Solutions for High Frequency Printed Circuit Boards

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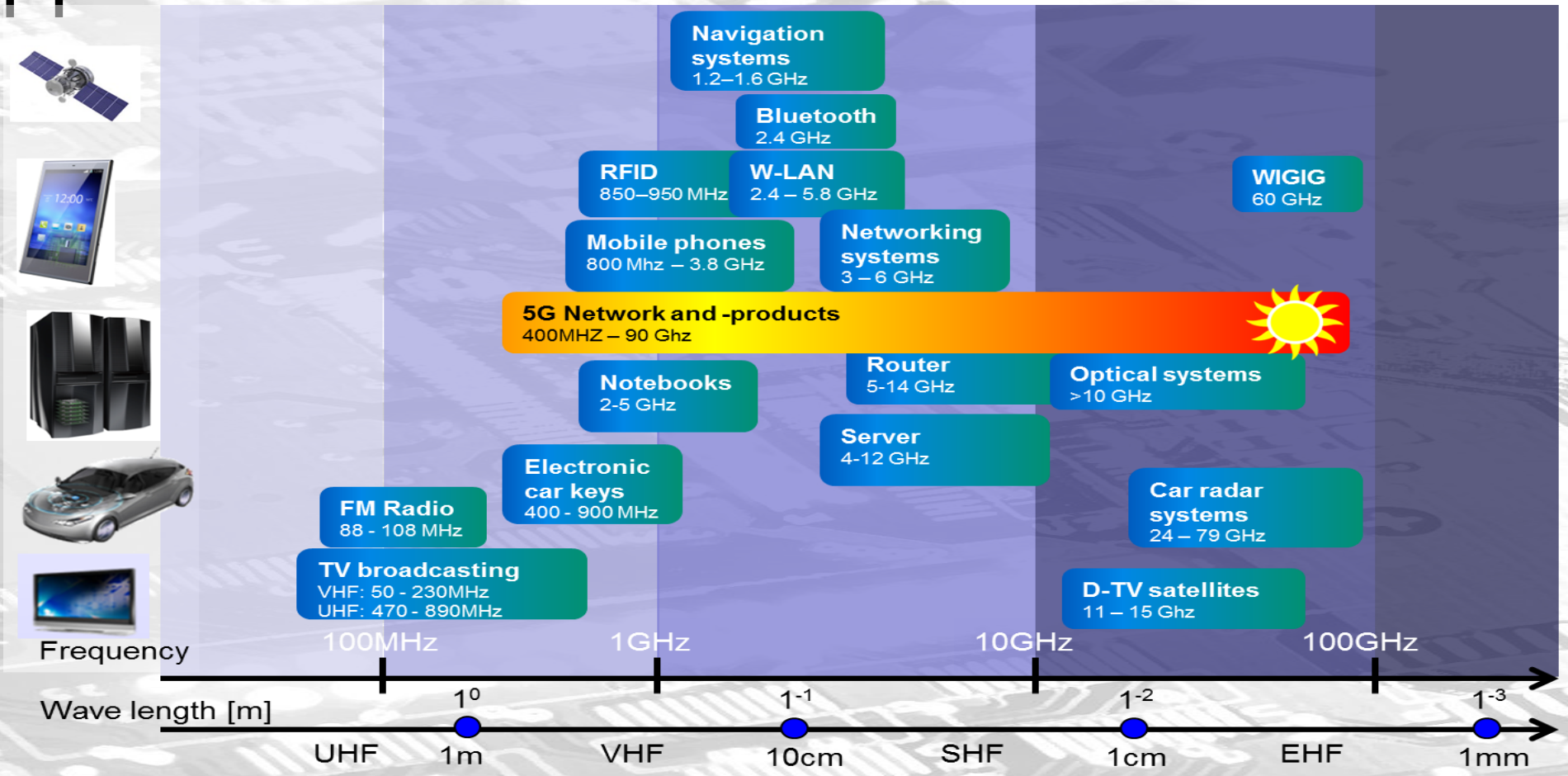
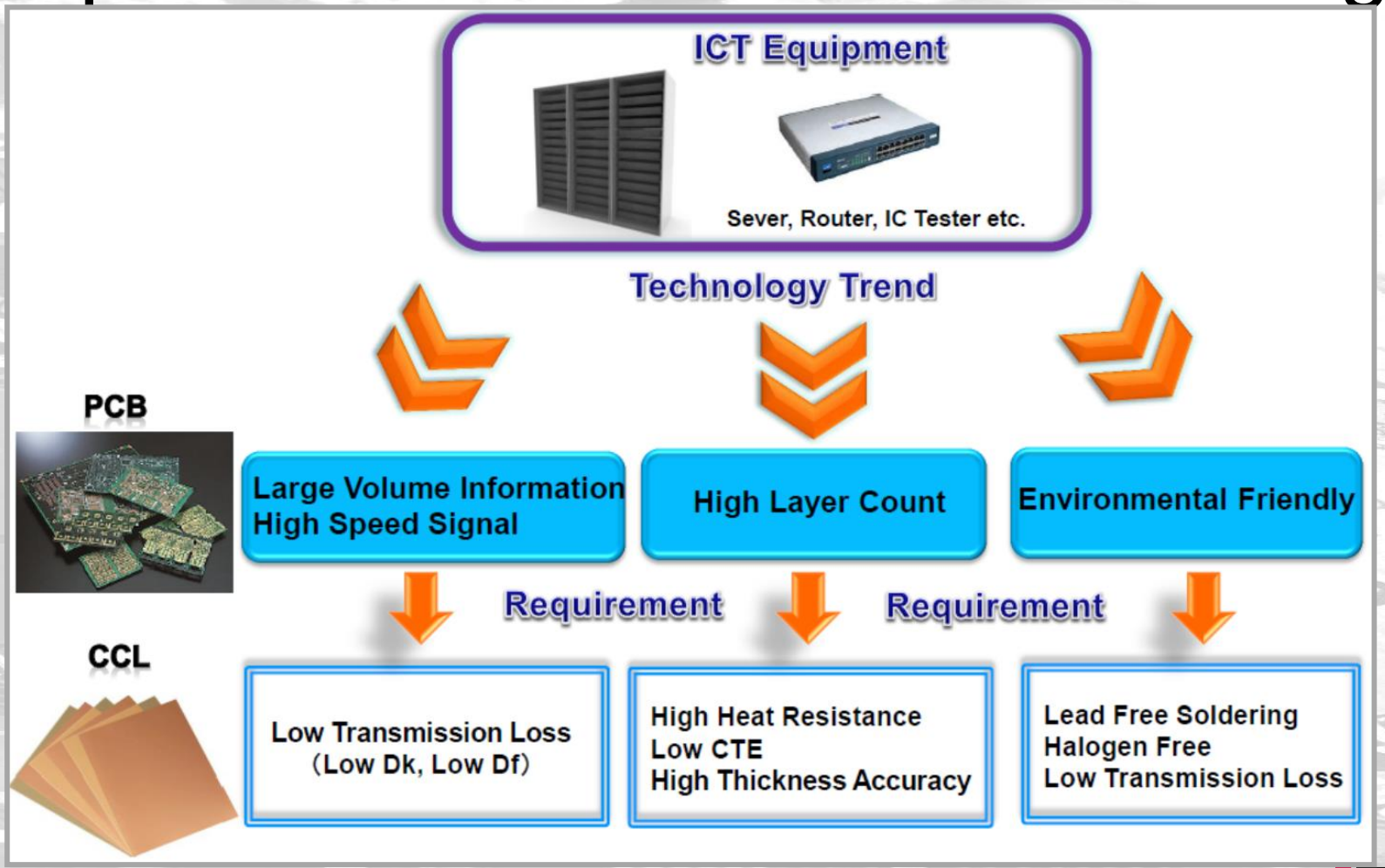
Content

- High speed laminate trends
- Key characteristics of dielectric laminates for high frequency/-speed circuit boards
  - Resin system
  - Glass cloth
  - Copper foil
- Summary and Key takeaways

High speed laminate trends – Examples of Applications



High speed laminate trends – ICT Segment



Source: Panasonic / LinLin ECWC13

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Electrical characteristics of resin – Why Low Dk/Df for High Frequency boards?

Formula of Transmission Loss (by Edward A Wolff)

Transmission Loss (α) = Conductor Loss(α_c) + Dielectric Loss(α_d)

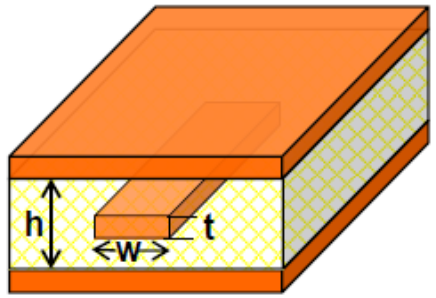
$$\alpha_c \propto \sqrt{Dk} \times R(f)$$

$$\alpha_d \propto 27.3 \times {}^{f}/_{c} \times \sqrt{Dk} \times \mathrm{Df}$$

R(f): Surface Resistance, Dk : Dielectric Constant

Df : Dissipation Factor, f : Frequency

c : Light Velocity

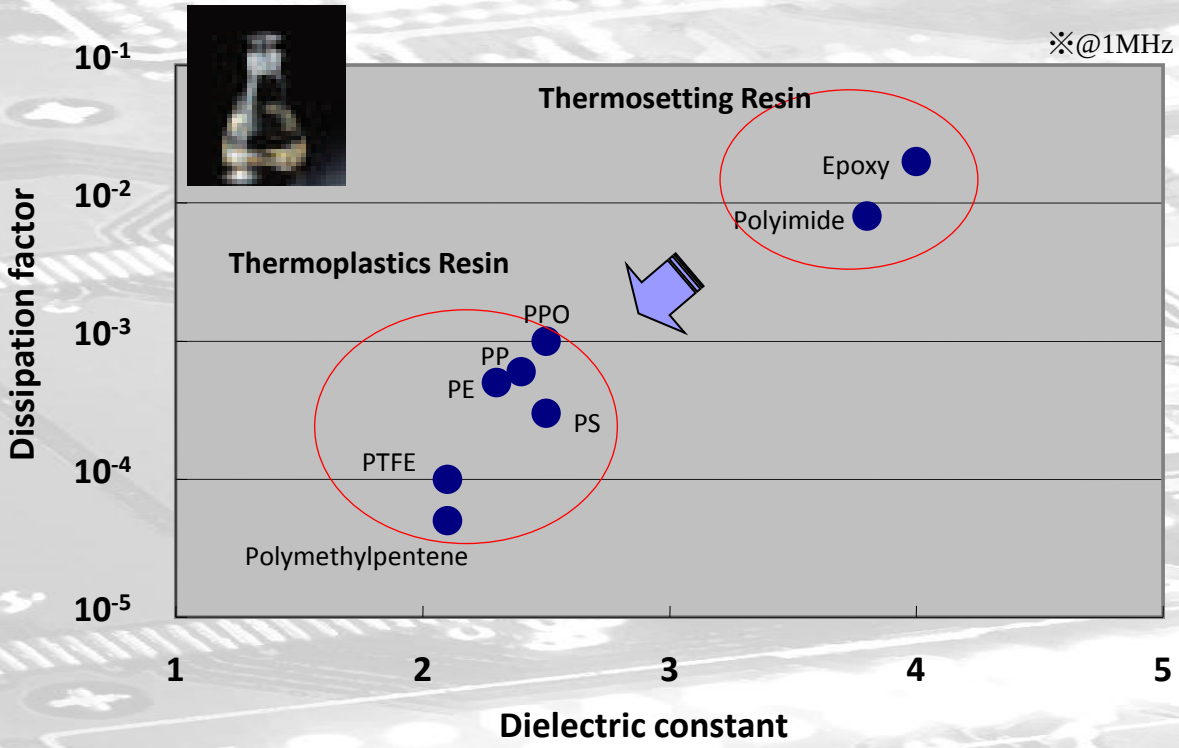


h : Dielectric Layer Thickness
w : Conductor Width
t : Conductor Thickness

- **Reduction of α_c : Lower Profile or Profile-free Conductor**
- **Reduction of α_d : Low Dk & Df Materials**

- Signal transmission loss is sum of conductor loss and dielectric loss.
- Dk and Df are both impacting on transmission loss.

Electrical characteristics of resin and glass cloth (Dk & Df)



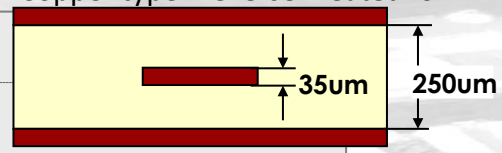
Properties of glass		E-glass	Low Dk glass
ε	10GHz	**6.6**	**4.7**
tanδ	10GHz	**0.0066**	**0.0035**
Thermal expansion	ppm/degC	5.5	3.4
Density	g/cm3	2.54	2.30

- Final properties of laminates and prepregs are combination of properties of resin- and glass cloth used.

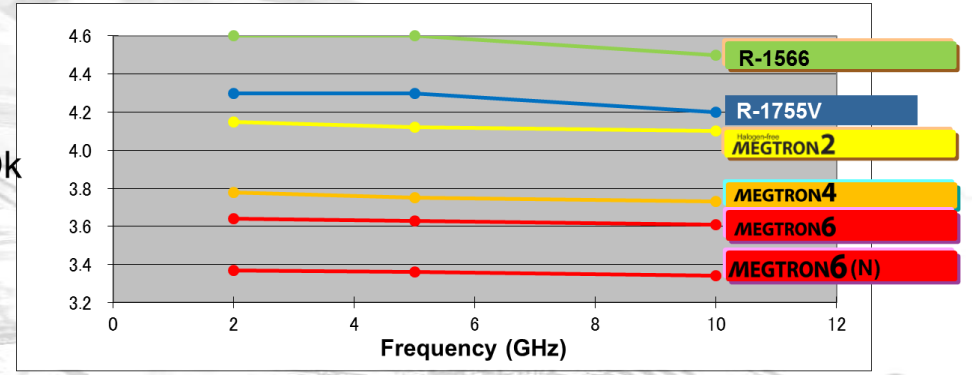
Electrical characteristics of resin – Transmission loss comparison

PCB construction

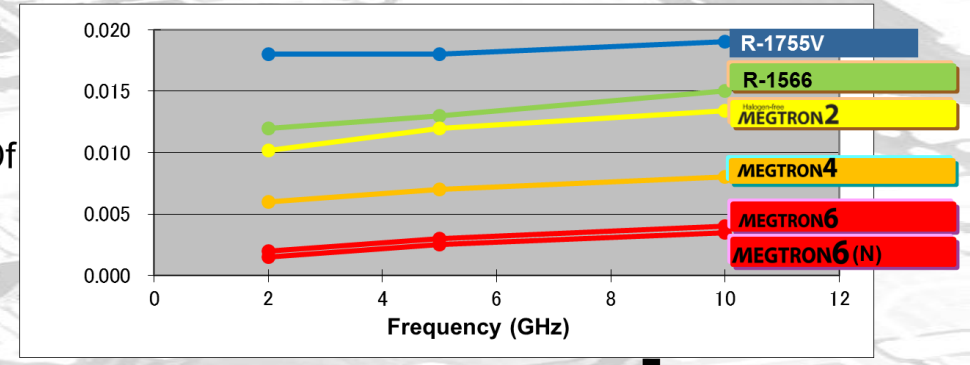
Copper type : Reverse Treated foil



① Dk

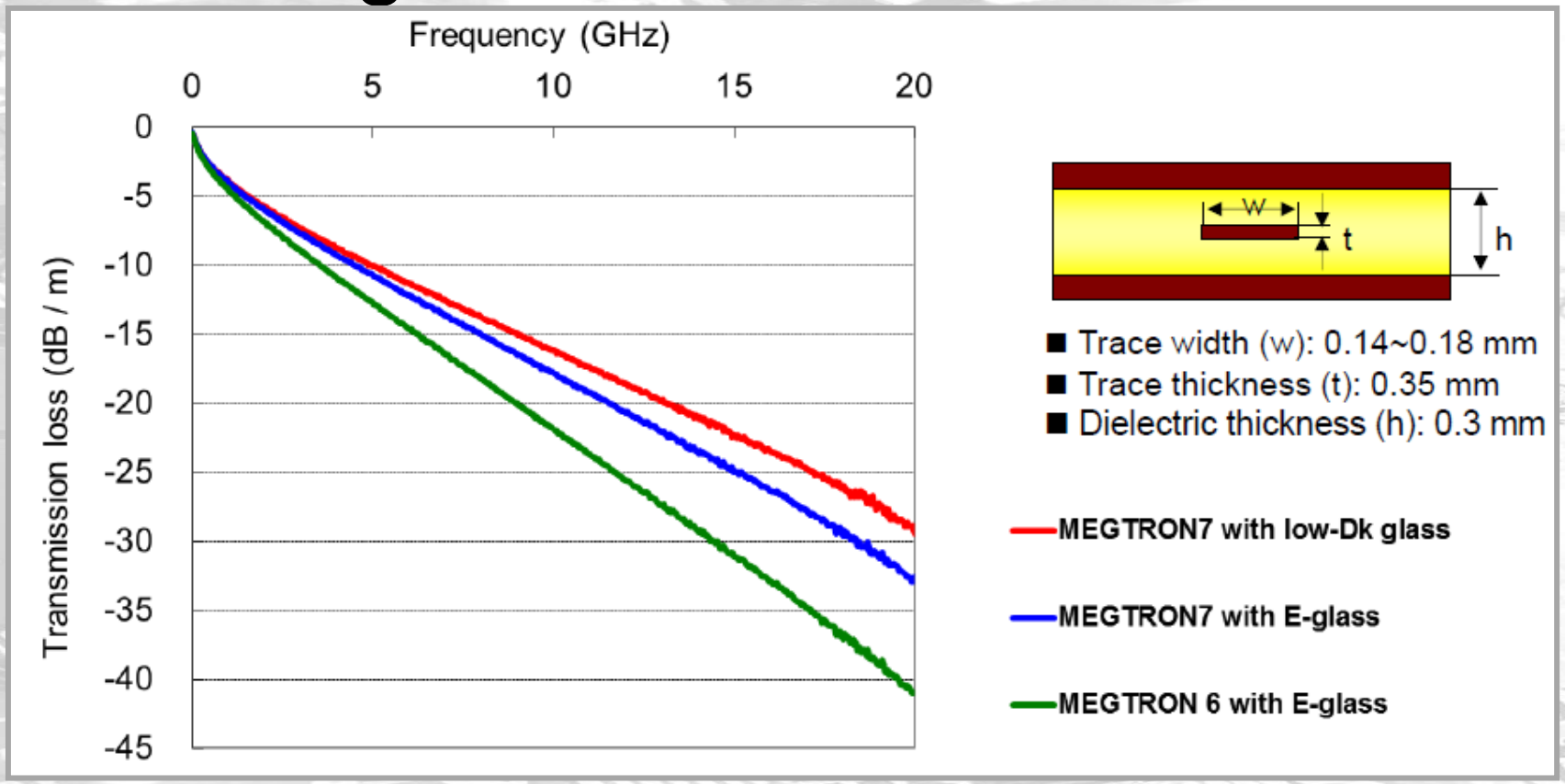


② Df



➢ Lower Dk & Df of materials has direct impact on signal transmission loss.

Electrical characteristics of glass – E-glass vs. Low Dk glass

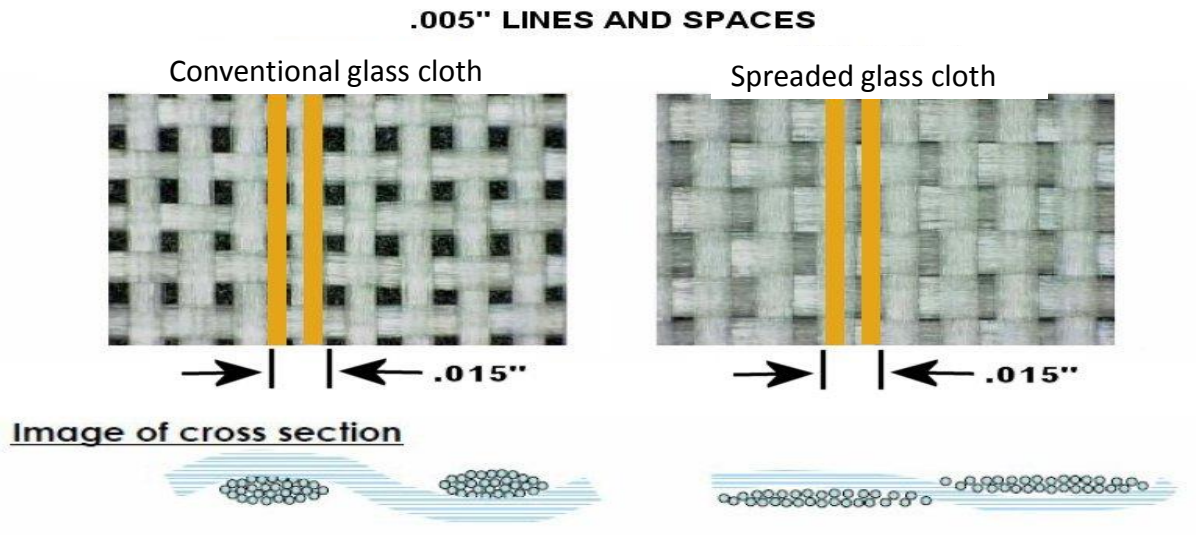


- The difference of transmission loss between E-glass and Low Dk-glass version of MEGTRON7 material is ~4dB/m at 20GHz.
- The impact is almost on the same as the difference between H-VLP and RT copper foil.

Key characteristics – Spreading of glass cloth

Differences in Propagation delay & loss are minimized with

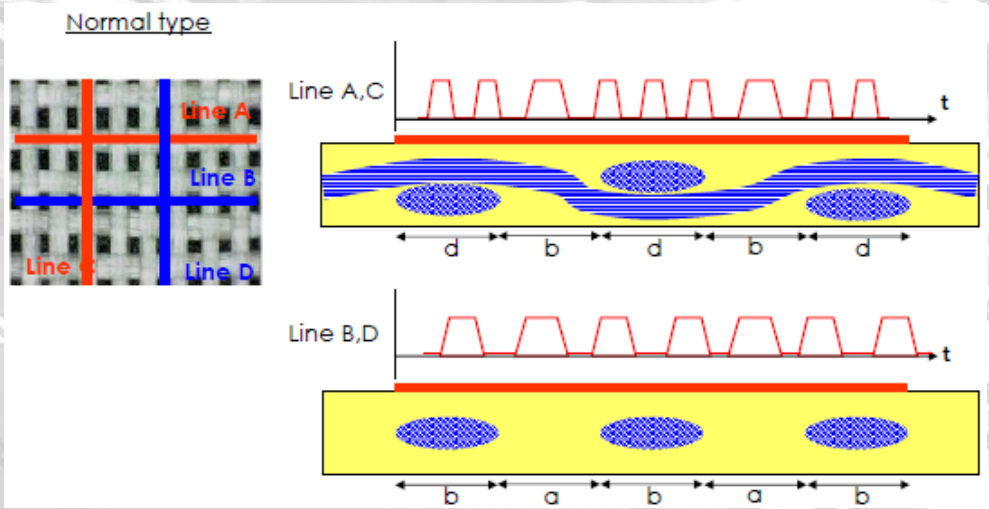
Spread-out Glass

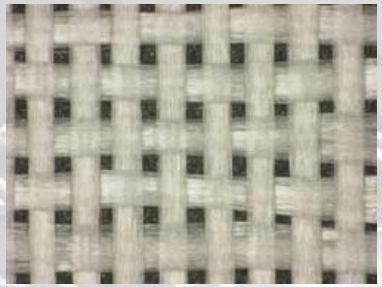


- Glass DK = 6.4 (IPC-4412)
  3.1.6.1 Dielectric Constant for Base E-Glass
  The DK of base E-glass to be used for printed board applications is 6.4 @ 1 GHZ
  (as measured by IPC-TM-650, Method 2.5.5.9)
- Resin/Filler Dk = 2.5 - 4.5

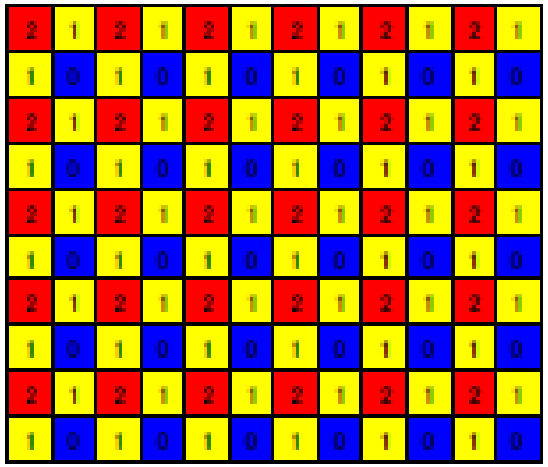
Key characteristics – Dk difference between glass and resin (”Skew effect”)

Conventional glass cloth type

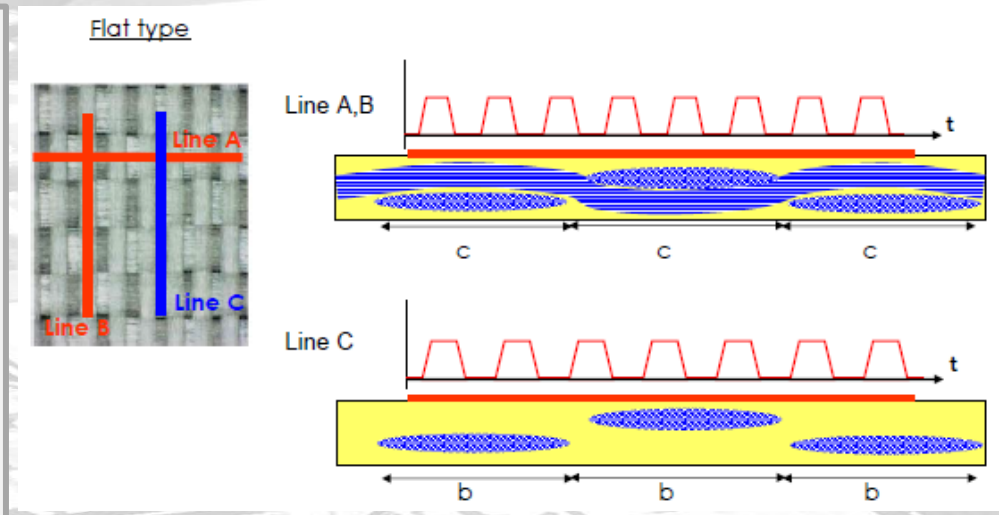




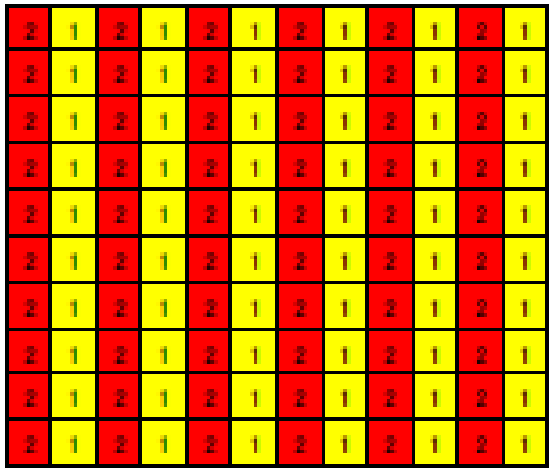
thread stack image

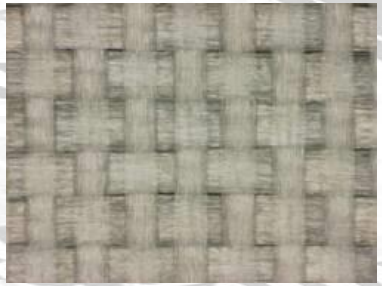


Spread-out glass cloth type



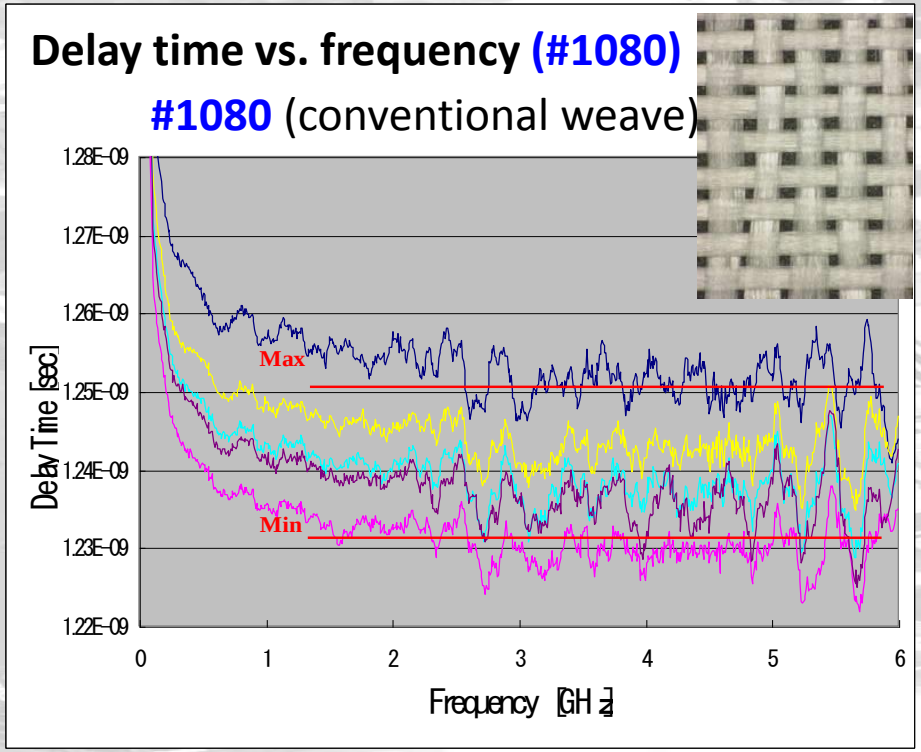
thread stack image

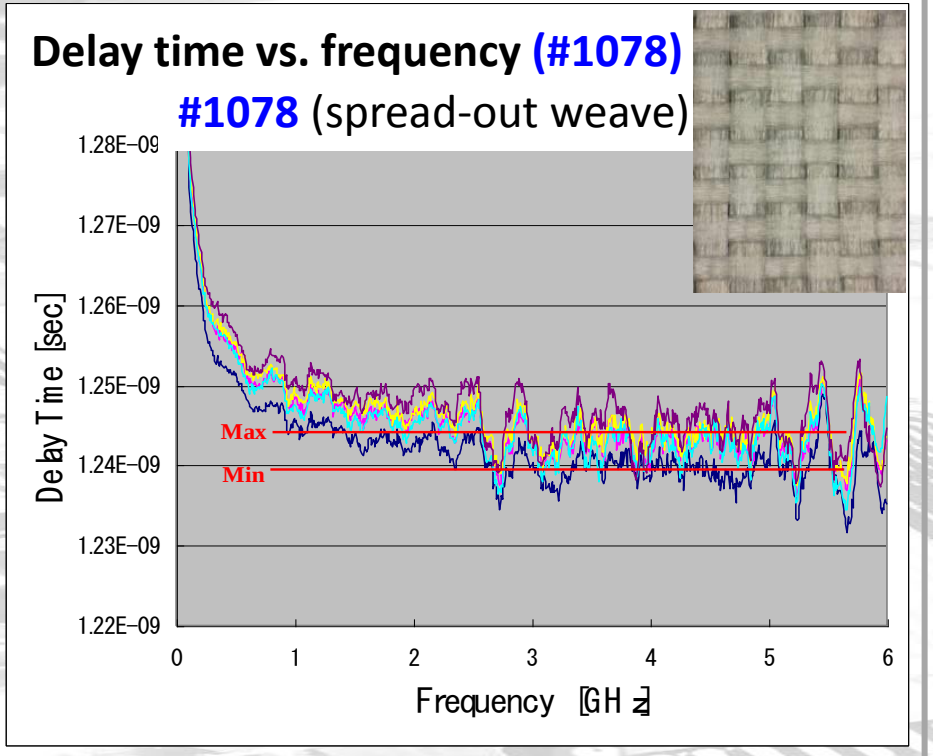


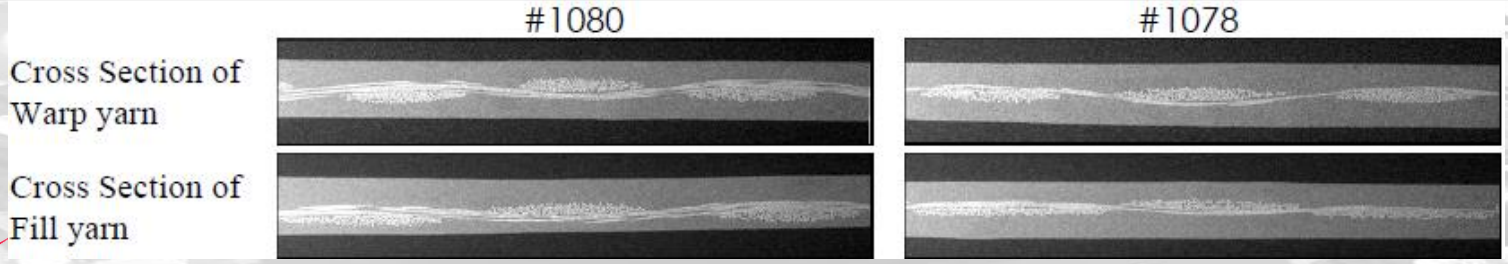


Key characteristics – Conventional glass vs. Spread-out glass

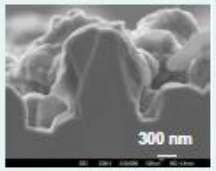
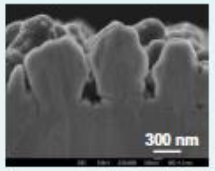
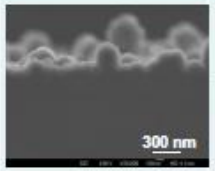
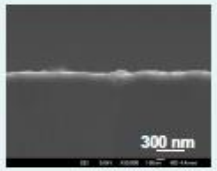
Delay Time vs Frequency

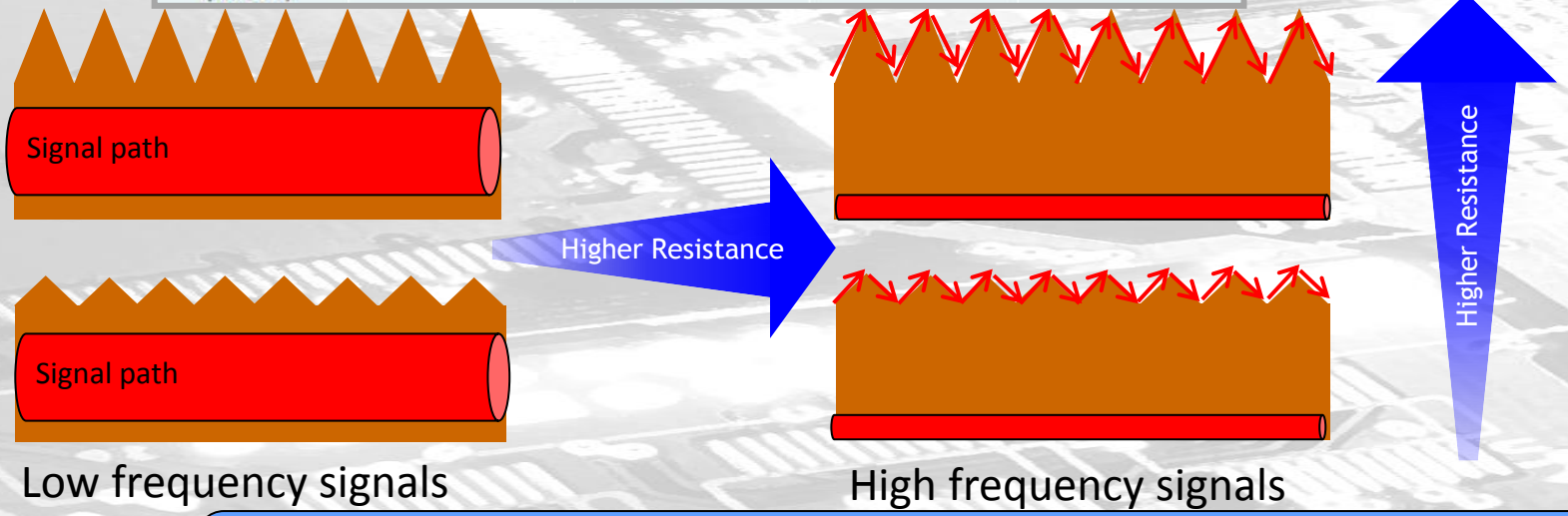






Key characteristics – Why copper foil roughness is important? (”Skin effect”)

Type	RT	H-VLP-1	H-VLP-2	H-VLP-3
X-section				
Rz (µm) (JIS B 0601-2001)	6.6	2.6	1.4	0.9
Peel Strength (kN / m)	0.89	0.89	0.69	0.80



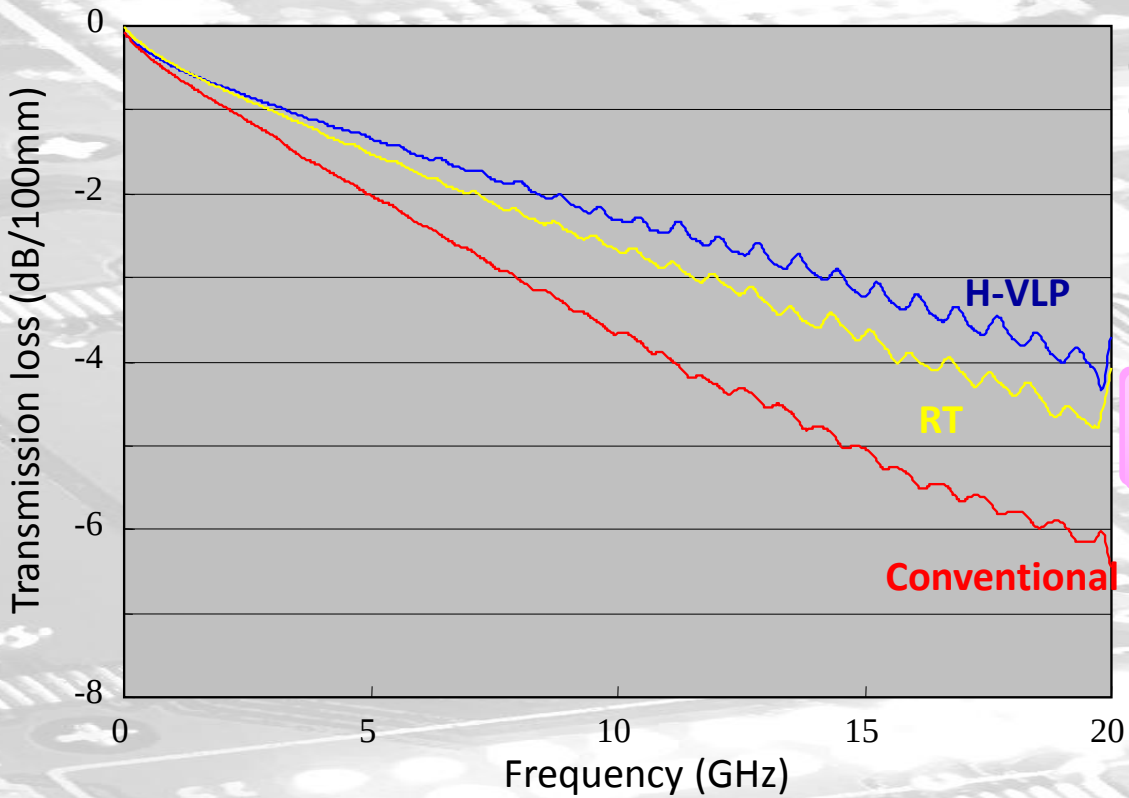
Low frequency signals

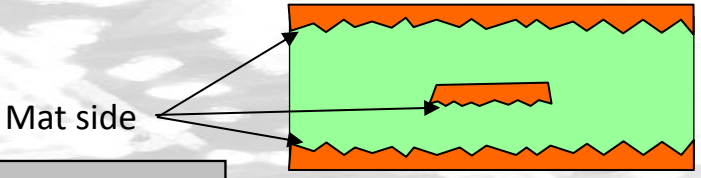
High frequency signals

Frequency	Skin effect depth
10 kHz	660 µm
100 kHz	210 µm
1 MHz	65 µm
10 MHz	21 µm
100 MHz	6.6 µm
1 GHz	2.1 µm
10 GHz	0.7 µm

- Copper profile is one of the main contributors for transmission loss for high frequency signals.

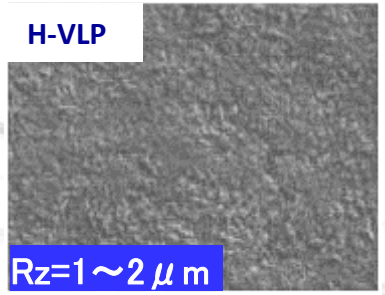
Key characteristics – Transmission loss vs. Copper foil type

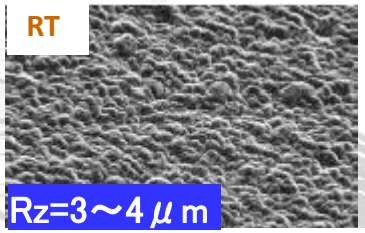


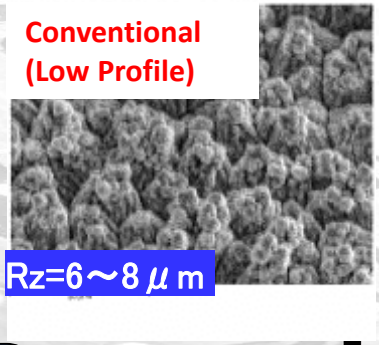


Cu Thickness : 35µm
Cu Type : H-VLP, RT, Conventional
Inner treatment Type : None
- Core : 6MIL (0.13t) (#2116x 1ply),
- Prepreg: #1080 RC64% *2ply
Line length : 100mm
Impedance : 50 Ω

MEGTRON6 [H-VLP]
MEGTRON6 [RT]







- Copper profile impact on transmission loss is getting bigger with higher frequencies.
- Copper foil profile has significant effect on transmission loss.

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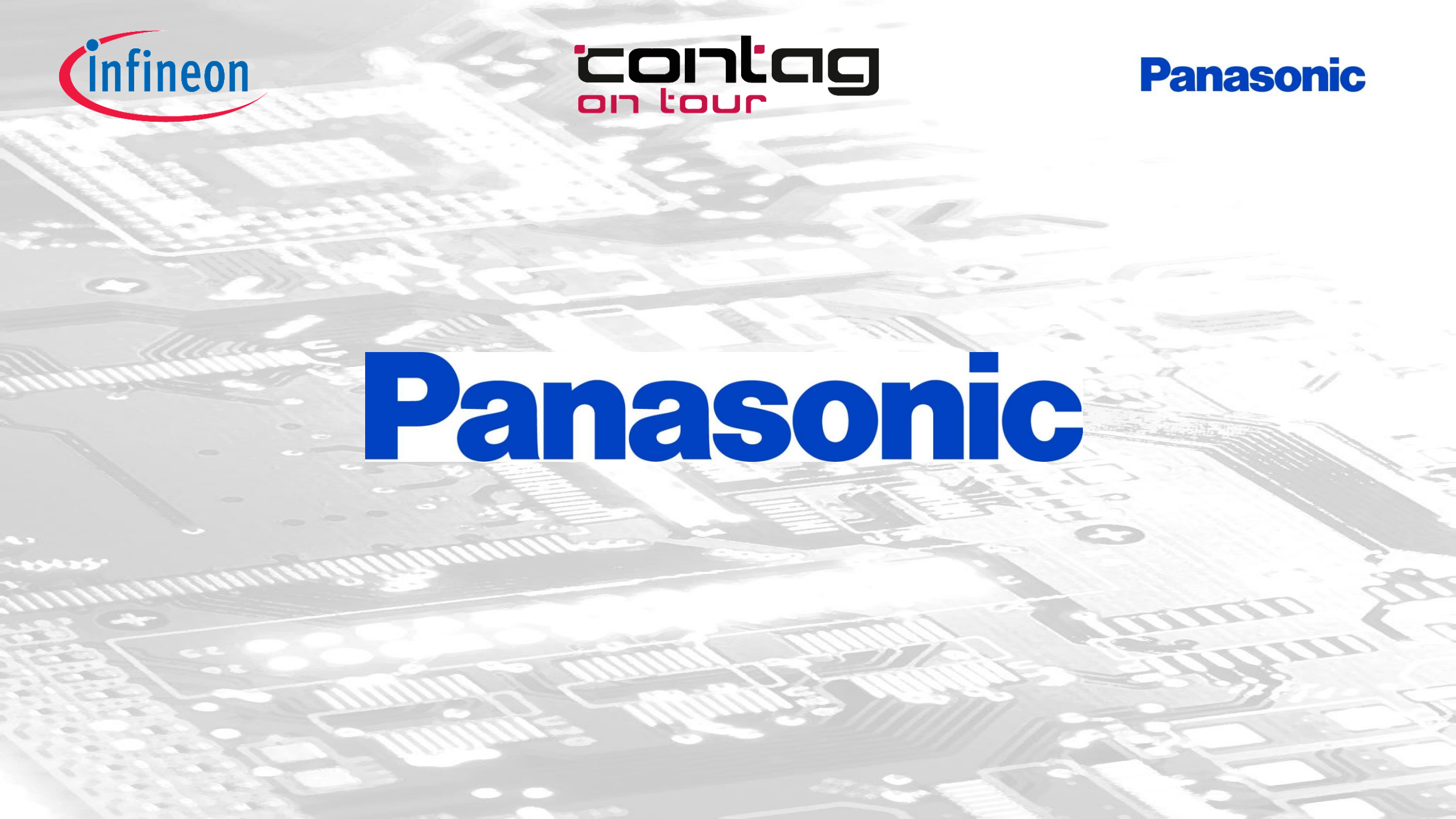
Summary and Key takeaways

- Higher the frequency requirements for application/PCB → more you need to understand laminates used in it.

- **Resin system**, **glass cloth** and **copper foil** have all significant impact on transmission loss in high frequency PCB‘s – good performance can be lost by specifying wrong property for other parameter.

- Low loss resin system, smooth copper profile and use of spreaded glass cloth style with Low Dk/Df properties, help to tackle challenges of high frequency signals.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