

DIGITAL WE DAYS

2024



TUNING THE RF: LEARN ABOUT  
IMPEDANCE DYNAMICS

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WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

# AGENDA



## **Comparative Examination of PCB Transmission Line Structures**

- Straight line
- Right Angle line



## **Connector Transmission Line Structure Comparison**

- Straight Center Contact
- Right Angle Center Contact



## **Analysis of Impedance Variation in Connector Contacts to PCB**

- End Launch
- Through-Hole Technology
- Surface-Mount Technology (SMT/THR)

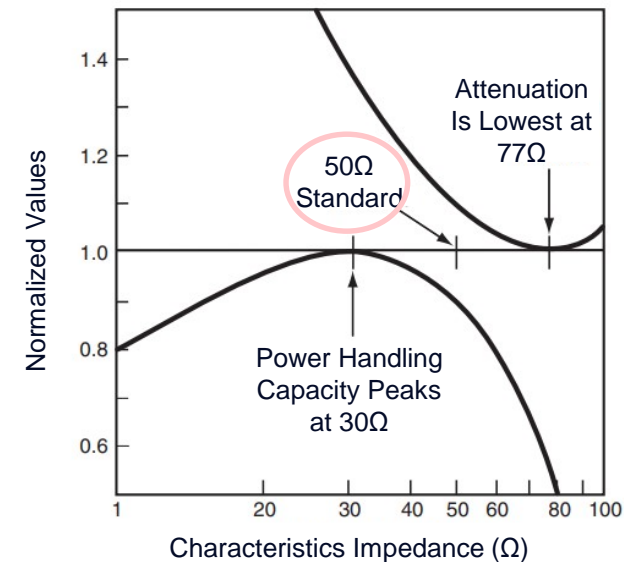
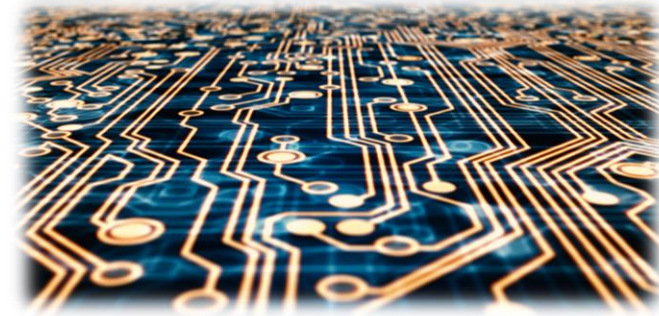


## **Optimizing Impedance and Tuning**

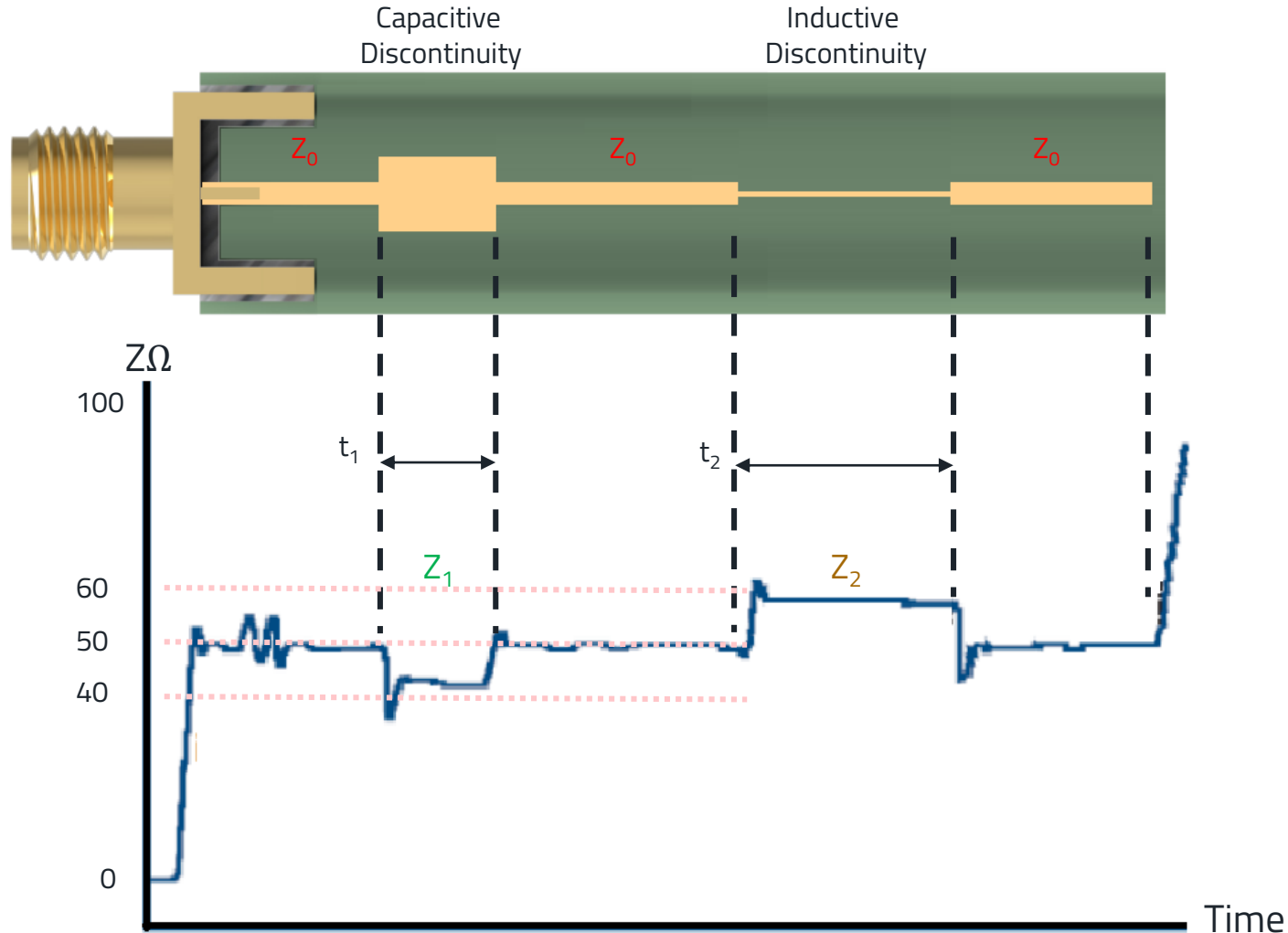
- Straight Center Contact
- Right Angle Center Contact

# WHY IMPEDANCE MATCHING MATTERS

- ✓ 1. Maximum power transfer
- ✓ 2. Minimization of signal reflections
- ✓ 3. Reduction of crosstalk
- ✓ 4. Minimization of energy loss



# GEOMETRY'S IMPACT ON IMPEDANCE CHANGES



$Z_0 \approx 50\Omega$  Standard

$Z_1 \approx 40\Omega$  Trace dimension increase

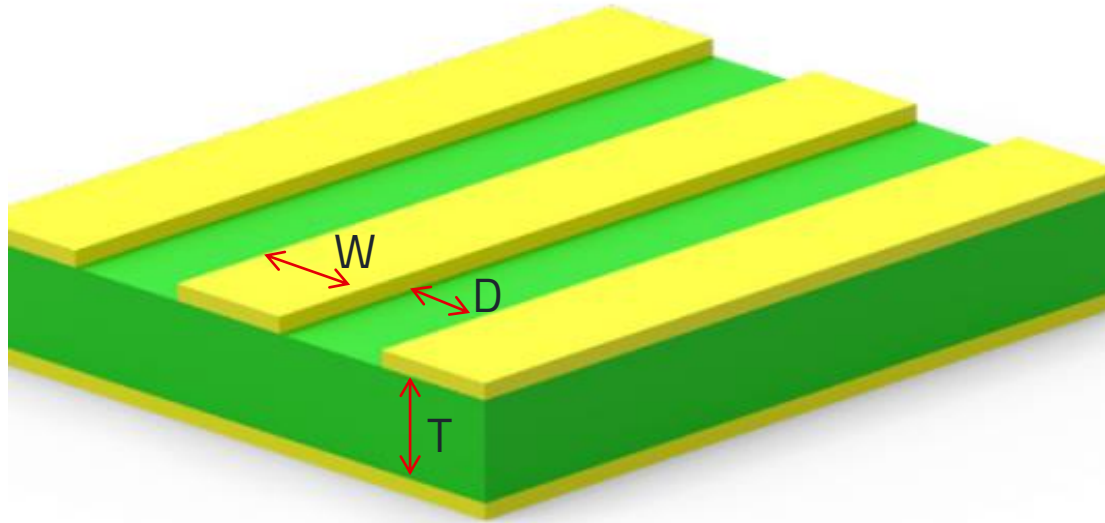
$Z_2 \approx 60\Omega$  Trace dimension decrease



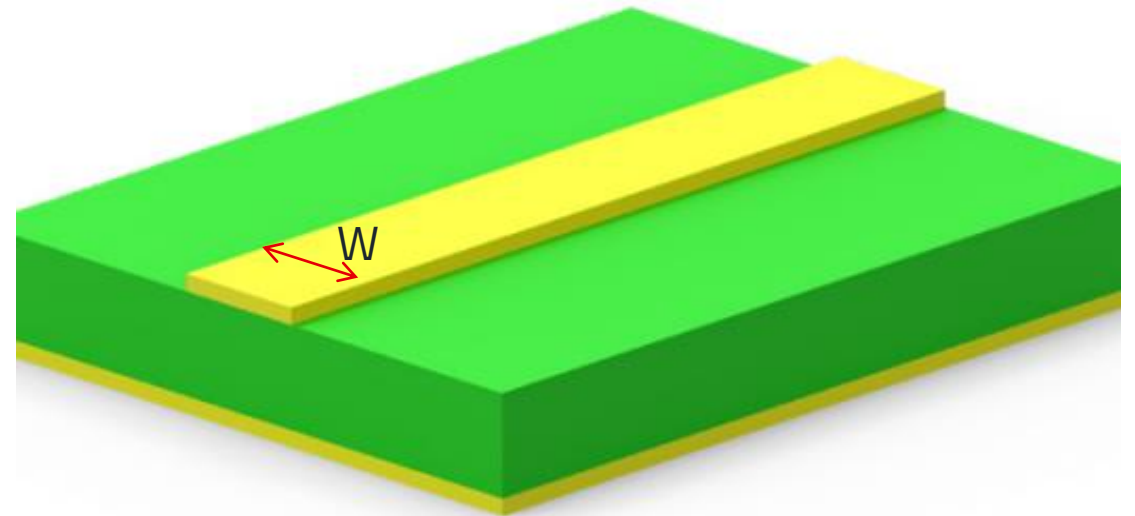
Trace dimension (Road) change

= Impedance Change

# TRANSMISSION LINE TYPES IN COMMON USAGE

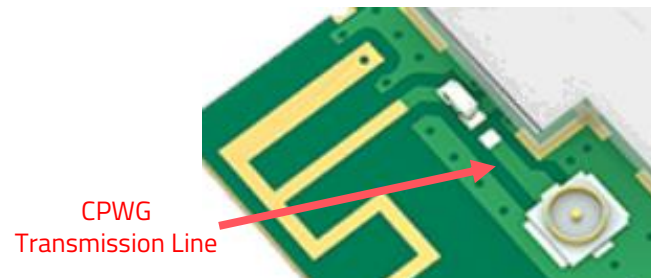


CPWG

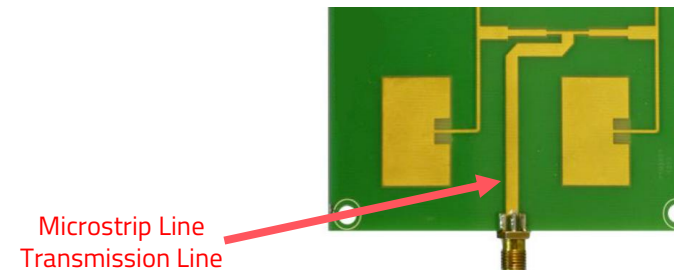


Microstrip Line

- Common usage in **connector** to signal source

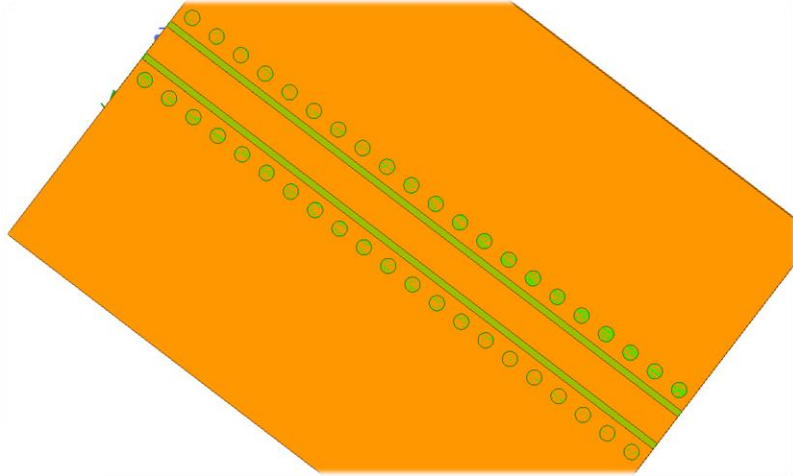


- Common usage in connector to **antenna** or test board

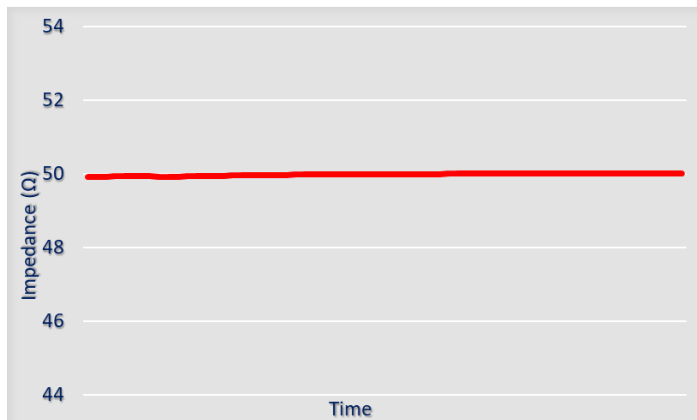


# COMPARATIVE EXAMINATION OF PCB TRANSMISSION LINE STRUCTURES

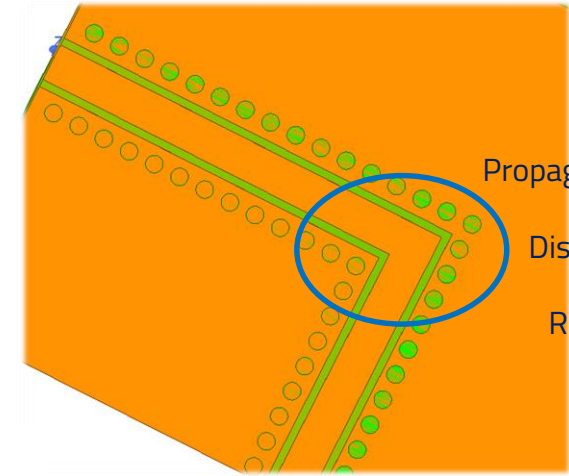
## Straight Trace



Straight trace keep impedance smooth.

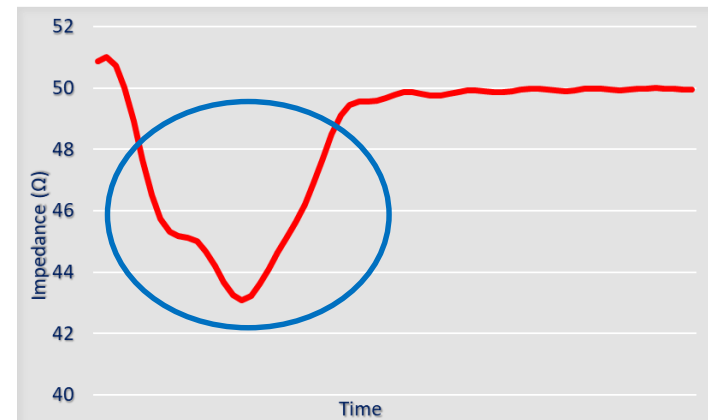


## Angular Trace



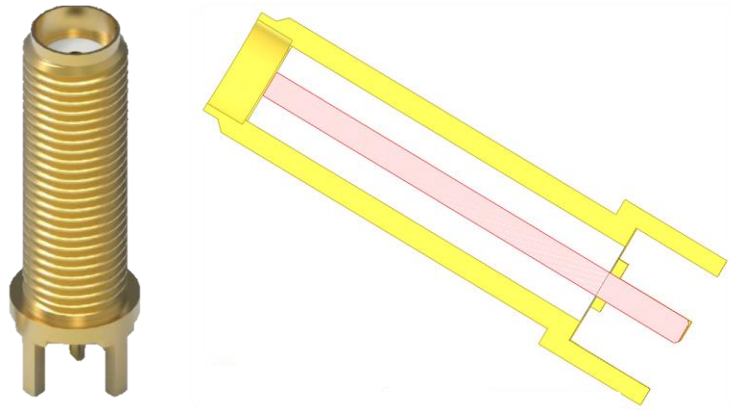
Propagation change  
Discontinuity  
Reflection

Angular area causes impedance lower.



# COMPARISON OF CONNECTOR TRANSMISSION LINE STRUCTURES

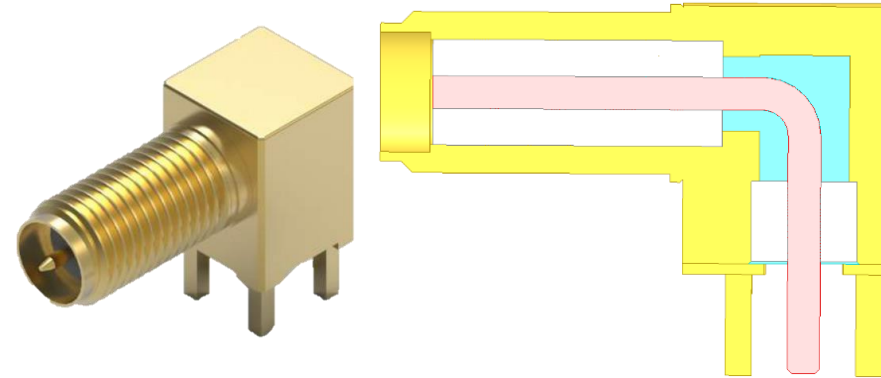
## Straight Connector



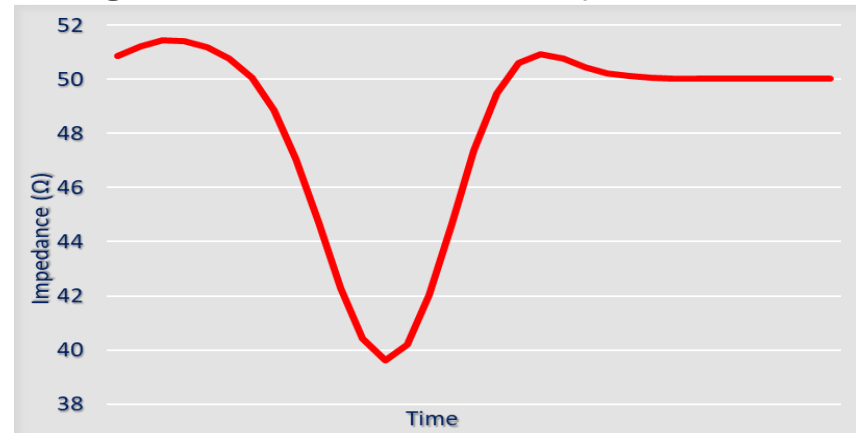
Straight center contact keep impedance smooth.



## Right Angle Connector

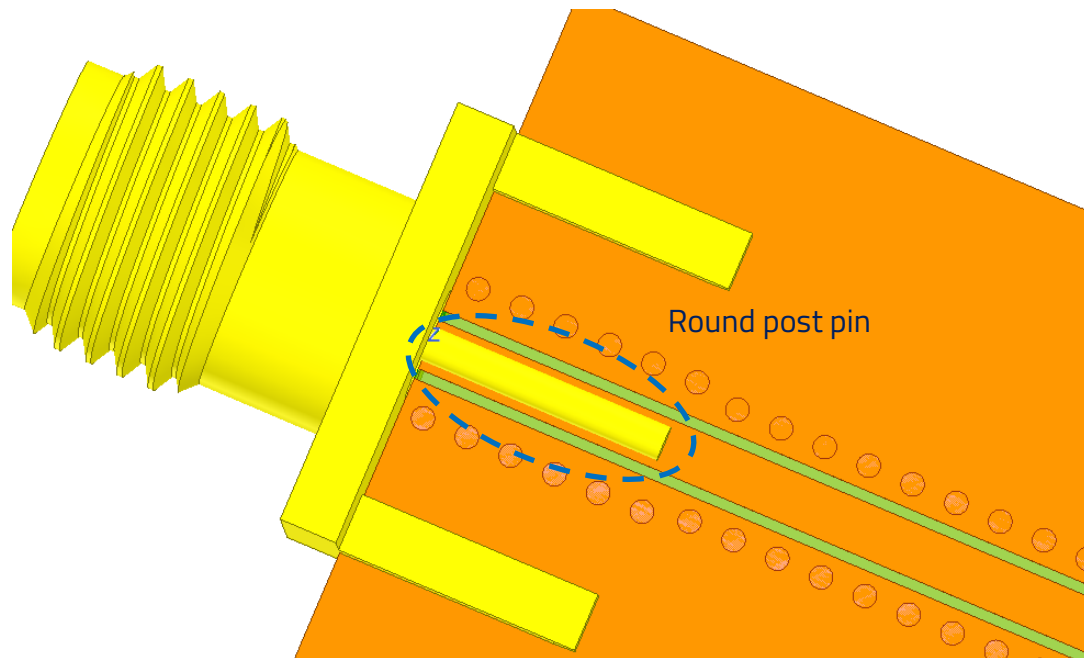


Angular center contact causes impedance lower.

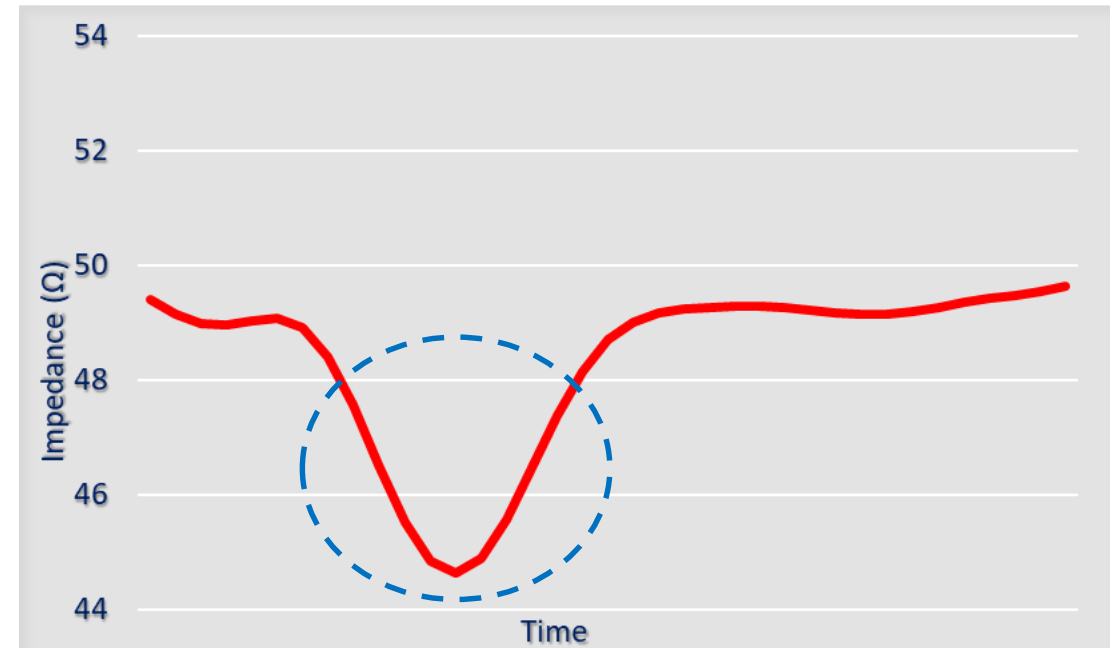


# IMPEDANCE VARIATION OF CONNECTOR CONTACTS TO PCB

## End Launch Connector Type



When connector center contact is engaged contact area (volume) increases.

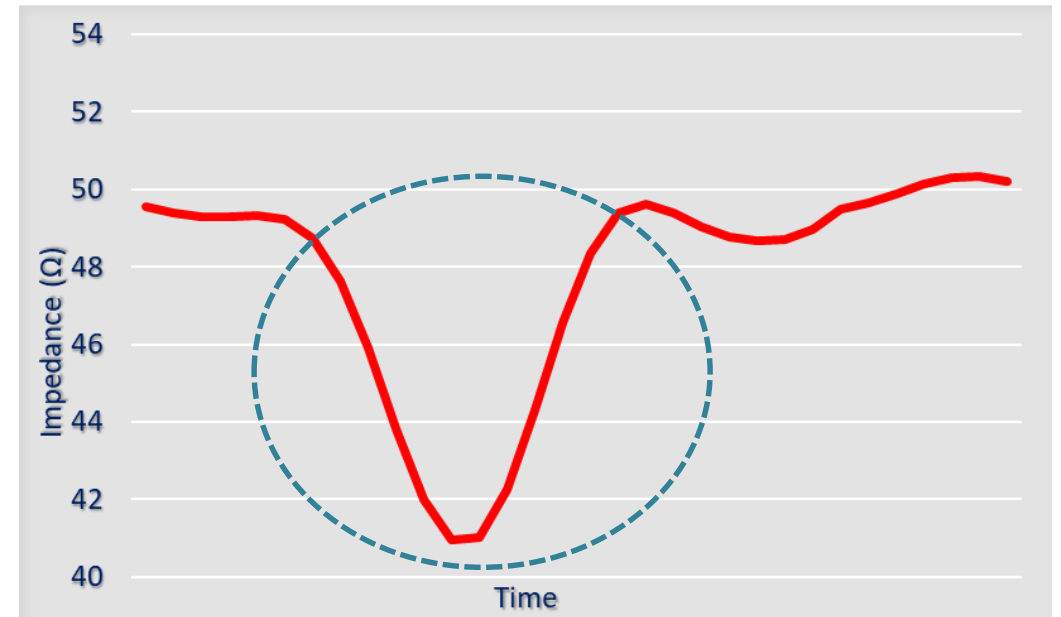
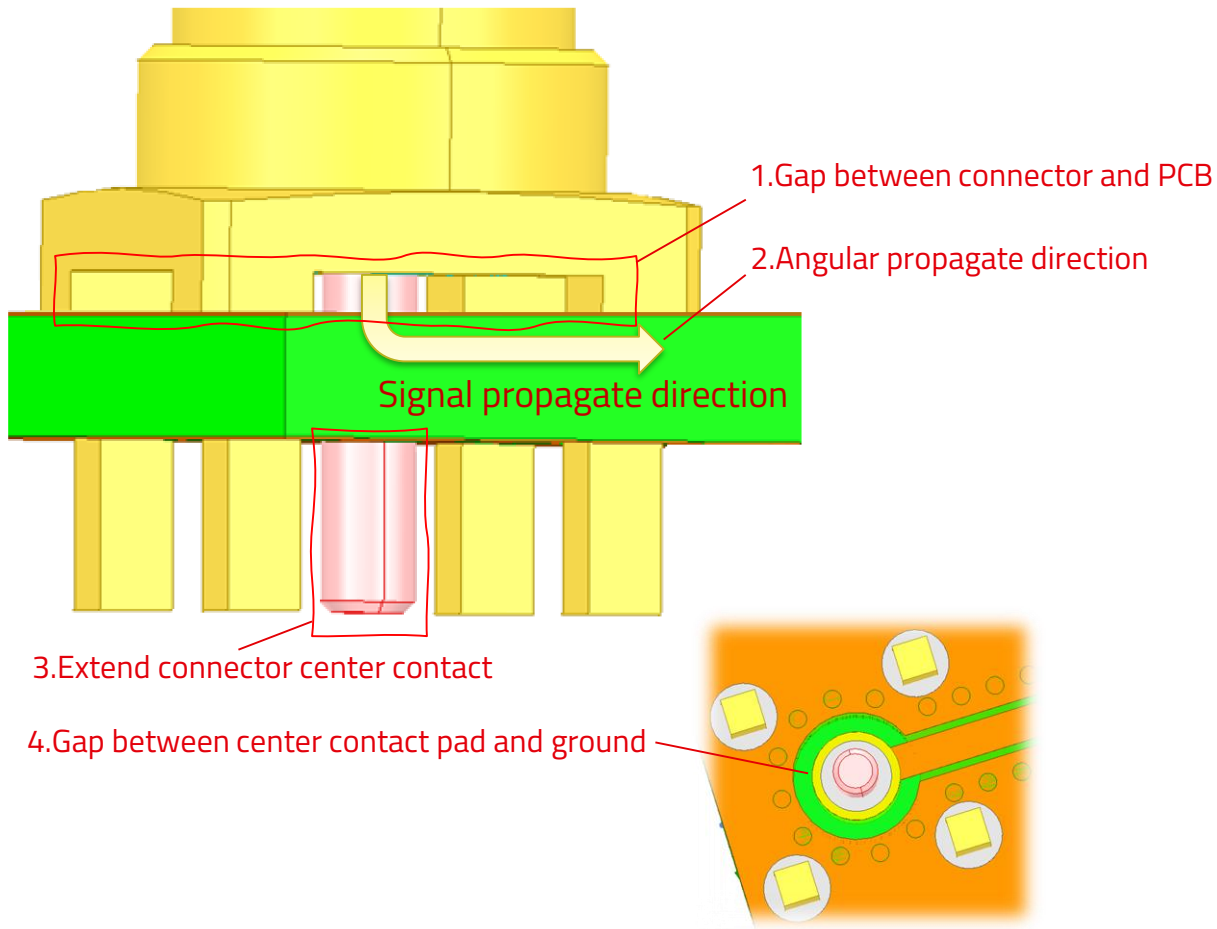


Impedance is lower at center contact engage area.



# IMPEDANCE VARIATION OF CONNECTOR CONTACTS TO PCB

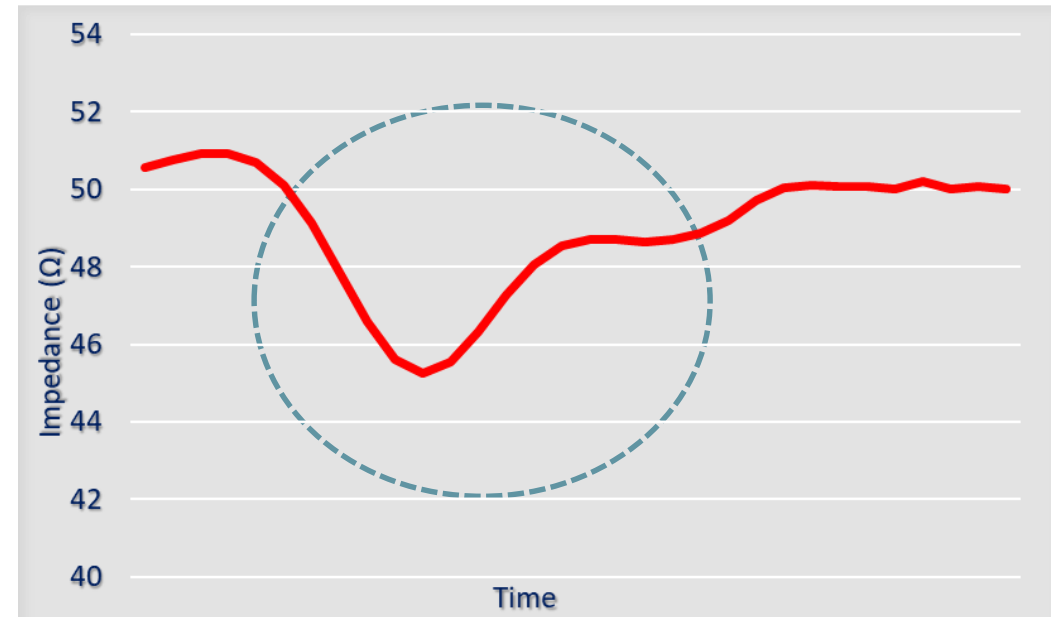
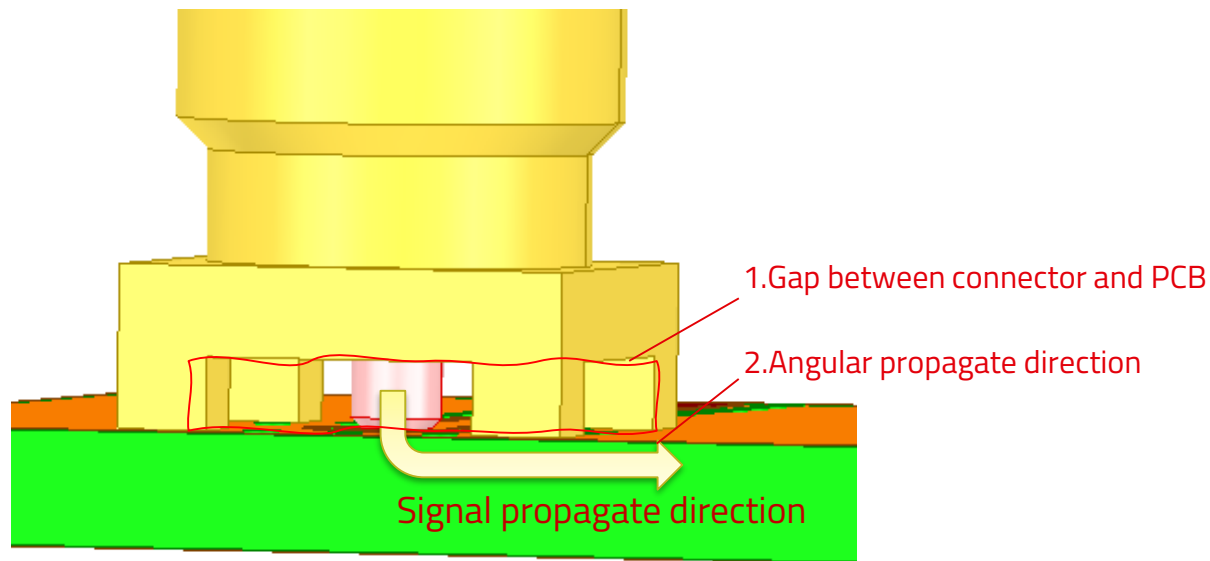
## THT Connector Type



The lower impedance is the result influenced by the various factors.

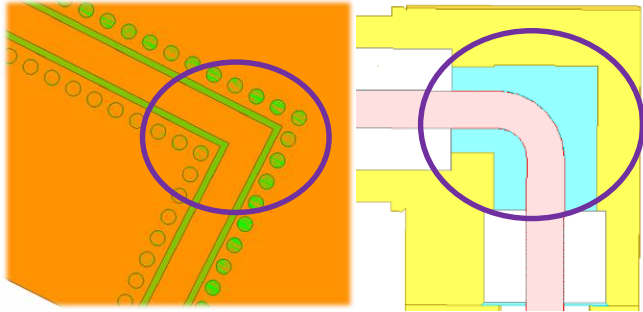
# IMPEDANCE VARIATION OF CONNECTOR CONTACTS TO PCB

## SMT Connector Type

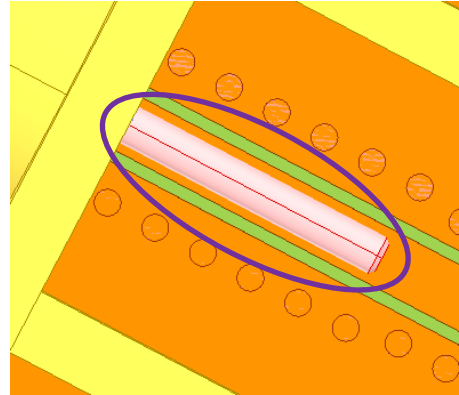


The lower impedance is the result influenced by the various factors.

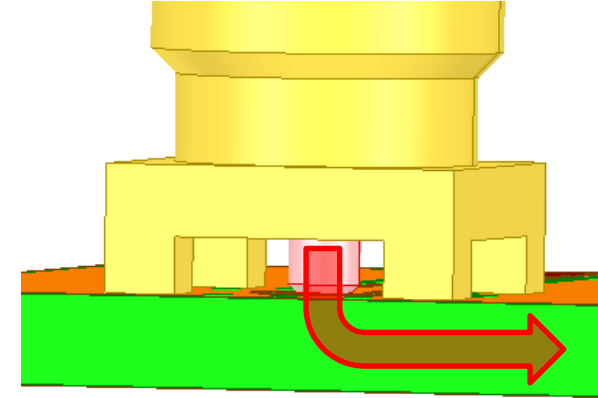
# SUMMARY OF FACTORS INFLUENCING IMPEDANCE VARIATION



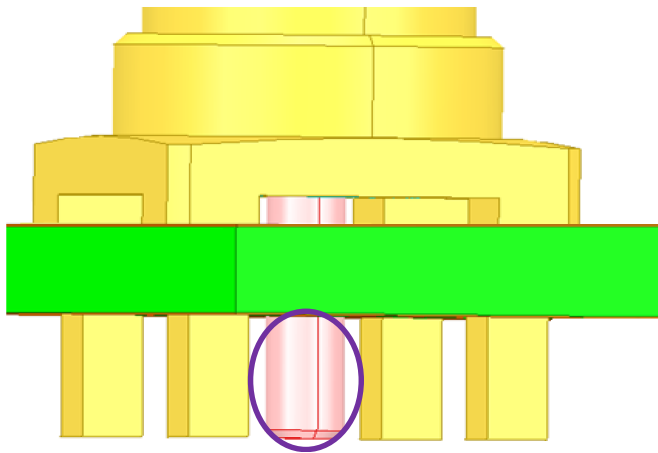
Angular trace



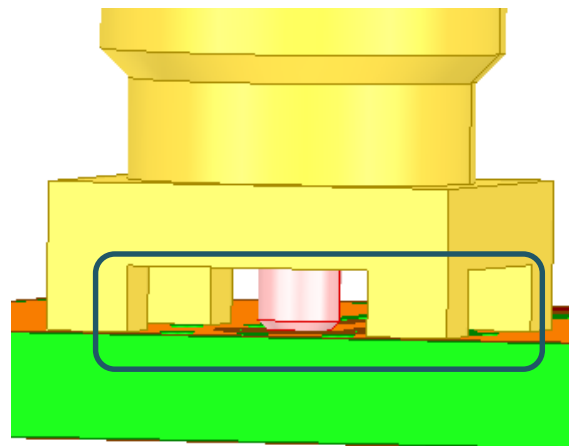
Center contact parts volume changed by connector solder pin



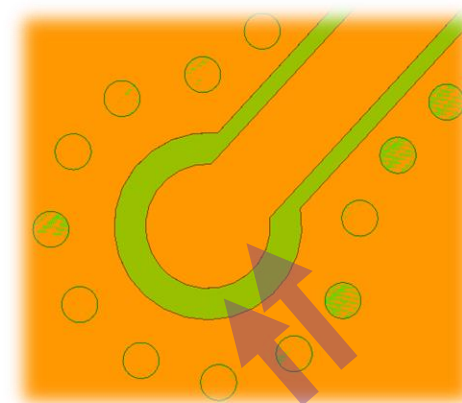
Angular signal propagation



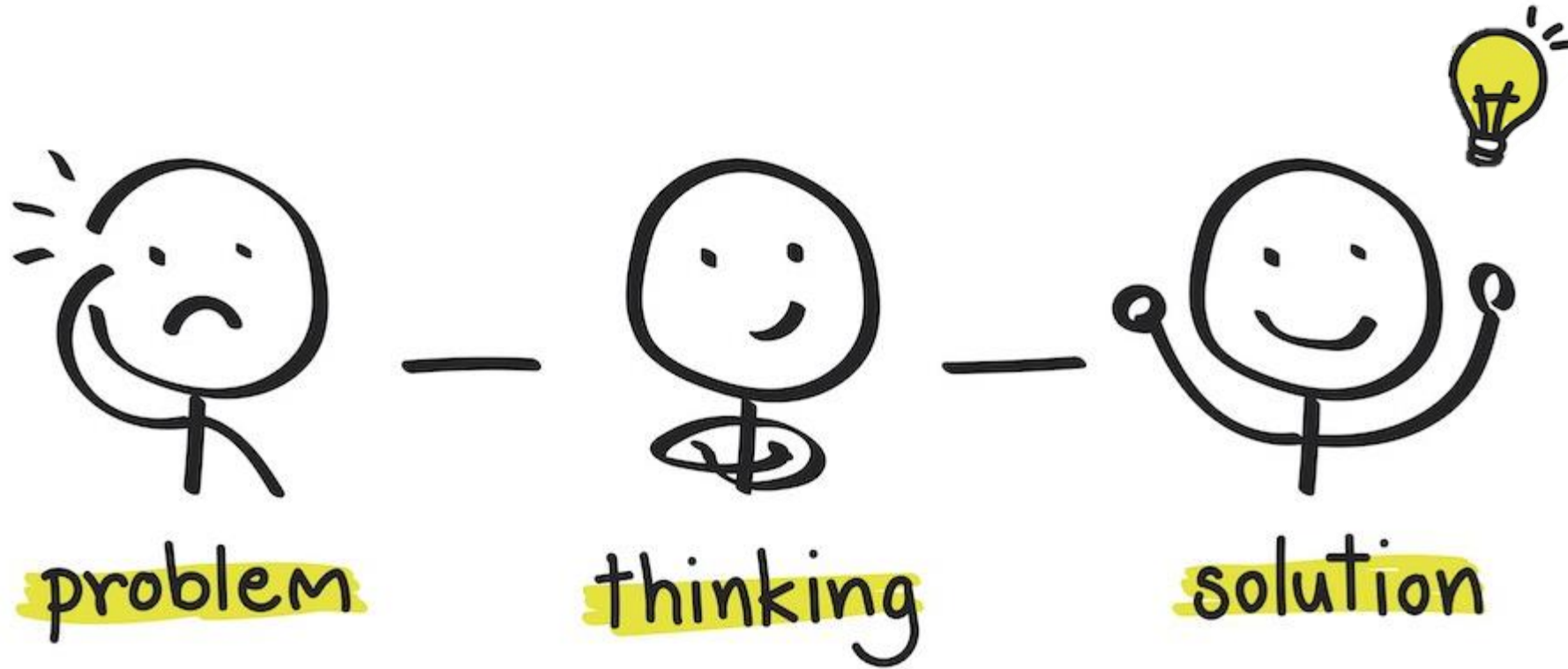
Extend Center Contact



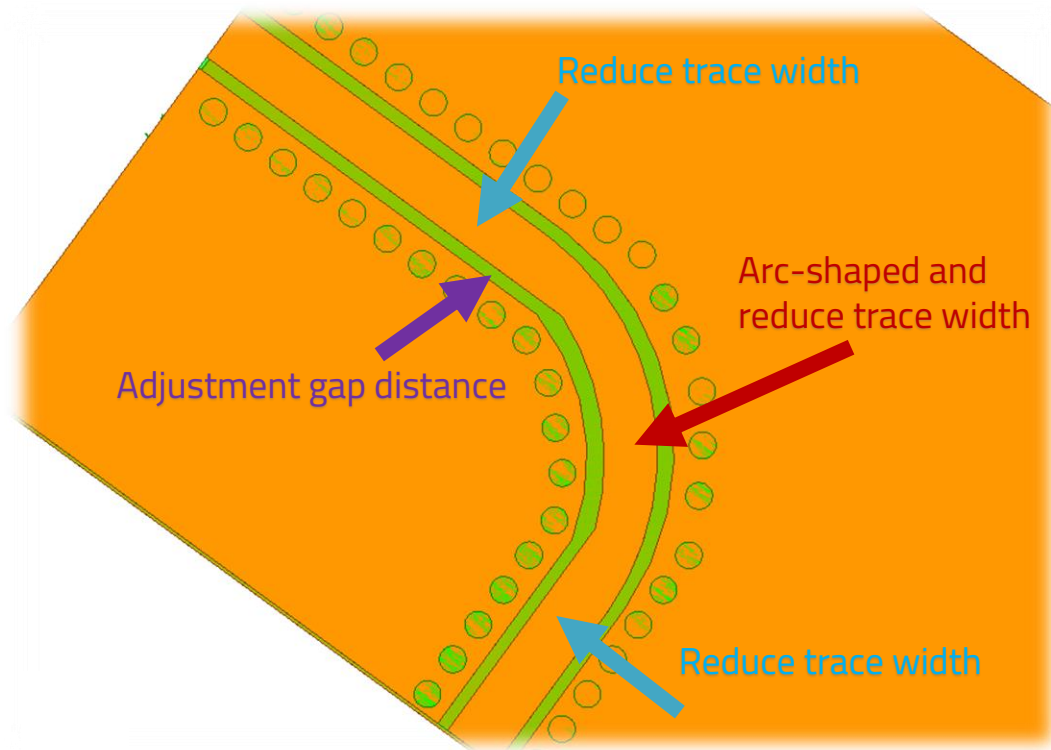
Gap between connector and PCB



Gap between pad and ground dimension, Shape of pad

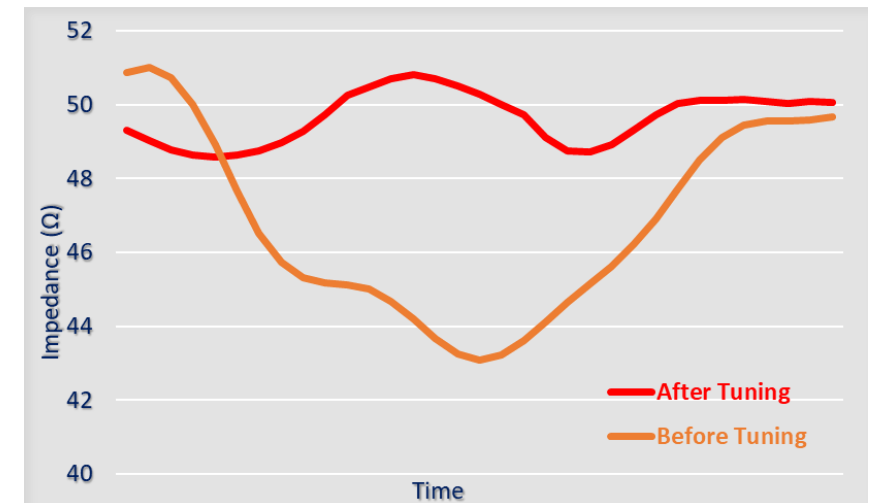


# IMPEDANCE MATCHING AND TUNING – TRANSMISSION LINE



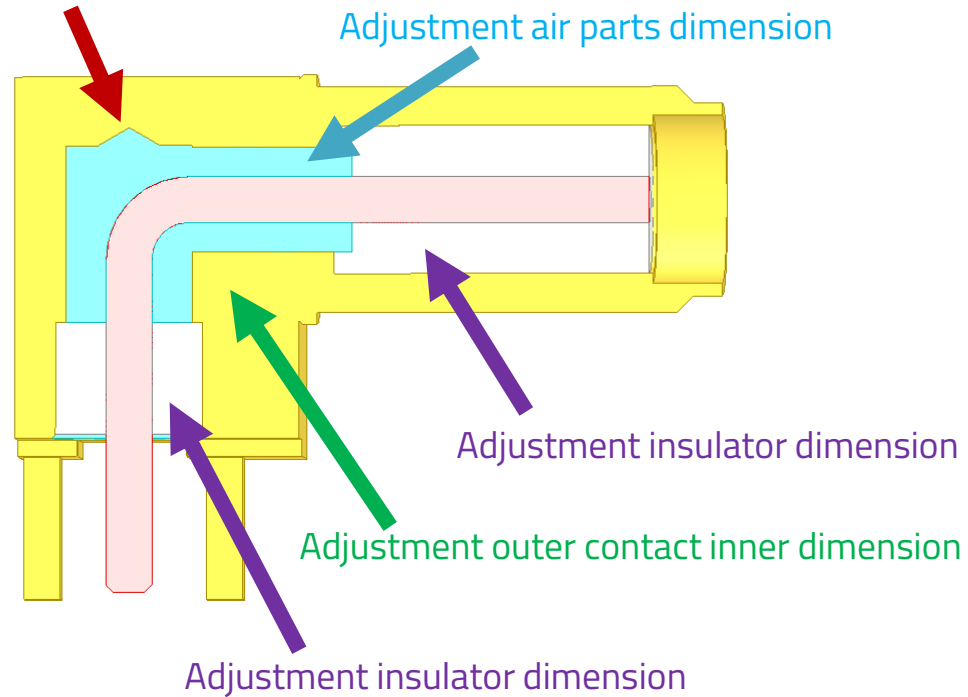
1. Arc-shaped design and reduced trace width:  
→ Angular parts can cause higher impedance; using an arc-shaped design can help in matching
2. Reducing trace width before and after angular parts:  
→ Angular parts can affect the impedance of straight sections
3. Adjustment gap distance:  
→ Assistant design for improved matching.

➤ Balancing the dimensions above the three points to match impedance



# IMPEDANCE MATCHING AND TUNING - CONNECTOR

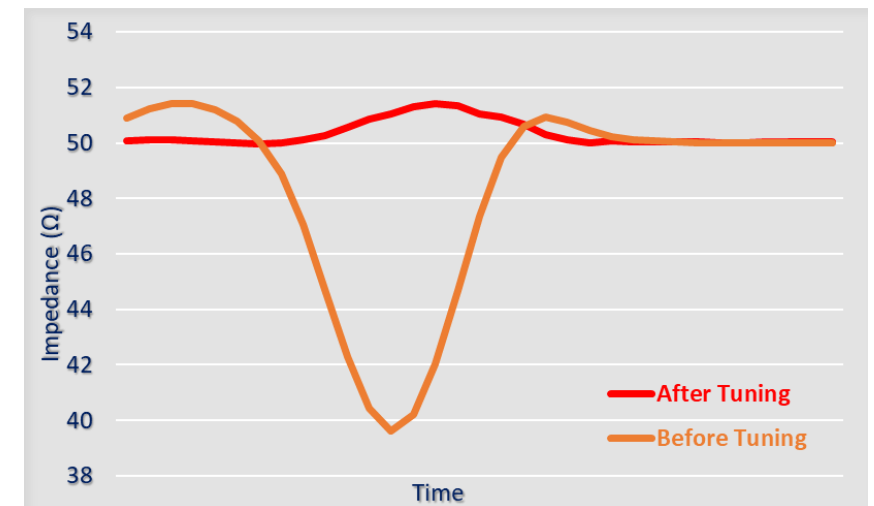
Create outer connector inner notch



➤ Balancing the dimensions above the four points to match impedance

Angular parts cause lower impedance. Adjustments to impedance are made through the following methods:

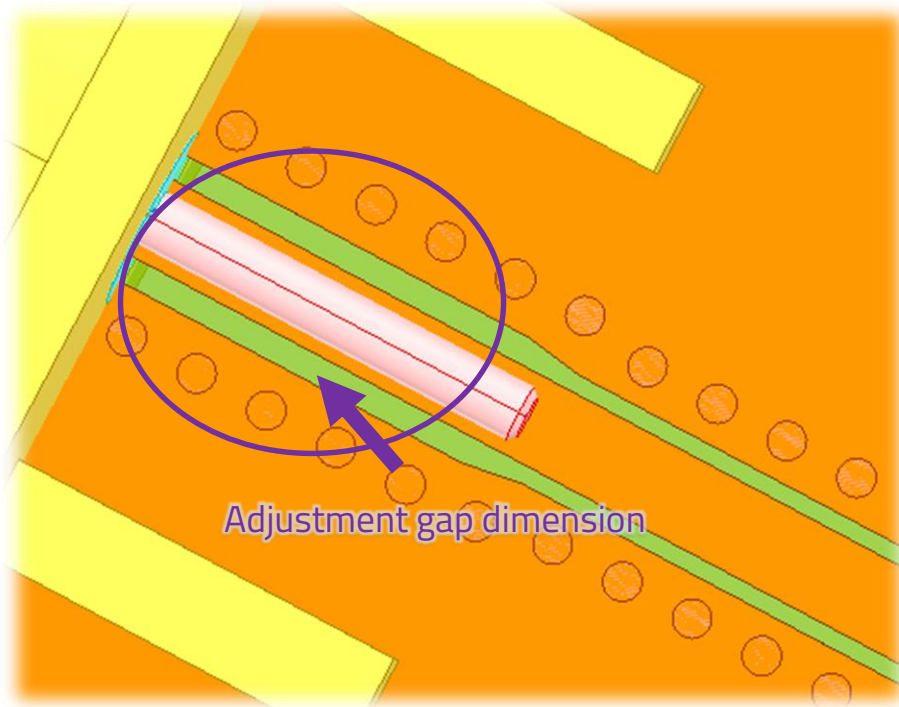
1. Creating an outer connector inner notch.
2. Adjusting air part dimensions.
3. Adjusting insulator dimensions.
4. Adjusting outer contact inner dimensions.



# IMPEDANCE MATCHING AND TUNING

## CONNECTOR AND PCB TRANSMISSION LINE CONTACT AREA

### End Launch Connector Type



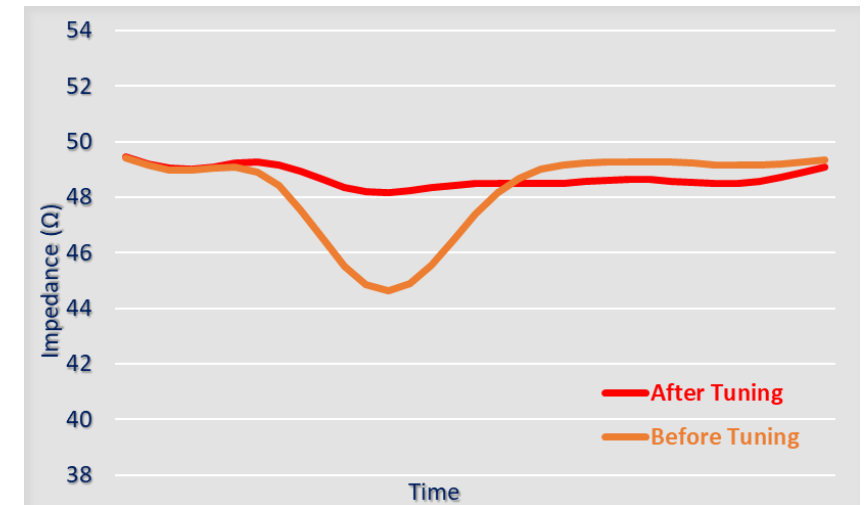
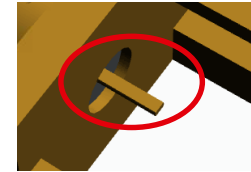
- Three methods above are commonly applied to adjust impedance for end launch type connectors.

Volume increases when the connector center contact is engaged that will cause impedance lower

1. Choose thinner connector center contact.

2. Tuning center contact layout dimension.

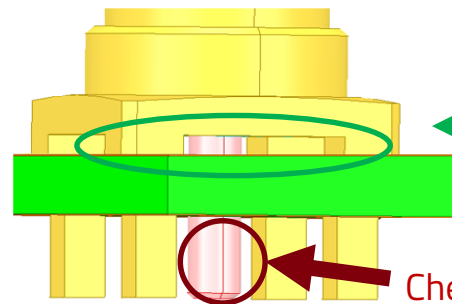
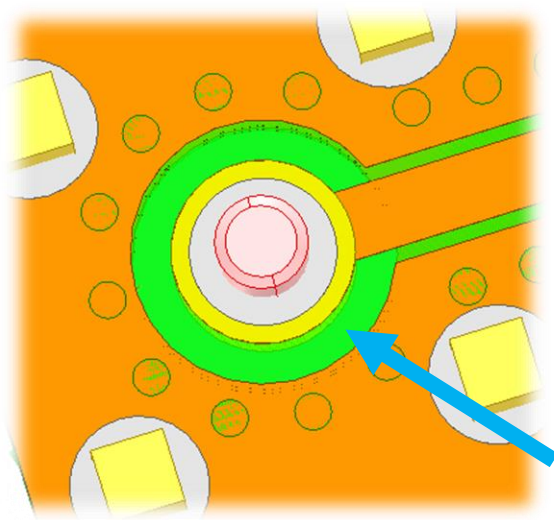
3. Adjusting gap dimensions between center contact and ground.  
(Main method for this example)



# IMPEDANCE MATCHING AND TUNING

## CONNECTOR AND PCB TRANSMISSION LINE CONTACT AREA

### THT Connector Type

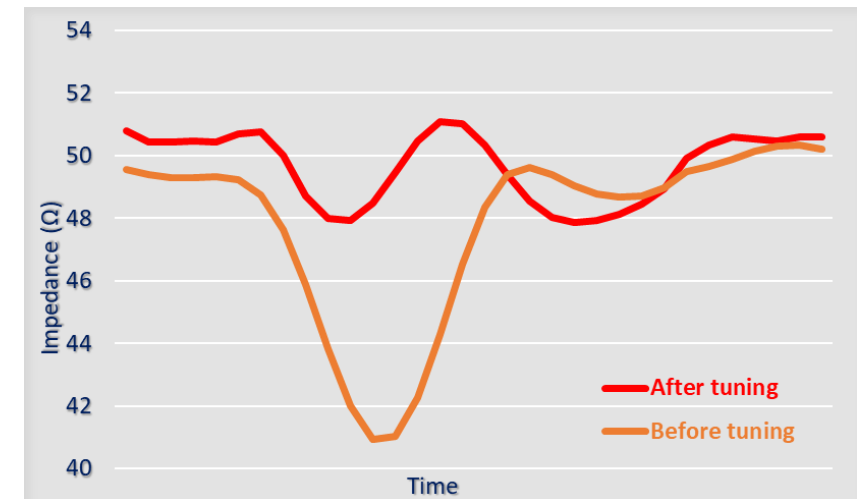


Check suitable gap dimension with simulation and sample testing.  
It is closely related to PCB material and thickness.

Check connector center contact length with simulation and sample testing

Adjust gap dimension

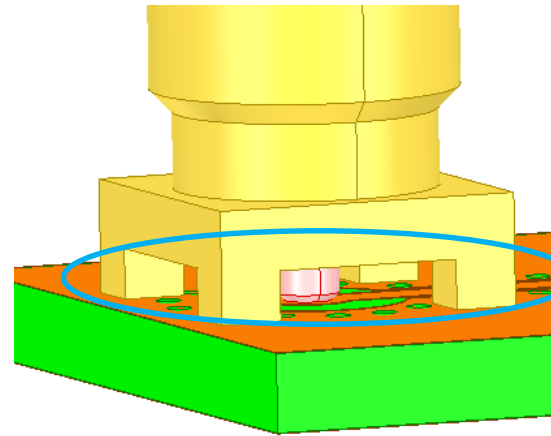
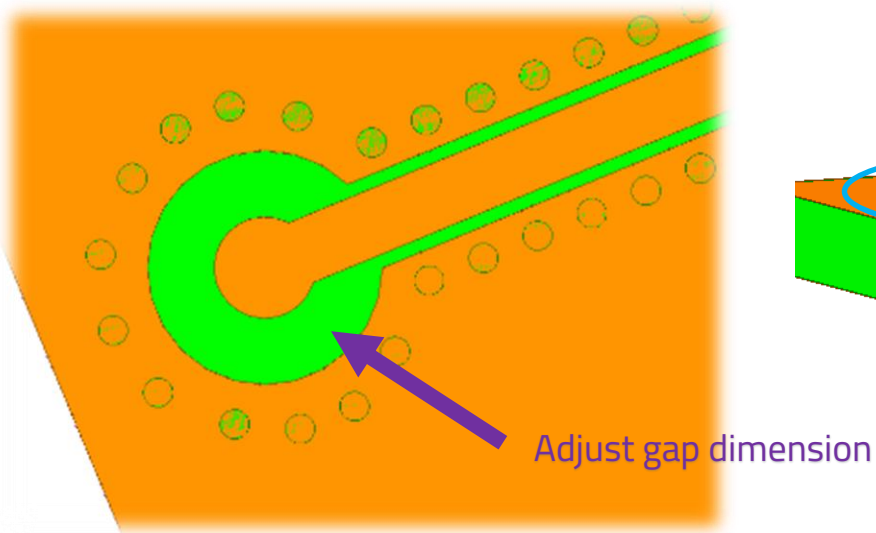
- The THT type connector has a significant effect on impedance due to the extended center contact.
- It is the difficult type to get the smooth impedance, therefore choose the suitable THT connector type is very important.





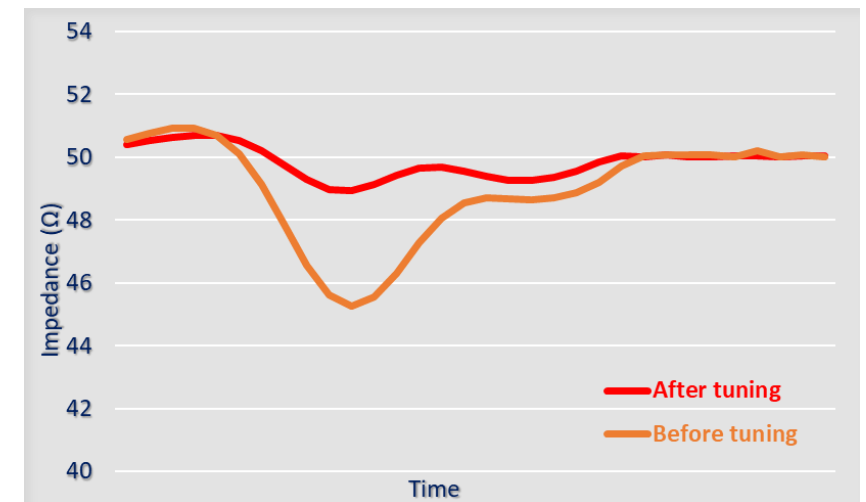
# IMPEDANCE MATCHING AND TUNING CONNECTOR AND PCB TRANSMISSION LINE CONTACT AREA

SMT Connector Type



Check suitable gap dimension with simulation and sample testing.  
It is closely related to PCB material and thickness.

- The SMT type connector similar with THT connector but without extend center contact parts effecting.
- It will be easier to get the better impedance than THT connector.



# SUMMARY

Transmission line in PCB



**Straight line** get the smooth impedance

**Angular line** will cause impedance changed, make arc design will make it better

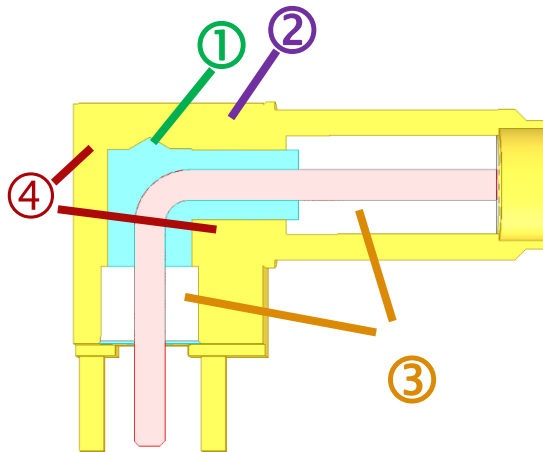
Transmission line in  
Connector



**Straight line** get the smooth impedance

**Angular line** will cause impedance, check the design point as below:

1. Creating an outer connector inner notch.
2. Adjusting air part dimensions.
3. Adjusting insulator dimensions.
4. Adjusting outer contact inner dimensions.



# SUMMARY

Connector contact with  
PCB transmission line



## End Launch Connector Type

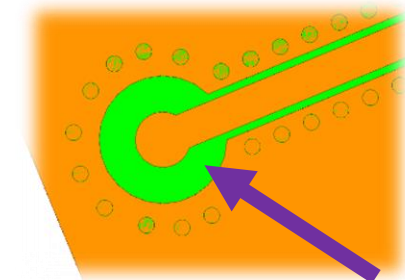
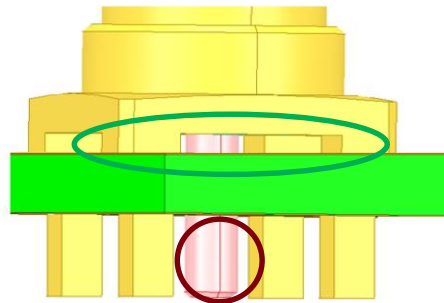
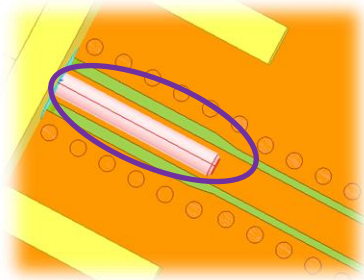
- Select suitable center contact
- Adjusting contact part layout / gap between center contact and ground

## THT Connector Type

- Select suitable center contact length connector
- Adjustment gap dimension between center contact and ground

## SMT Connector Type

- Adjustment gap dimension between center contact and ground



### APPLICATION NOTE

ANE012 | Coaxial PCB Connector  
PCB-Transmission Line Design Guide

Olan Tsai



# THANK YOU

[Coax-Team@we-online.com](mailto:Coax-Team@we-online.com)



# Questions

## & Answers



We are here for you now!  
Ask us directly via our chat or via E-Mail.

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[Jason.Chang@we-online.de](mailto:Jason.Chang@we-online.de)  
[Olan.Tsai@we-online.com](mailto:Olan.Tsai@we-online.com)