

ACCURATE PARASITIC INDUCTANCE DETERMINATION OF A CERAMIC CAPACITOR THROUGH 2-PORT MEASUREMENT

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Background

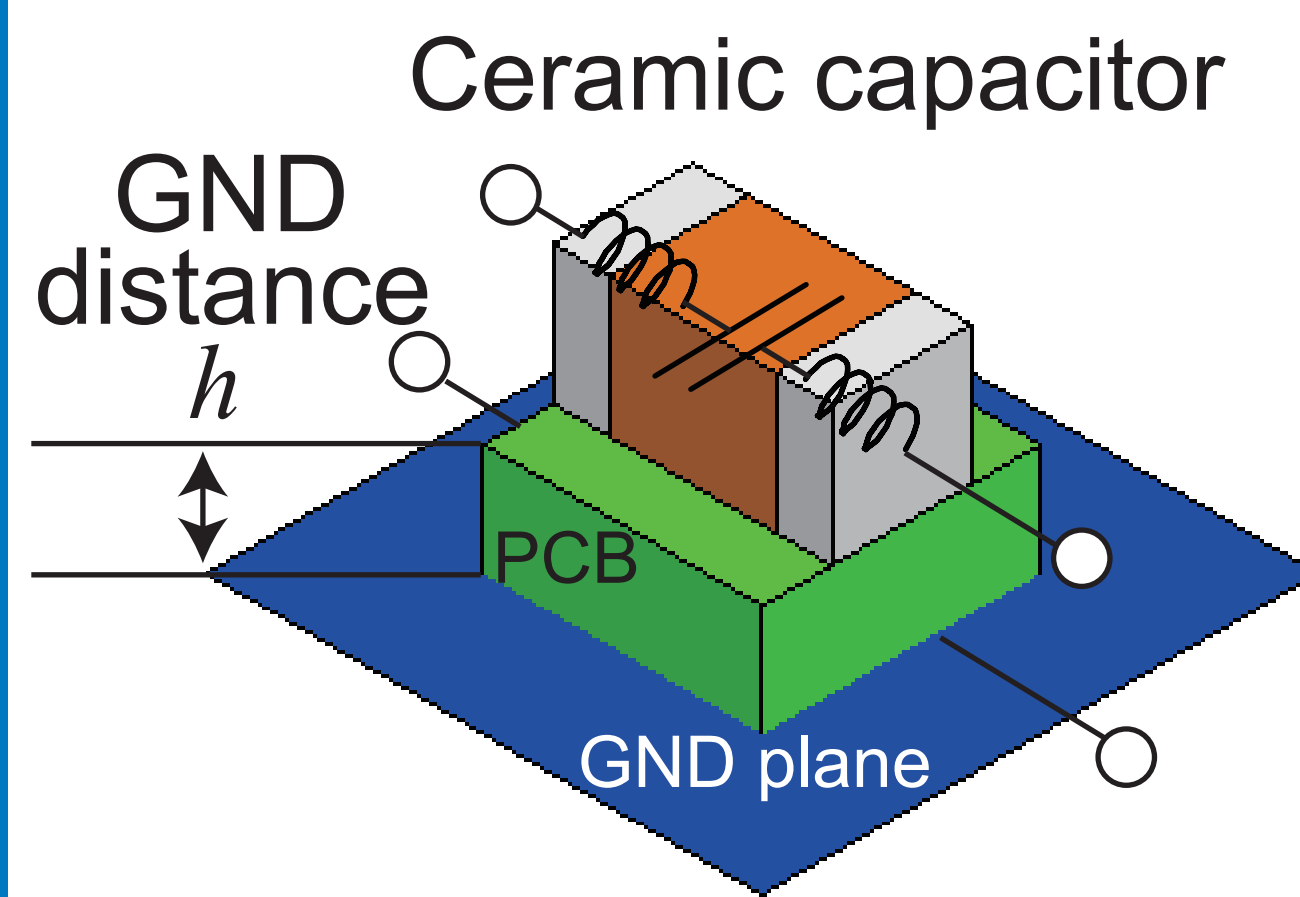
Electrical device trends

- High frequency operation
- Low operation voltage
- High power consumption

Voltage fluctuation and EMI problems become severe

Simulation of Print Circuit Board (PCB) is important

Purpose of this work

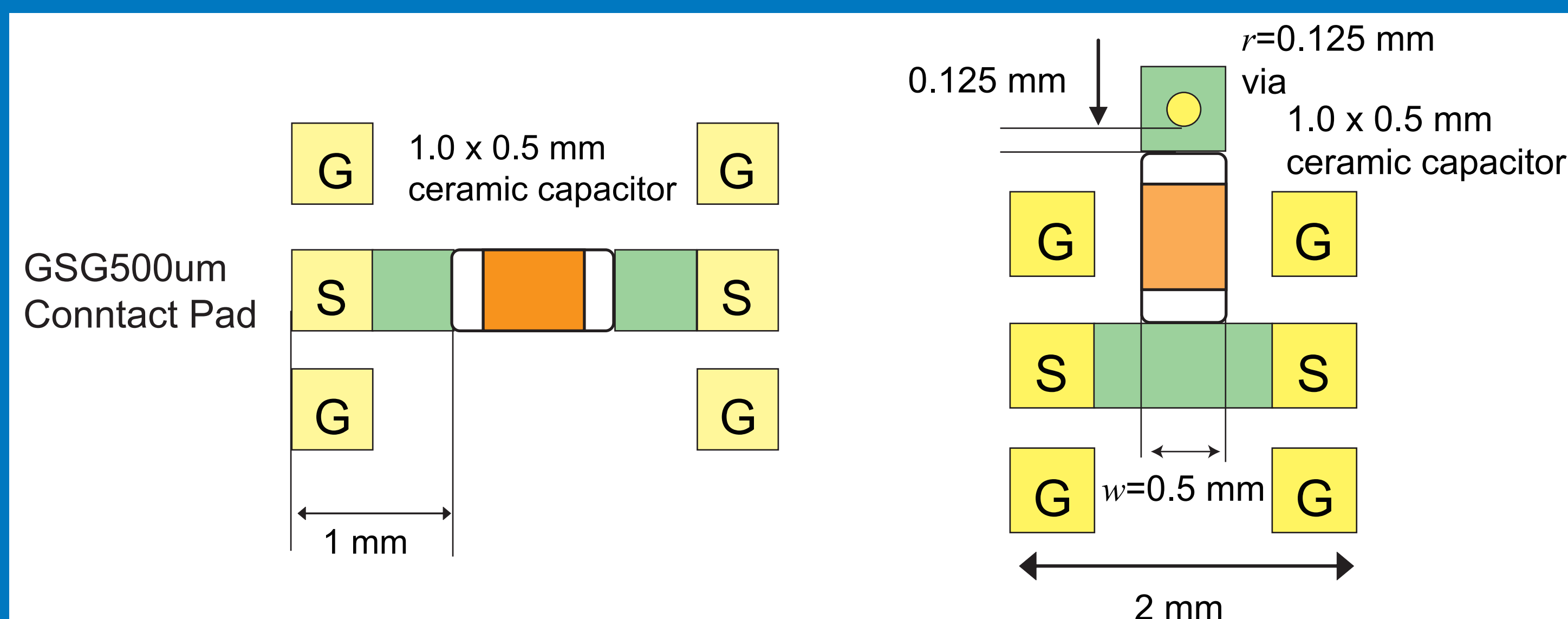


Our 2-port ceramic capacitor model

- Parasitic L of ceramic capacitor is too low (in the order of 100pH)
- Parasitic L is an open-loop partial L (Both ends of the model are opened)
- Parasitic L depends on GND distance h

We propose accurate determination method of parasitic L of capacitor and validate proposed model

Two Measurement Methods



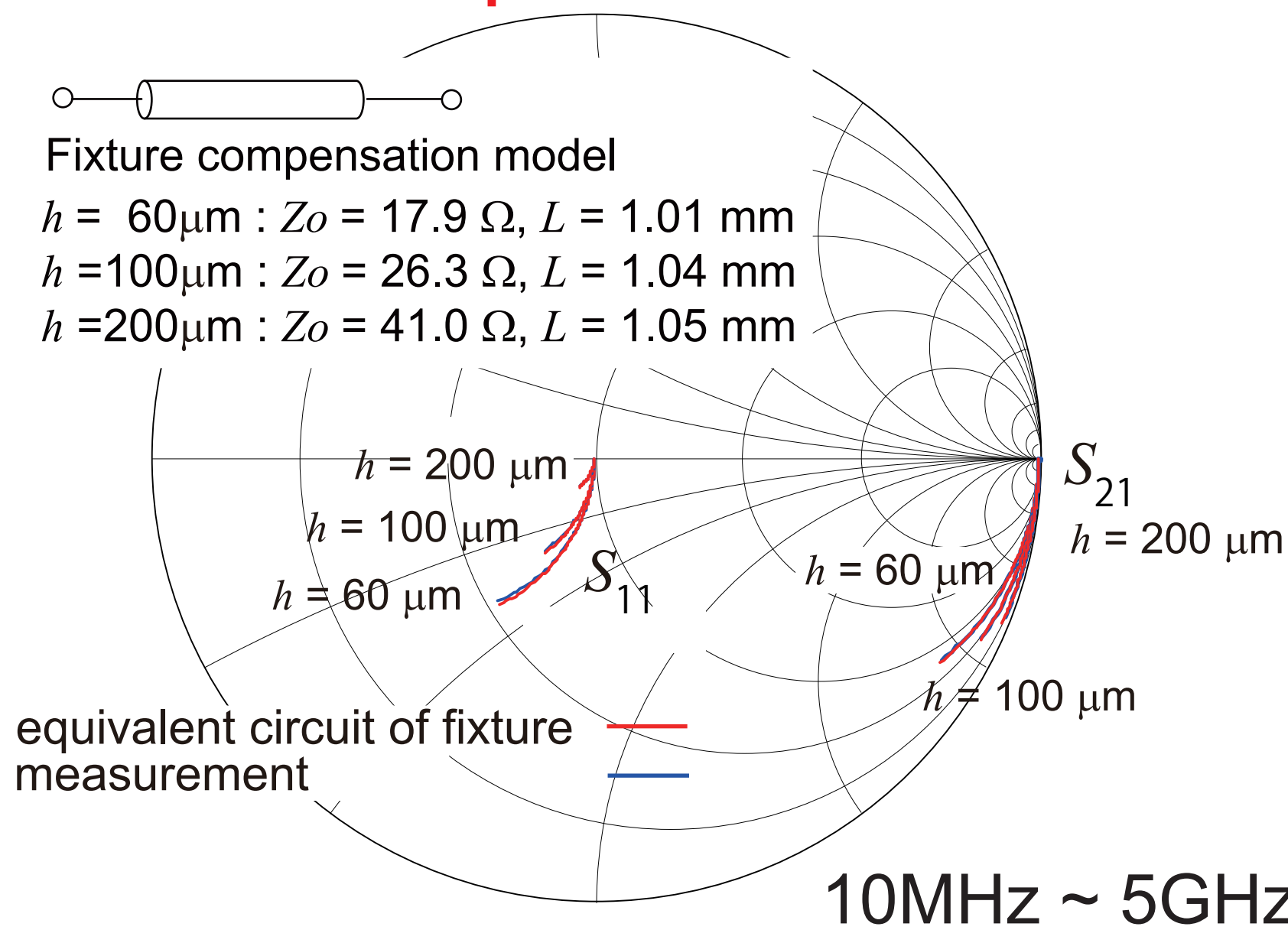
GND distance $h = 60 \mu\text{m}$, $100 \mu\text{m}$, and $200 \mu\text{m}$.

(a) Series 2-port meas. (b) Shunt 2-port meas.

Required compensation

- Series: phase rotation by access lines
- Shunt: via and access line L for open loop L

Fixture compensation model

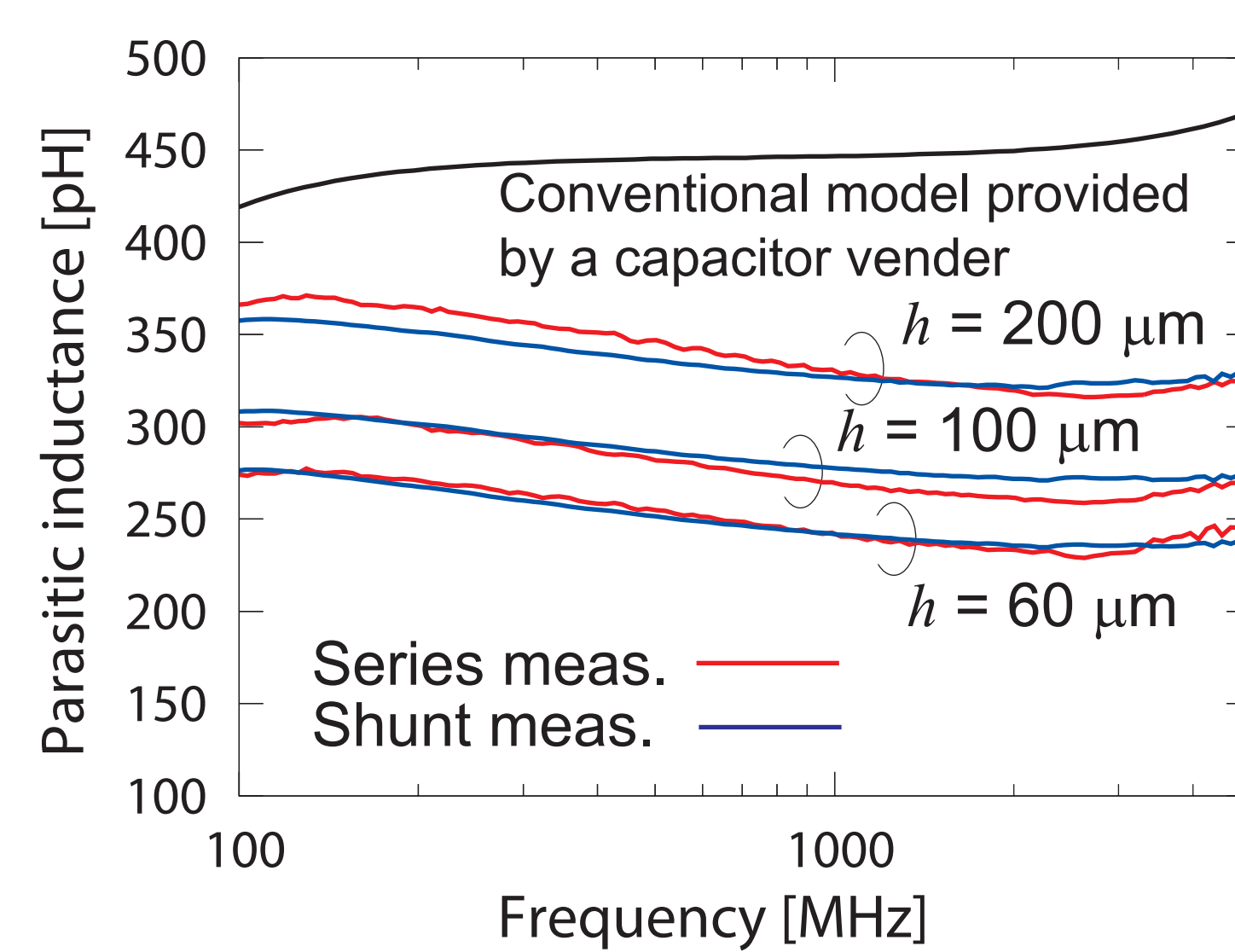


Measure through pattern for compensation model

Symmetric equivalent circuit model of the through pattern is constructed

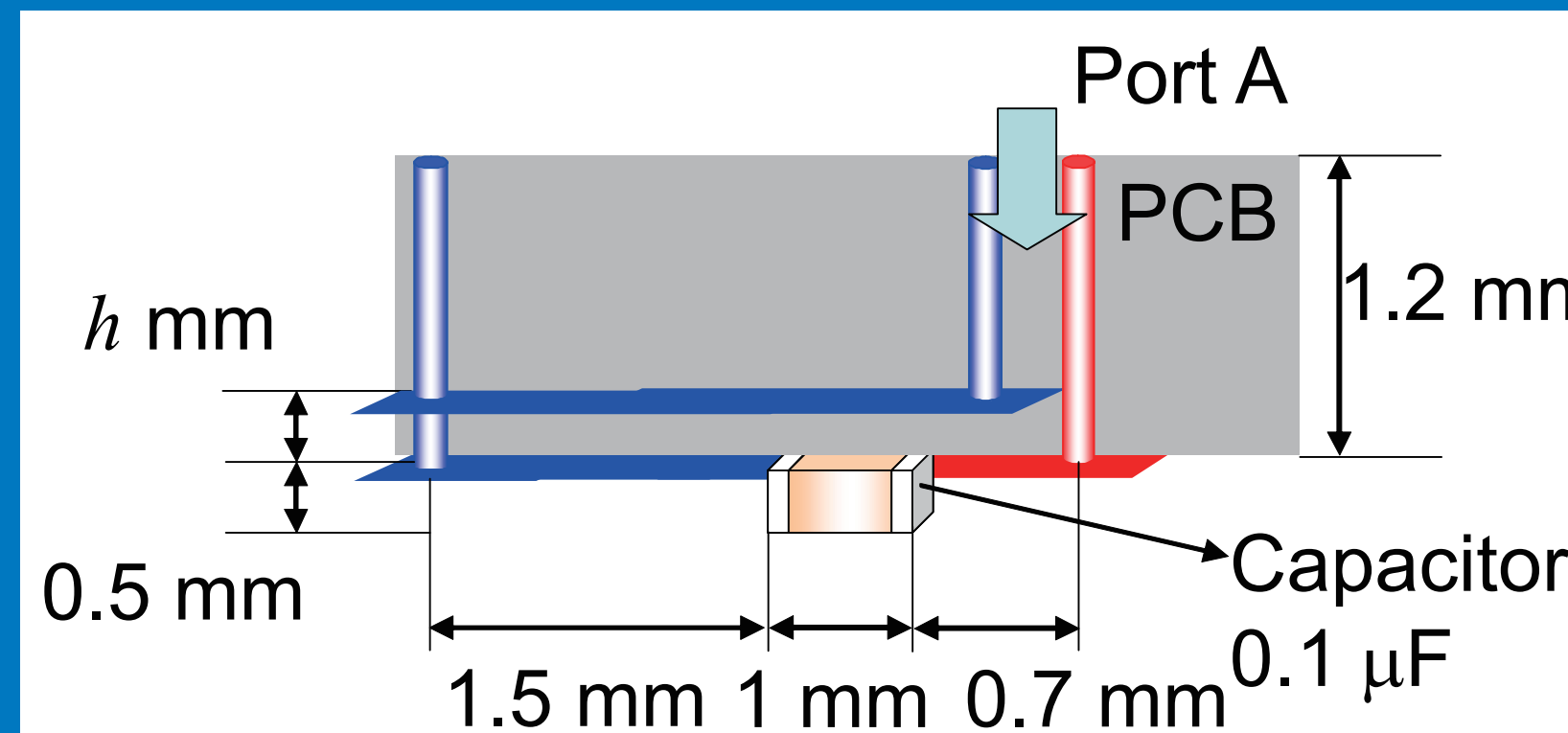
Parasitic L through Measurement

Measurement result of 1.0x0.5mm ceramic capacitor



- Both measurement match very well
- Parasitic L takes different value by more than 100 pH depending on the GND distance h .

Validation of proposed model



A PDN inductance from Port A is simulated by using proposed model and compared with measurement result.

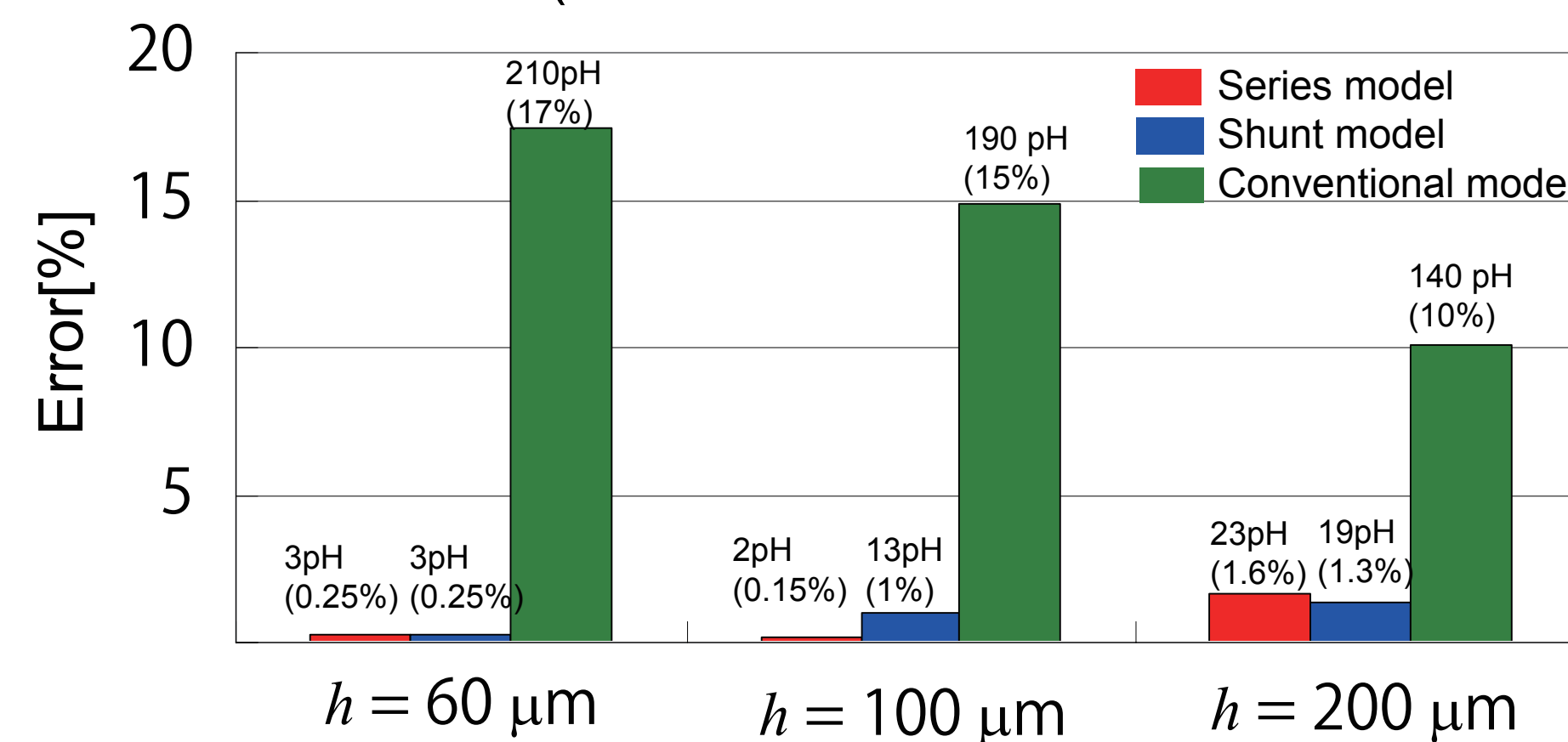
Dimension of the PDN of PCB(cross sectional view)

Simulation procedure

- 1) Calculate 3-port PCB model by using electromagnetic simulator
- 2) Extract 2-port capacitor model by the measurements.
- 3) Connect the capacitor model into the 3-port PCB model and then calculate total inductance from port A.

Simulation and measurement result

Error of L at 1GHz (Reference: measured total L from Port A)



Sim. results by using proposed model match very well with meas.

Measurement procedure through series fixture

S_{meas} : Measured S parameter of capacitor with fixture

S_{fix} : S parameter of the fixture model

$$\mathbf{T}_{\text{cap}} = \mathbf{T}_{\text{fix}}^{-1} \mathbf{T}_{\text{meas}} \mathbf{T}_{\text{fix}}^{-1}$$

$$Z_{\text{cap}} = \frac{1 - S_{\text{cap}21} - S_{\text{cap}12} - |S_{\text{cap}}|}{1 - S_{\text{cap}11} - S_{\text{cap}22} - |S_{\text{cap}}|}$$

$$L_{\text{cap}} = \frac{\text{Im}\{Z_{\text{cap}}\}}{\omega}$$

Measurement procedure through shunt fixture

S_{meas} : Measured S parameter of capacitor with fixture

S_{fix} : S parameter of the fixture model

L_{excess} : Excess via and pattern L (see proceeding paper for detail)

$$\mathbf{T}_{\text{cap}} = \mathbf{T}_{\text{fix}}^{-1} \mathbf{T}_{\text{meas}} \mathbf{T}_{\text{fix}}^{-1}$$

$$Z_{\text{cap}} = 25 \frac{S_{\text{cap}21}}{1 - S_{\text{cap}21}}$$

$$L_{\text{cap}} = \frac{\text{Im}\{Z_{\text{cap}}\}}{\omega} - L_{\text{excess}}$$

Conclusions

- Two accurate 2-port measurement methods of parasitic L for ceramic capacitor are proposed
- Parasitic L measured by two different methods matches well
- Our proposed 2-port model is useful for accurate PDN simulation.