Design and Testing of a Reference PCB for Environmental Conditioning

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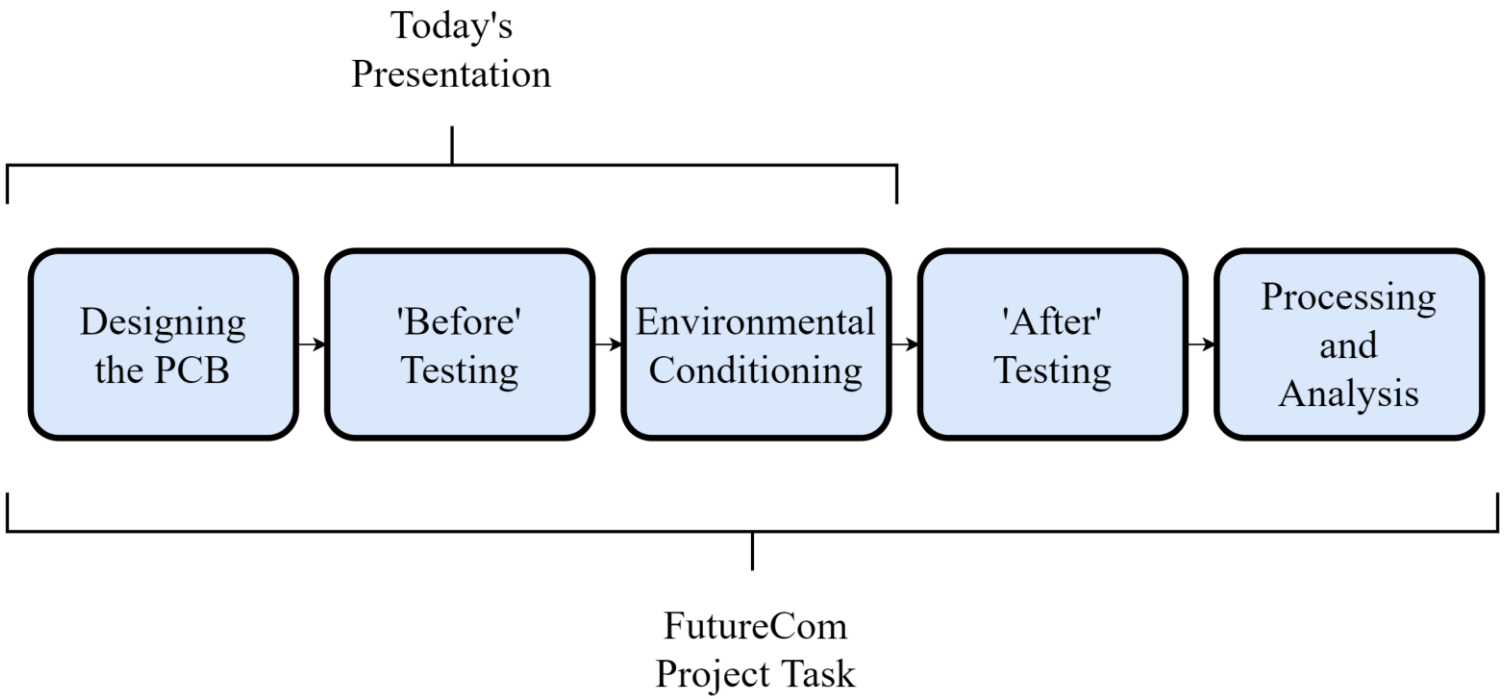
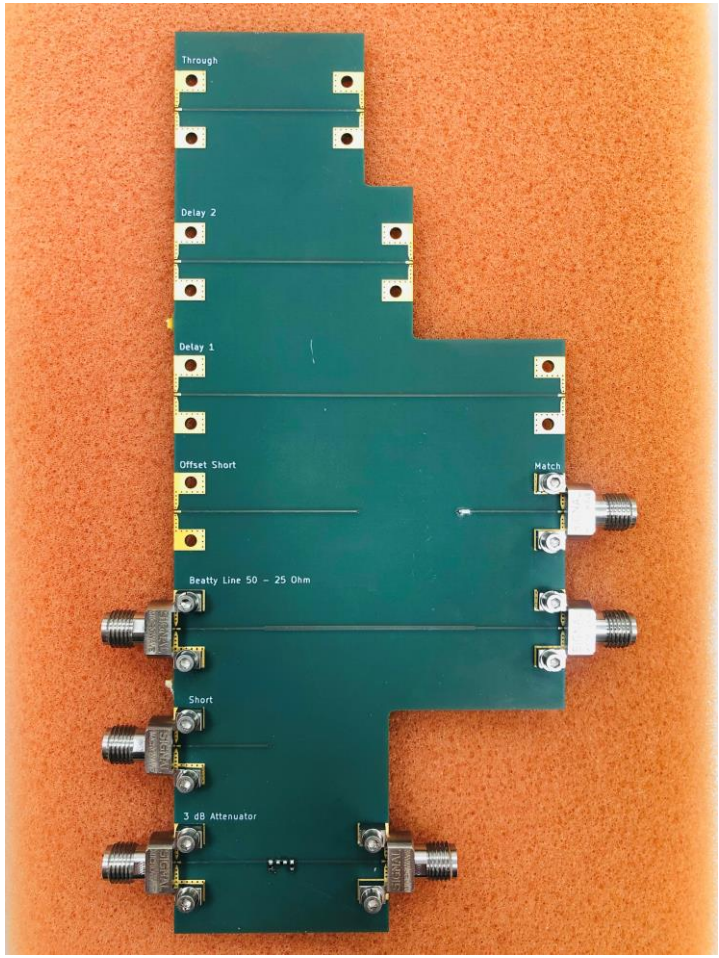
Background

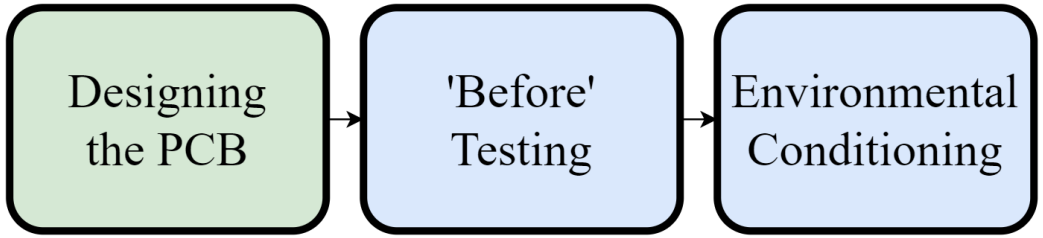
- Part of the EMPIR-funded ‘FutureCom’ project
- Tackle challenges of implementing future communication technologies
- The focus is on RF and Microwave circuit performance in harsh environments
- Collaboration with IMBiH (Institute of Metrology of Bosnia & Herzegovina)

Outline


Today's
Presentation
Designing the PCB
'Before' Testing
Environmental Conditioning
'After' Testing
Processing and Analysis
FutureCom
Project Task


Through
Delay 2
Delay 1
Offset Short
Match
Beatty Line 50 – 25 Ohm
Short
3 dB Attenuator

PCB Design Goals



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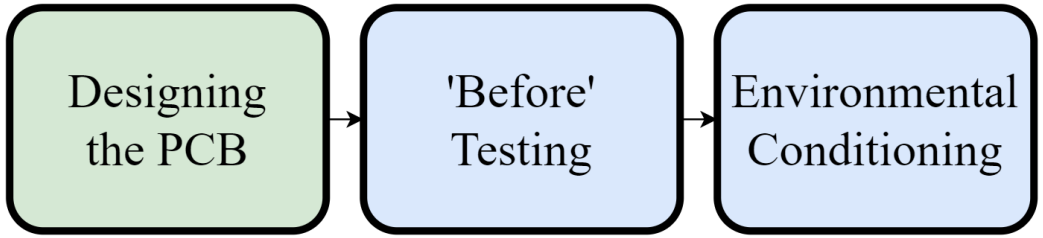
RF Measurements for future communications applications

- To learn *how* printed RF and Microwave circuits respond to harsh environments (temperature, humidity)
  - design goal: build a PCB that is representative of something that would be used in telecommunication technologies such as 5G, IoT, CAV…
  - design goal: use inexpensive PCB materials that work well in the sub 6 GHz band

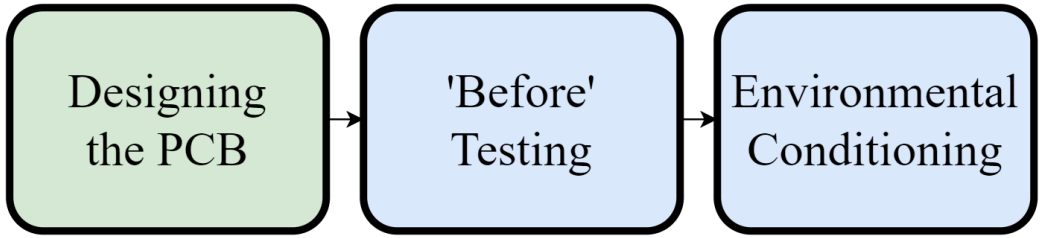
PCB Formfactor



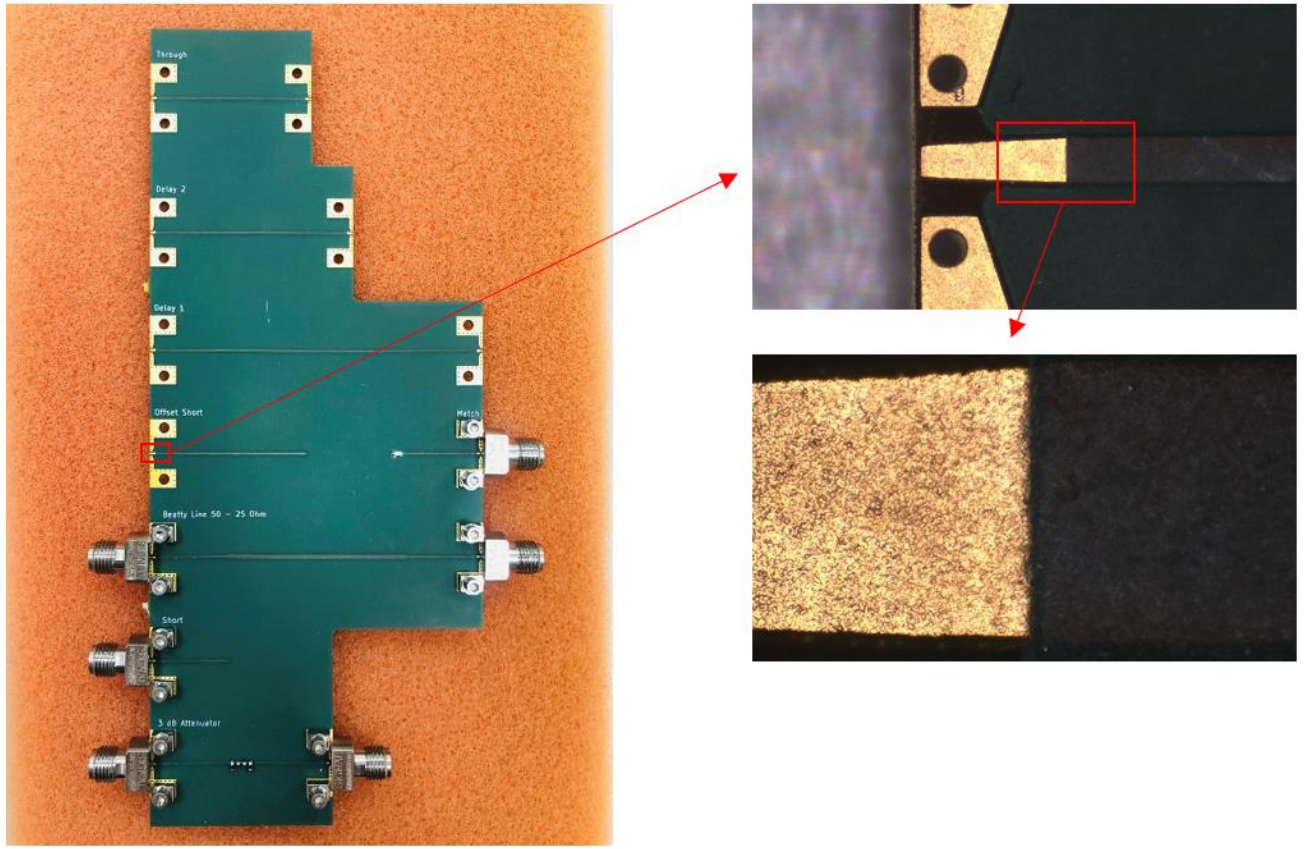
- 4-layer design
- Nominal 1.6 mm board thickness
- Chosen to emulate popular RF and microwave 4-layer PCBs

PCP L No	CAM L No	Layer No	Material Type	Component Type	Pre-preg Style	Unitary Thickness	Cu Thk Adjustment	P-Preg Qty Final Cu	Layer Cu Area (Sq")	% Copper Coverage	Effective Thickness	Impedance Layer Type	Polar H Values	Avg Min Separation	Drill / Sub Stacks
1	1	1		Foil		17.1	20.1	37.2	216.0	100%	37	CI Sig			
			PCL 370HR	Pre-preg	2113,59	102		1			102	4.09	213	213	
			PCL 370HR	Pre-preg	2116,56	122		1			122	4.14			
2	2	2		Cu Layer		34.3	-3	31.3	137.5	64%	20	CI Ref-Plane			
			PCL 370HR	Core	0.991ML	1000					1000		N/A	1000	
3	3	3		Cu Layer		34.3	-3	31.3	137.5	64%	20	CI Ref-Plane			
			PCL 370HR	Pre-preg	2116,56	122		1			122	4.14	213	213	
			PCL 370HR	Pre-preg	2113,59	102		1			102	4.09			
4	4	4		Foil		17.1	20.1	37.2	216.0	100%	37.2	CI Sig			

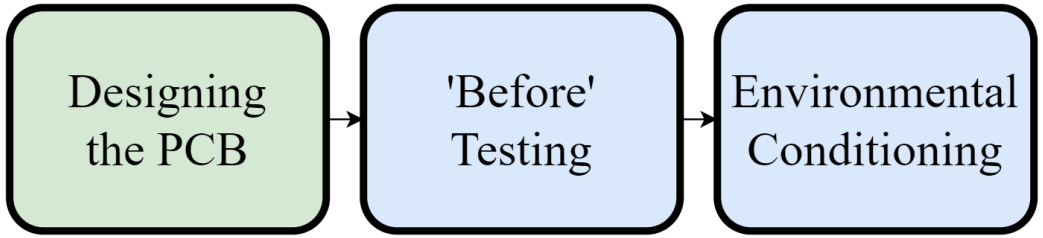
PCB Materials



- Isola 370 HR prepreg + core
- Soldermask
- Electroless nickel immersionless gold (ENIG) finish
- Selective finishing

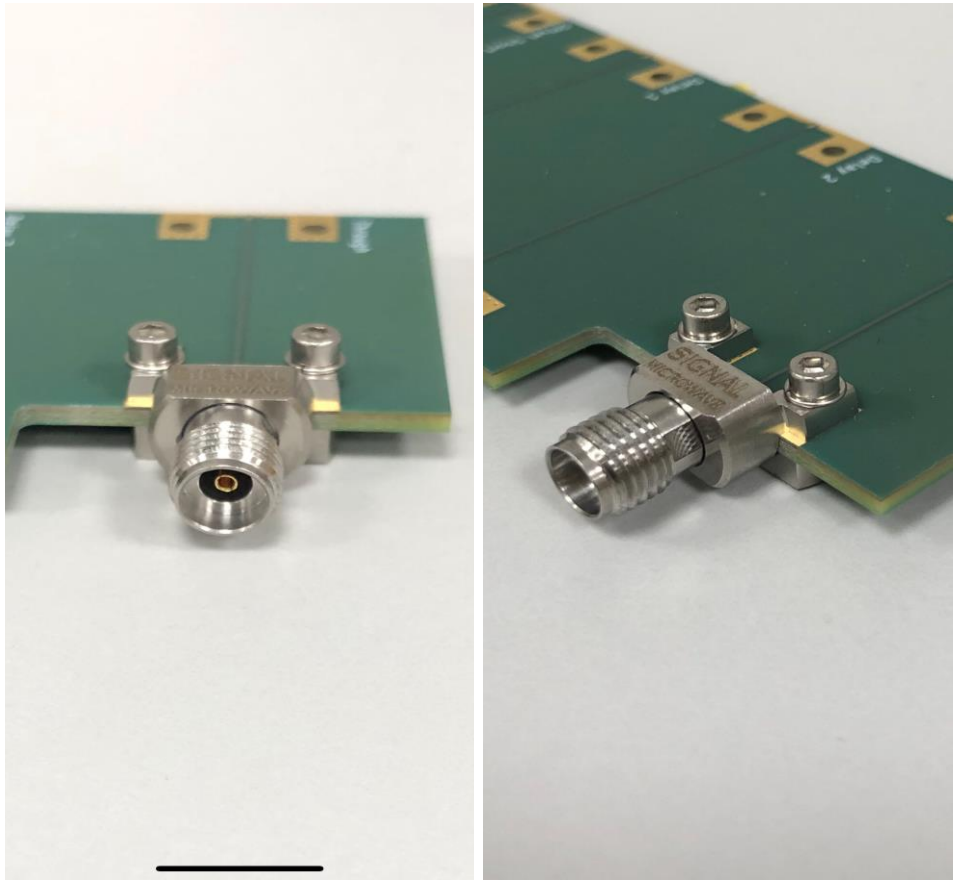


Connectorisation



- Metrology grade 2.92 mm end-launch connectors

- Screw connectors allows for isolation of PCB’s response to environmental conditioning



PCB Measurement Setup

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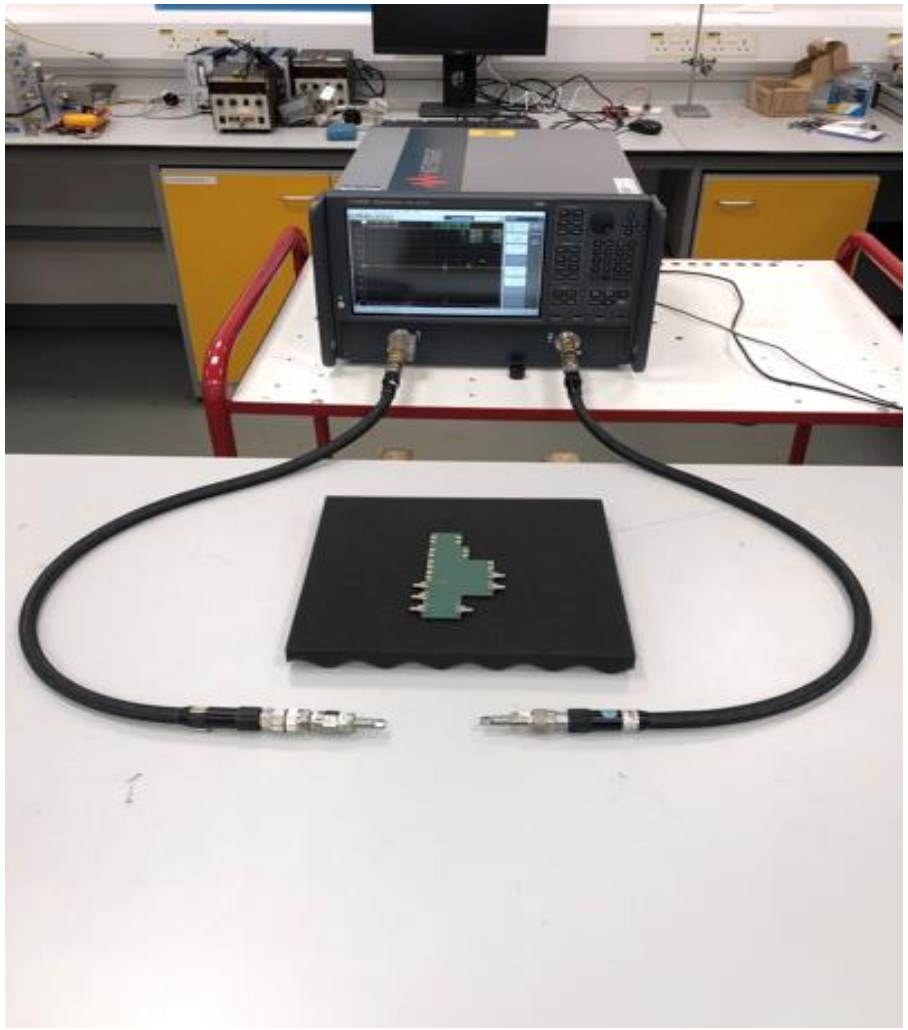

RF and Microwave Measurements

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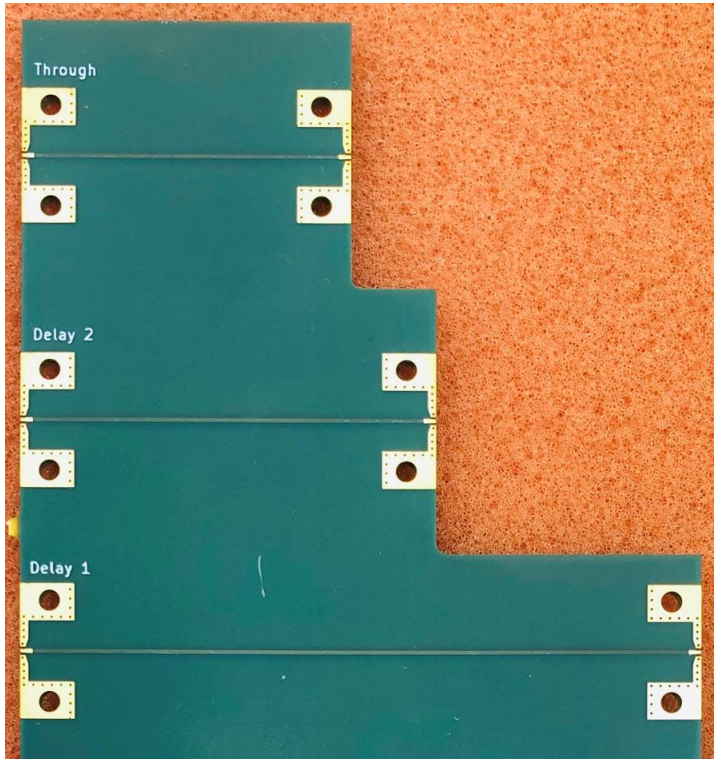
RF Measurements for future communications applications

- Basic printed structures used to assess the performance of the circuits:

Structure	Description
Through	Connector launches + track length (28.74 mm)
Delay 1	Connector launches + track length (61.92 mm)
Delay 2	Connector launches + track length (36.79 mm)
Beatty Line	Connector launches + 14.36 mm length of 376 µm width track + 33.08 mm length of 743 µm width track +14.47 mm length of 376 µm width track (tapered transitions between different widths of track)
Short	Connector launch + track length 14.37 mm + via to ground
Offset Short	Connector launch + track length 29.10 mm + via to ground
Load	Connector launch + track length 14.37 mm + 50 ohm surface mount resistor to ground
3 dB Attenuator	Connector launch + track length 14.37 mm + pi network of surface mount resistors with a nominal 3 dB attenuation + track length 14.37 mm



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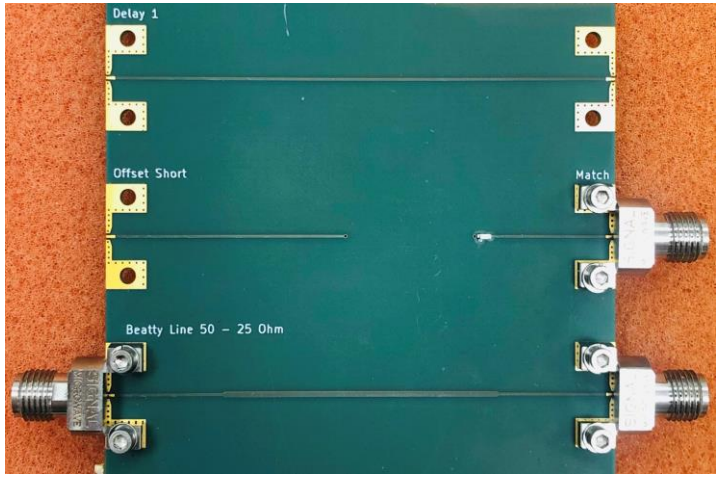

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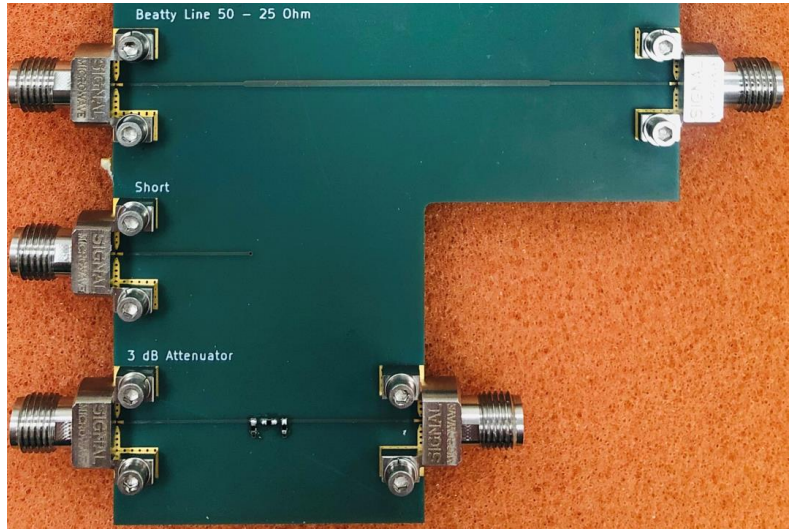
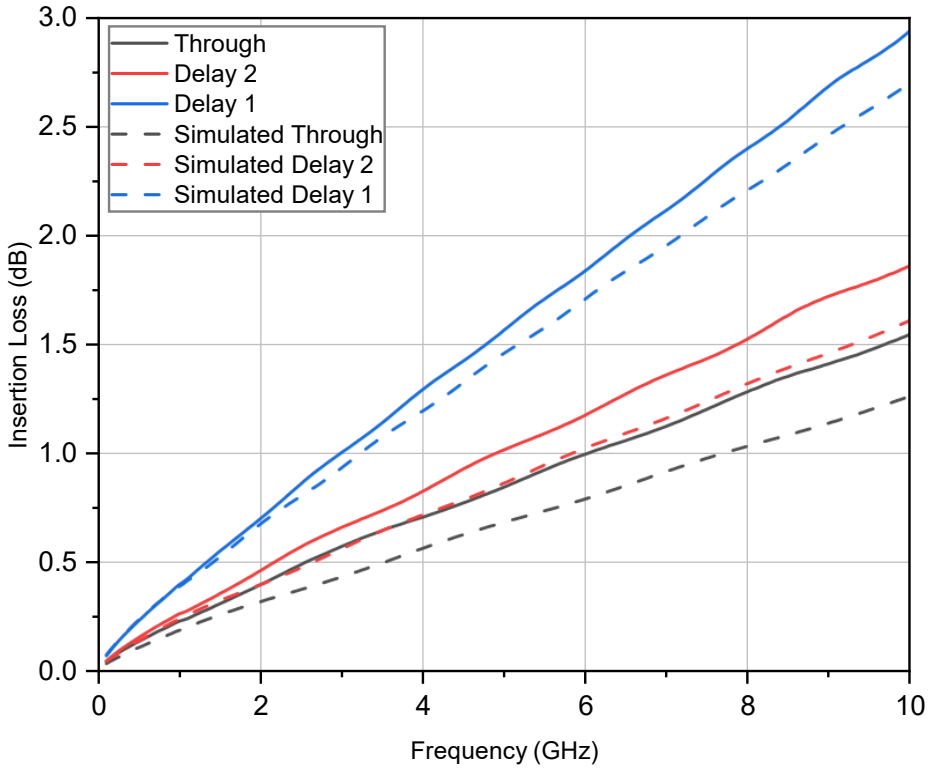


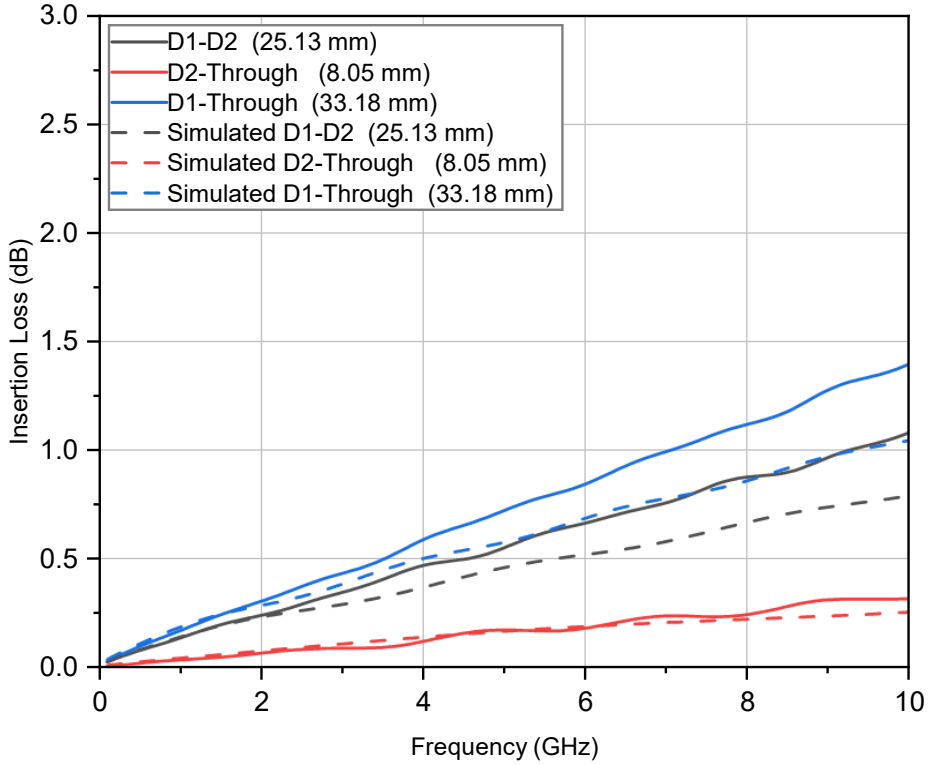
Some ‘Before’ Data

- Comparison of insertion losses of different microstrip lines and their simulated equivalents:



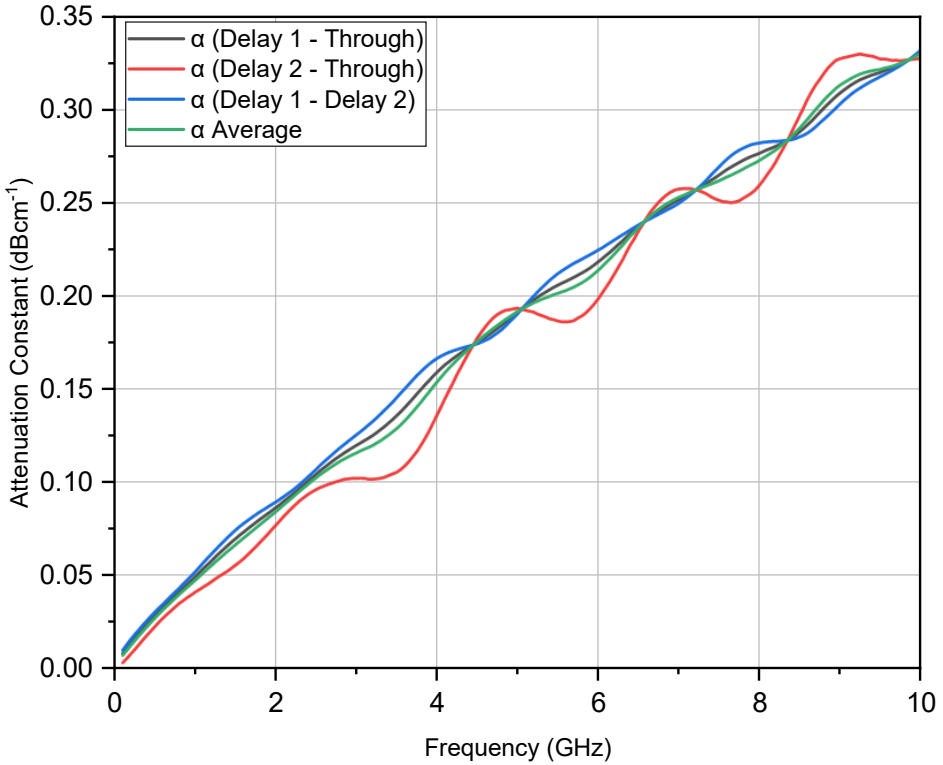
Some ‘Before’ Data

- Comparison of *differenced* insertion losses of different microstrip lines and their simulated equivalents:



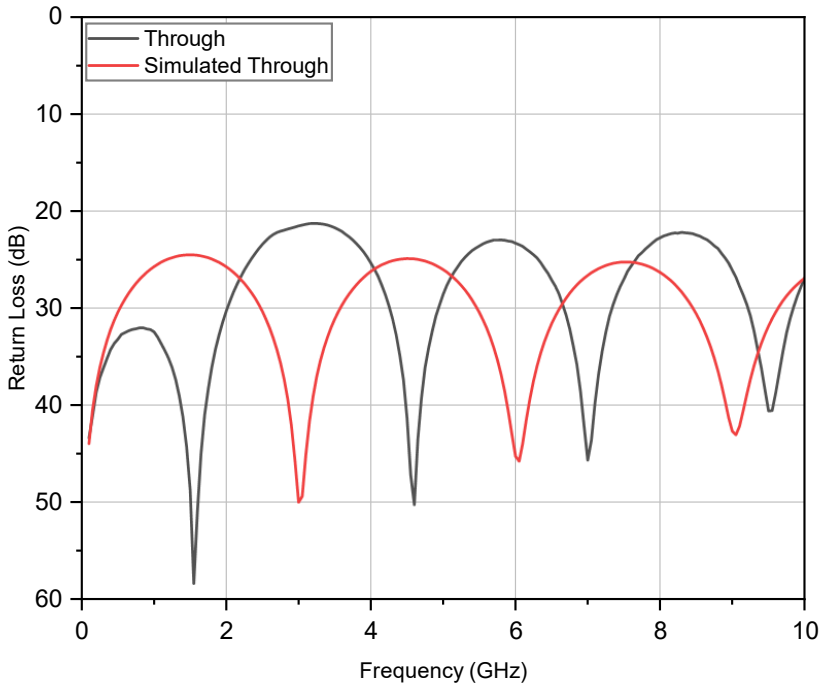
Some ‘Before’ Data

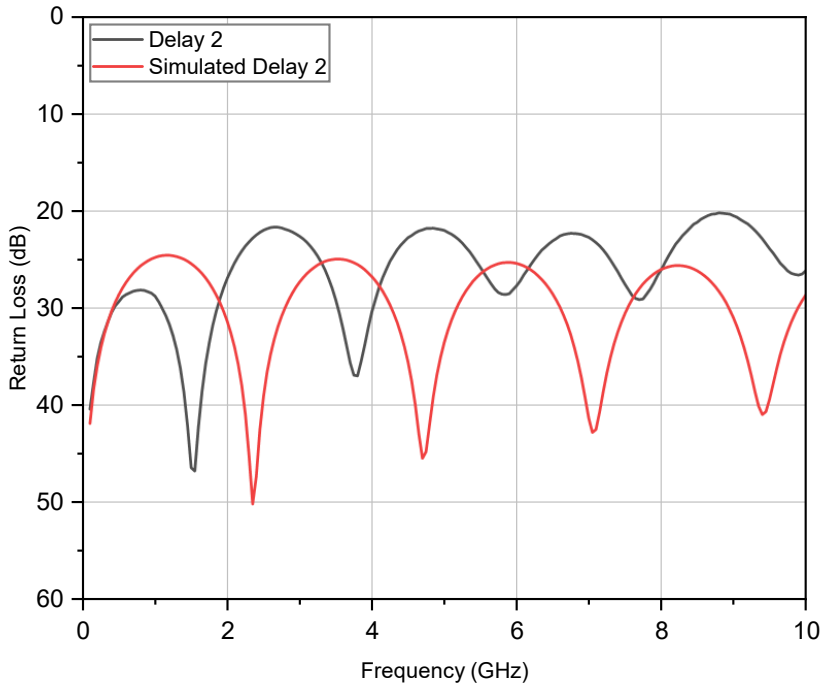
- Comparison of derived attenuation constant, α, from difference microstrip lines along with their average:

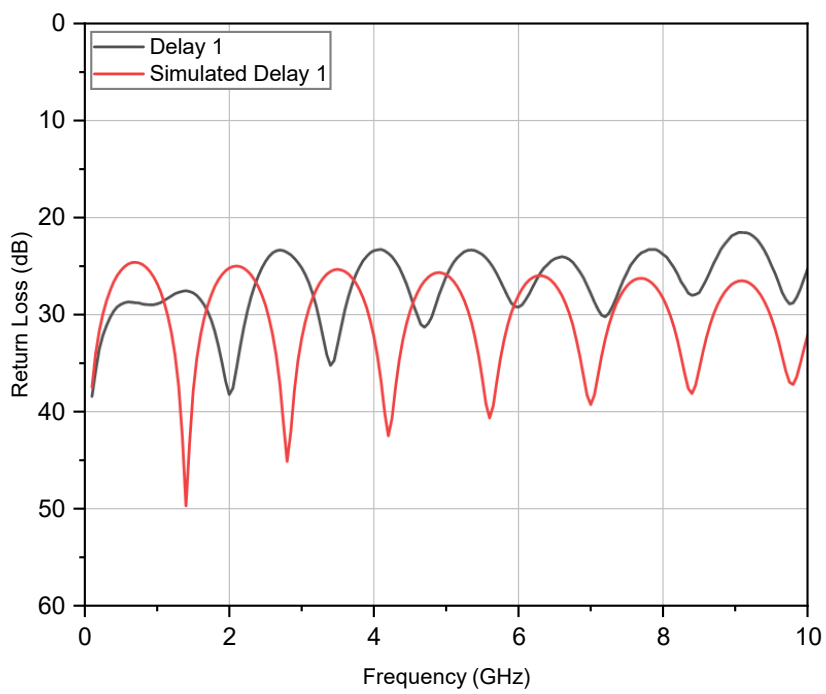


Some ‘Before’ Data

- Return loss comparison of the different microstrip lines and simulated equivalents; as the line’s length is increased more ripple is observed
- Generally good return loss with minimum measured loss of around 20 dB

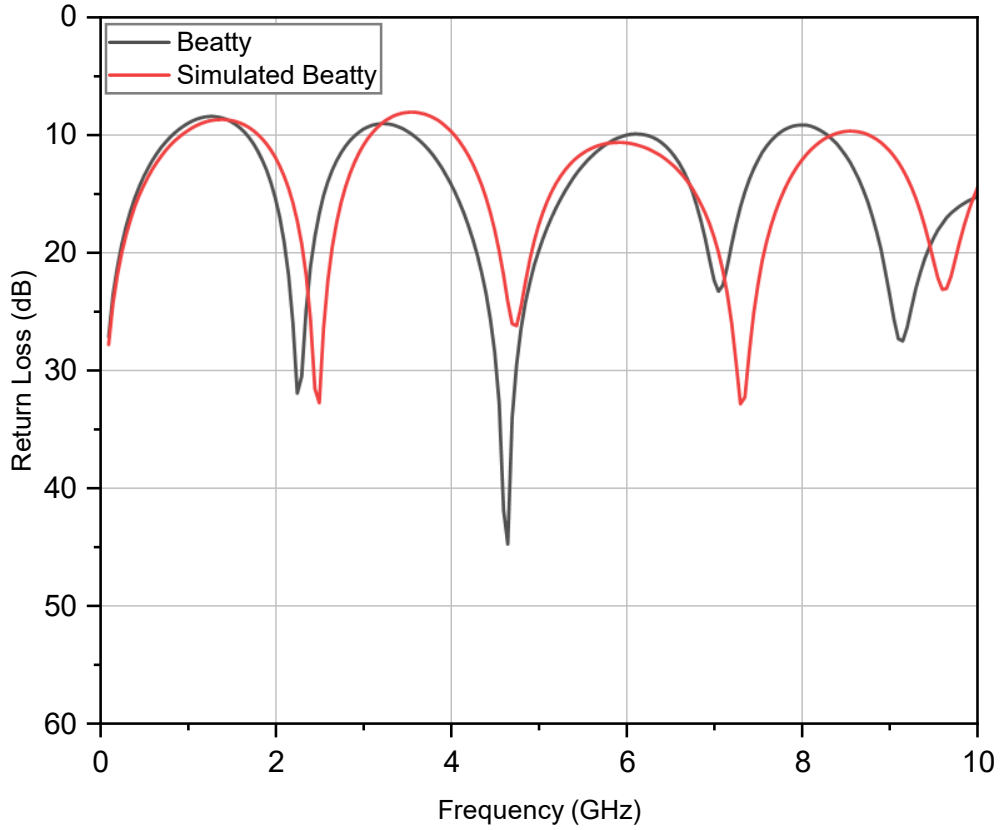


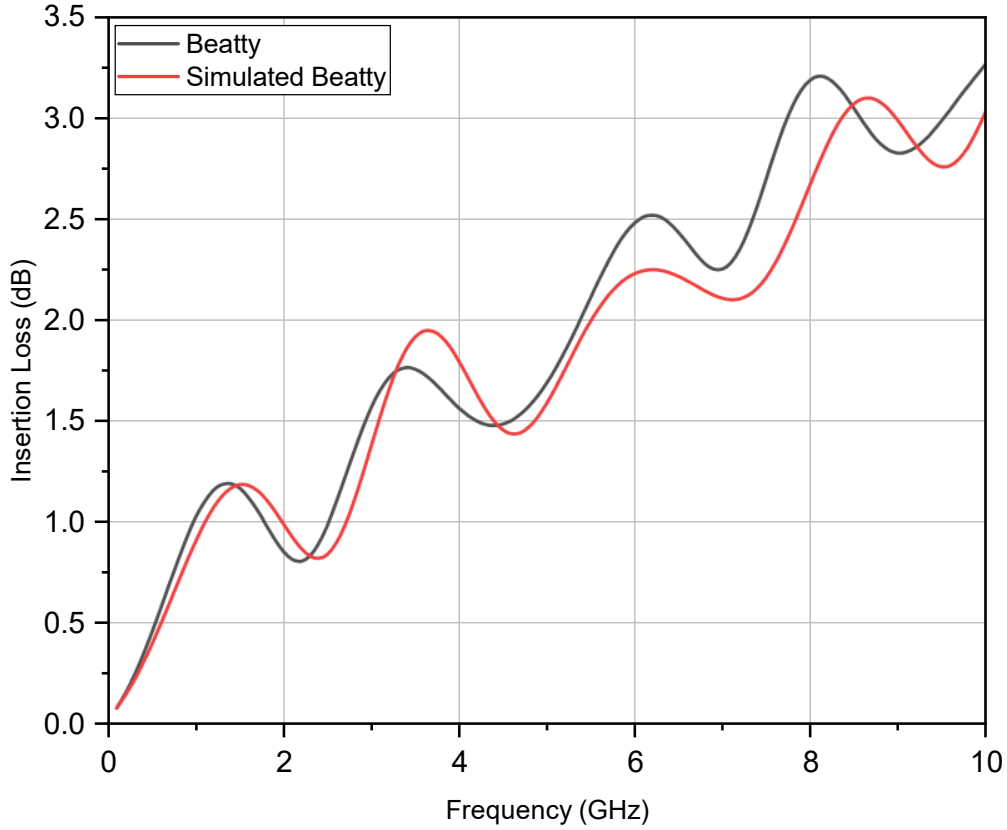




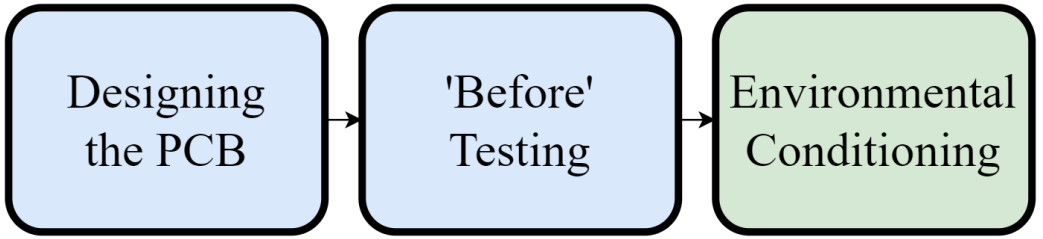
Some ‘Before’ Data

- Beatty line return loss and insertion loss with simulated equivalent circuit comparison:





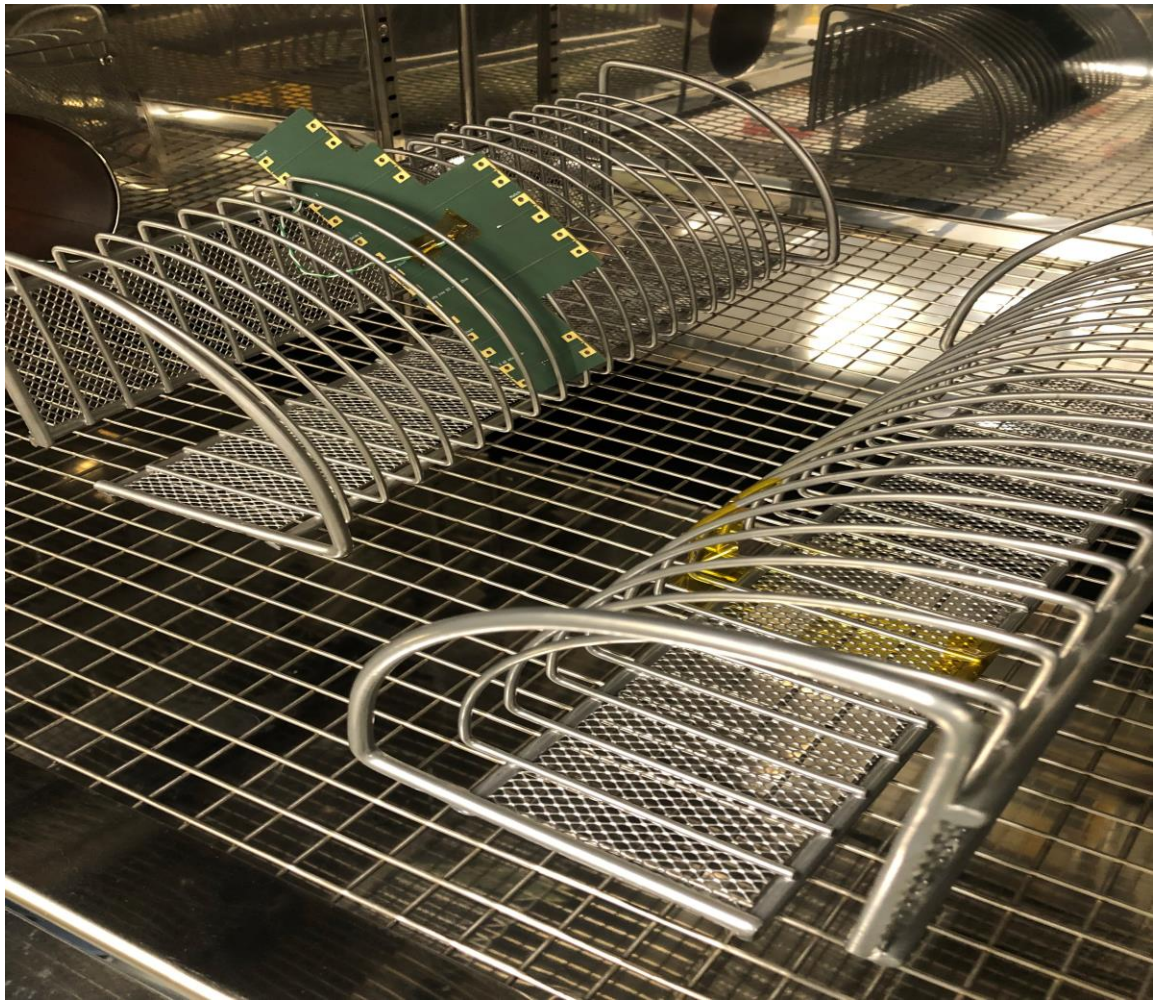
Environmental Conditioning



- Thermal Cycling
  - - 40°C to 80°C, 500 cycles
- Damp Heat Testing
  - 85°C at 85 % humidity, 500 hours
- Isothermal Ageing
  - 125°C, 500 hours

PCB Thermal Cycling

Designing the PCB → 'Before' Testing → Environmental Conditioning



A work in progress…

- Design improvements/optimisations?
- Testing different substrate materials at different bands?
- Testing different structures, transmission line types, active components?
- Testing stackups, layering of the PCBs?
- Different conditioning regimes?

- Any other suggestions?

Thanks for your attention

Contact details:

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