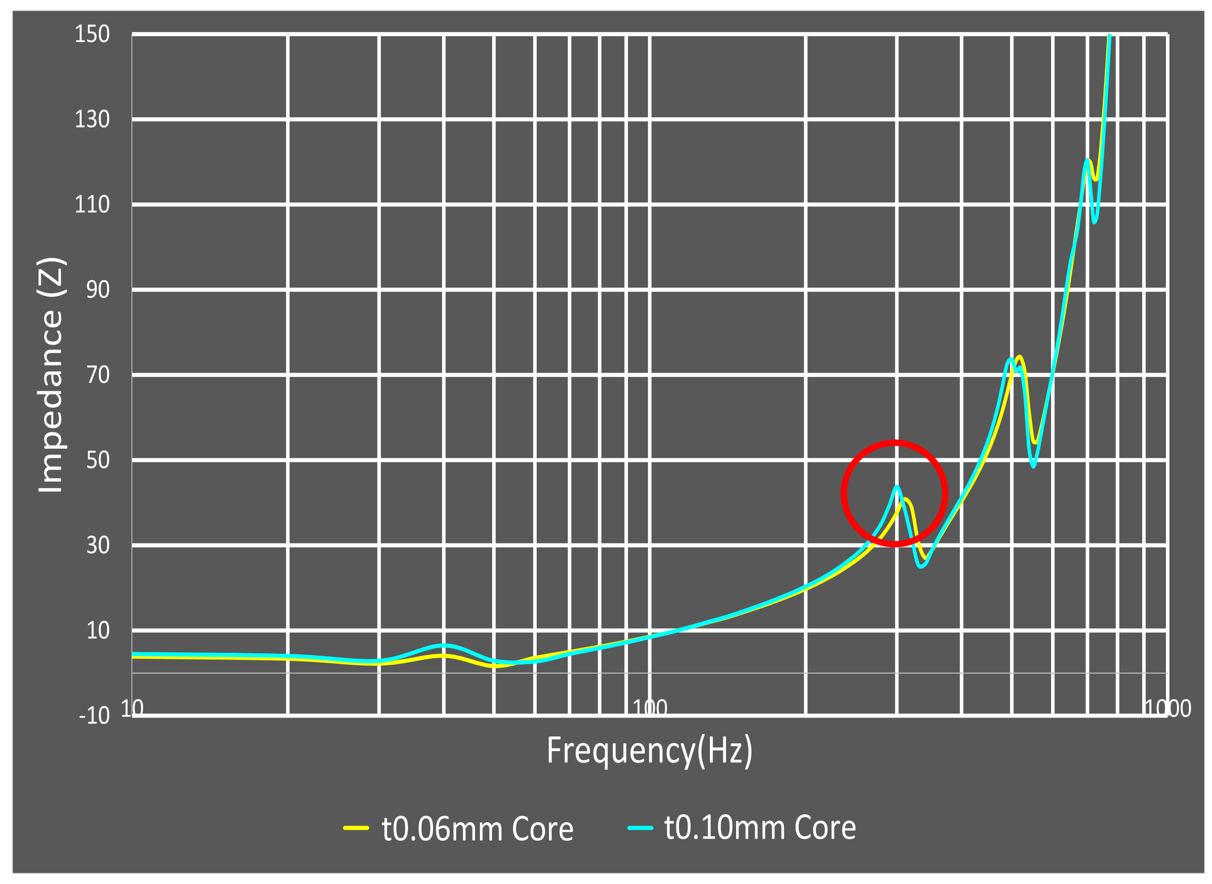


Figure 4 : Insulation Layer Thickness(Mat B)

Insulation Layer Thickness

60µm insulation layer shows higher anti-resonance in Material A while 60µm Insulation layer shows slightly better performance in Material B. Theoretically thinner insulation layer has higher capacitance and performs better; however, we suspect Material A result was affected by Dk difference ; Actual Dk is 3.65 for 60µm insulation layer and 3.71 for 100µm insulation layer in Material A.

[No clear trend]

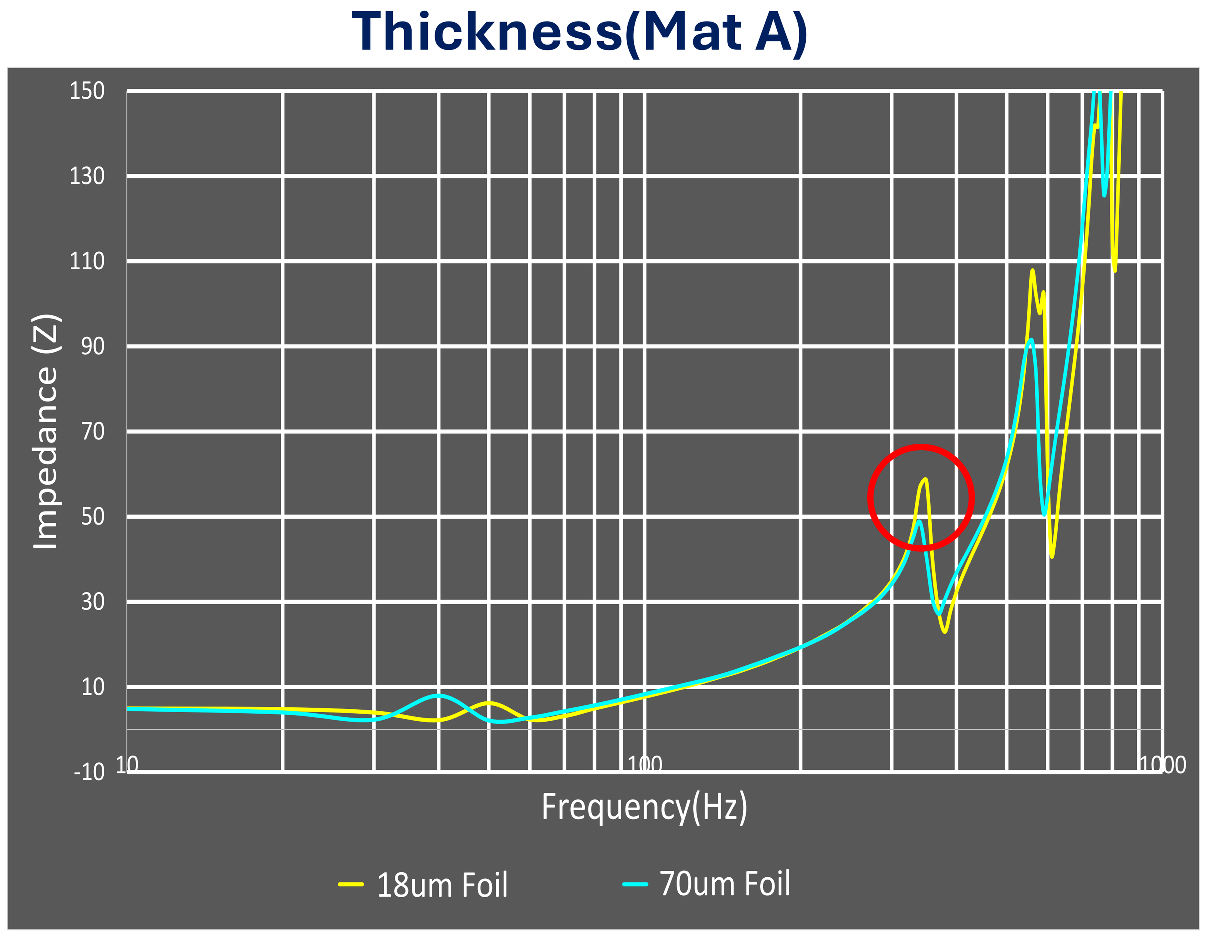


Figure 5 : Copper foil thickness (Insulation Layer Thickness 60µm)

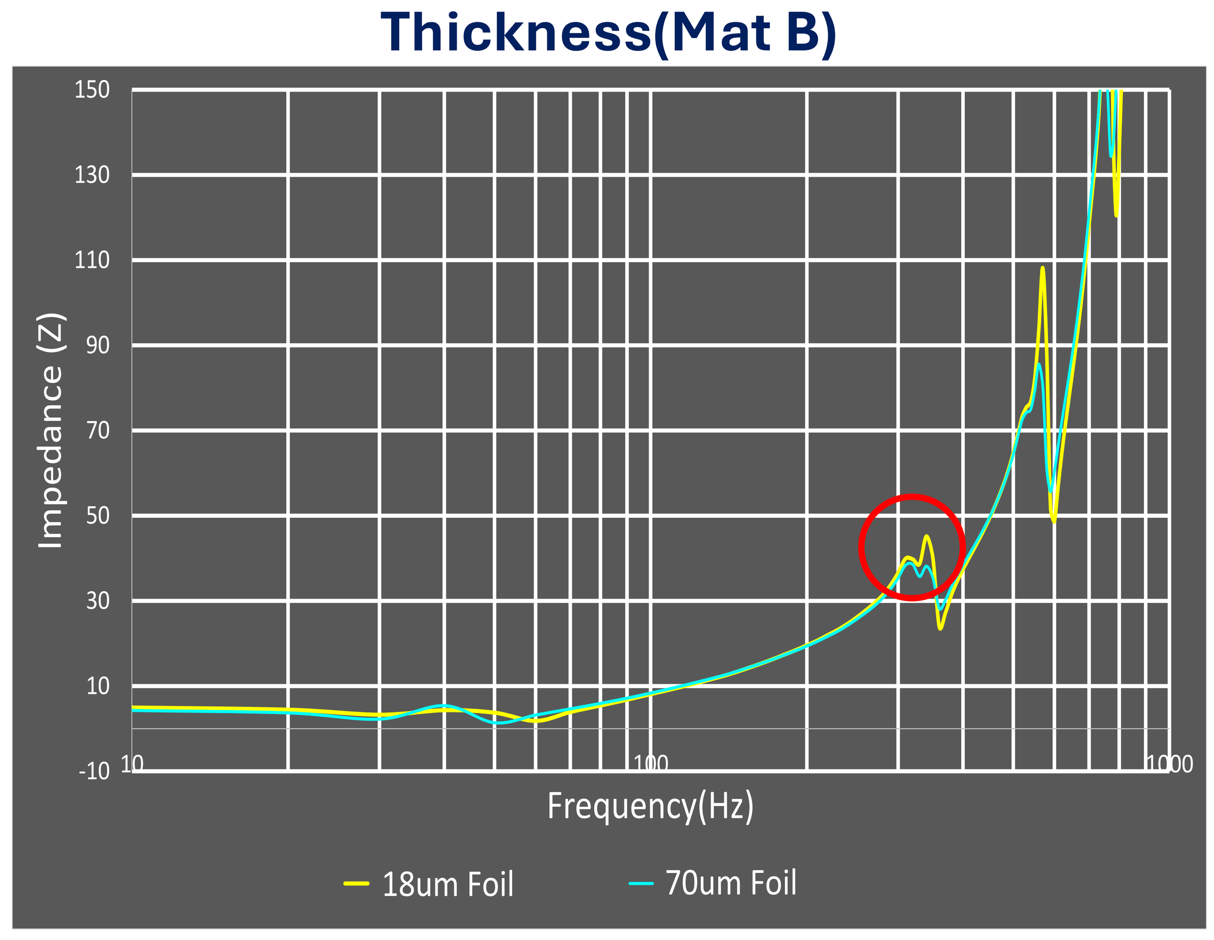


Figure 6 : Copper foil thickness (Insulation Layer Thickness 100µm)

Copper Foil Thickness

Thinner copper foil (18µm) shows higher anti-resonance when compared to thicker copper foil (70µm).

[Thick copper : Better]

Conclusion

Experimental results shows the stability of power characteristics increases under the following conditions:

- Designs : Close allocation of Power and Ground, wide & short pattern, without Anti-pad
- Materials : High Dk insulation Material, Thick Copper Foil

Close power and ground design restricts signal layer assignment. Wide and short pattern requires more thickness. With the specified PWB thickness, power characteristics stabilization requires the reduction of signal layers, which is unrealistic.

As the solutions to this issue, we recommend :

1) Increasing the number of layers using thinner Insulation material (50µm or less)
2) Adopt Multi Wiring Board (MWB®)
3) Adopt high-density interconnect technologies such as board-to-board connection (BtoB)

Follow-up works

- To investigate the effects of the size of Anti-pad to Power Characteristics.
- To investigate the effects of Thinner Insulation Layer (50µm and below)

Questions ?

If you have any questions, please contact

K Wai Kit	Kato Masahiro	Yamaguchi Hiroyuki
Author	Co-Author	Co-Author
k.waikit.yf@lincstech.com	katoh.masahiro.ut@lincstech.com	yamaguchi.hiroyuki.pf@lincstech.com