

AFSIW Y-Junction Circulator for High-Power Handling New Space Applications

I. Marah^{1,2}, A. Ghiotto² and J-M. Pham¹

¹Cobham Microwave, Les Ulis, France

²Univ. Bordeaux, Bordeaux INP, CNRS, IMS, Talence, France

Speaker : Issam MARAH

Outline

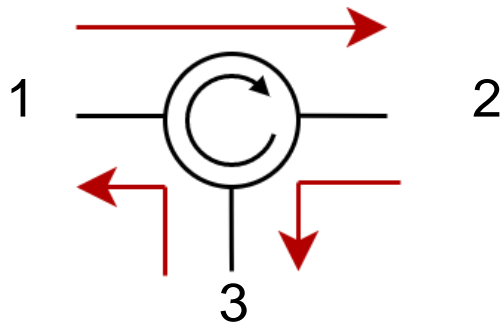
- Introduction
- AFSIW technology
- Power handling of circulators
- Proposed AFSIW circulator
- Measurement and tests
- Further Work
- Conclusion

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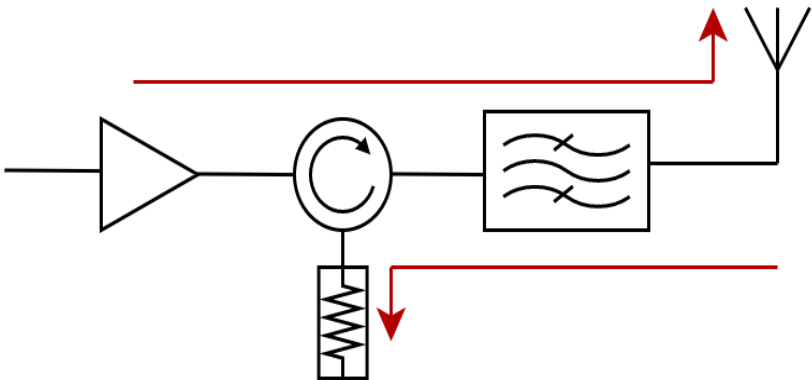
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Introduction

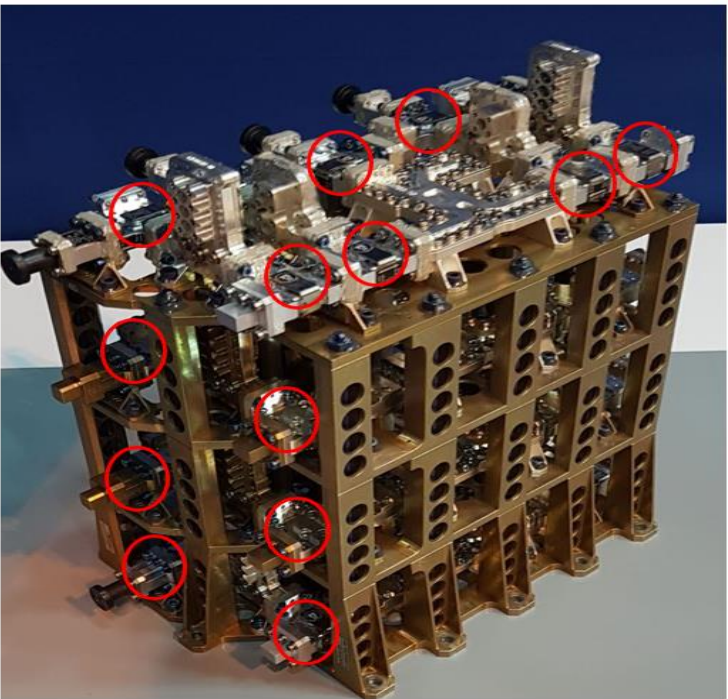
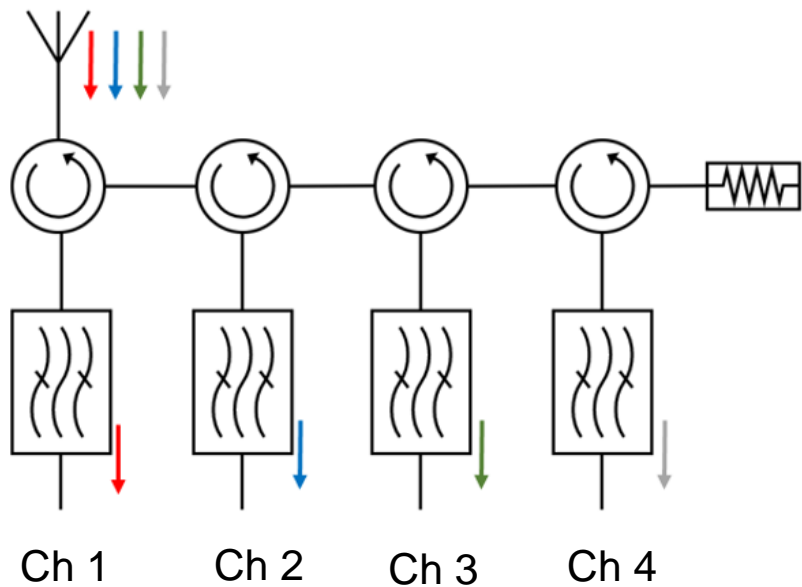
- Circulator**



- Isolator Implementation**

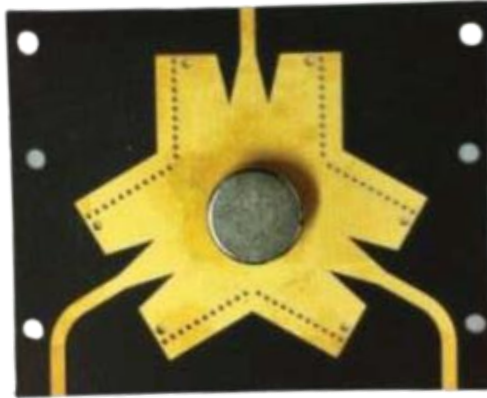


- IMUX / OMUX**



IMUX : EUMW 2018 Thales Alenia Space

SIW and AFSIW



SIW



- Low cost
- High integration density
- Low weight
- Self shielded
- Compact



- Medium insertion loss
- Medium quality factor
- Medium power handling

Technological Alternatives



Air-Filled SIW



- Low cost
- High integration density
- Low weight
- Self shielded
- Low insertion loss
- High quality factor
- High power handling

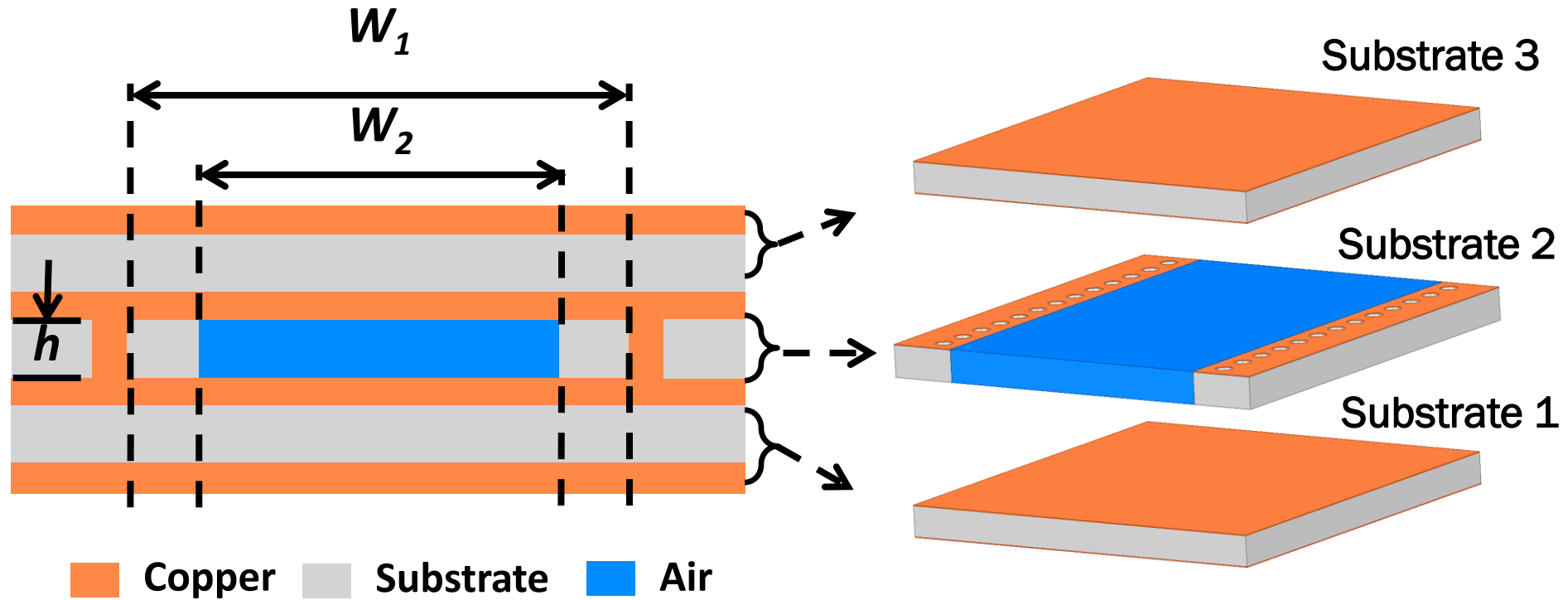


- Less compact

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AFSIW Technology



High degrees of freedom leading to creative designs

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Power Handling

Thermal Breakdown

- Surface current intensity
- Component insertion loss
- Materials thermal conductivity
- Environment
- Component size : Height and Area



Vacuum

{ferrite, dielectric, vacuum}

Metal post

Multipactor

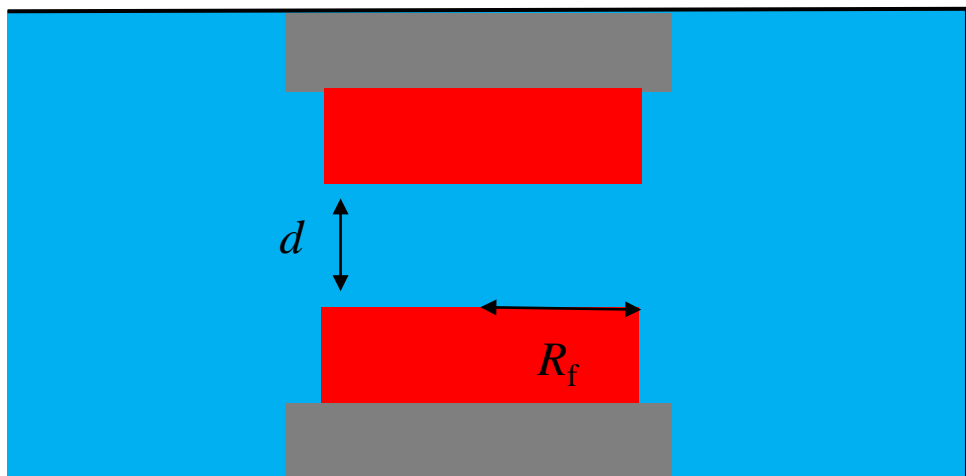
- Electrical field intensity
- Materials secondary emission
- Operation frequency
- Magneto static field

Self Heating \equiv Height/Area

Multipactor $\equiv f \times$ critical gap

Commercial WG Circulator

Thermal Behavior Benefits



Ferrite
 Vacuum
 Metal post



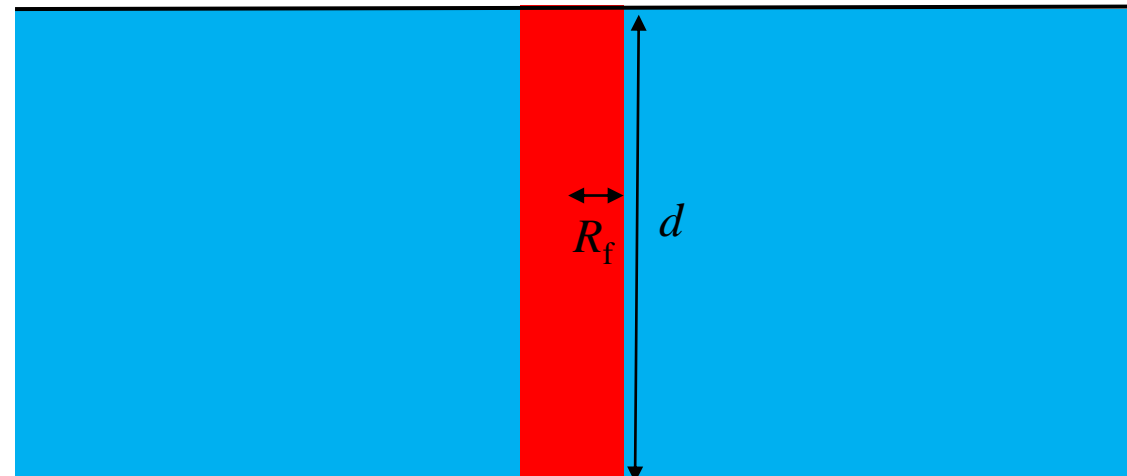
- Large ferrite radius
- Small ferrite Height
- Good thermal behavior



- Low critical gap : d
- Low multipactor margin



Multipactor Benefits



Ferrite
 Vacuum



- High critical gap : d
- High multipactor margin



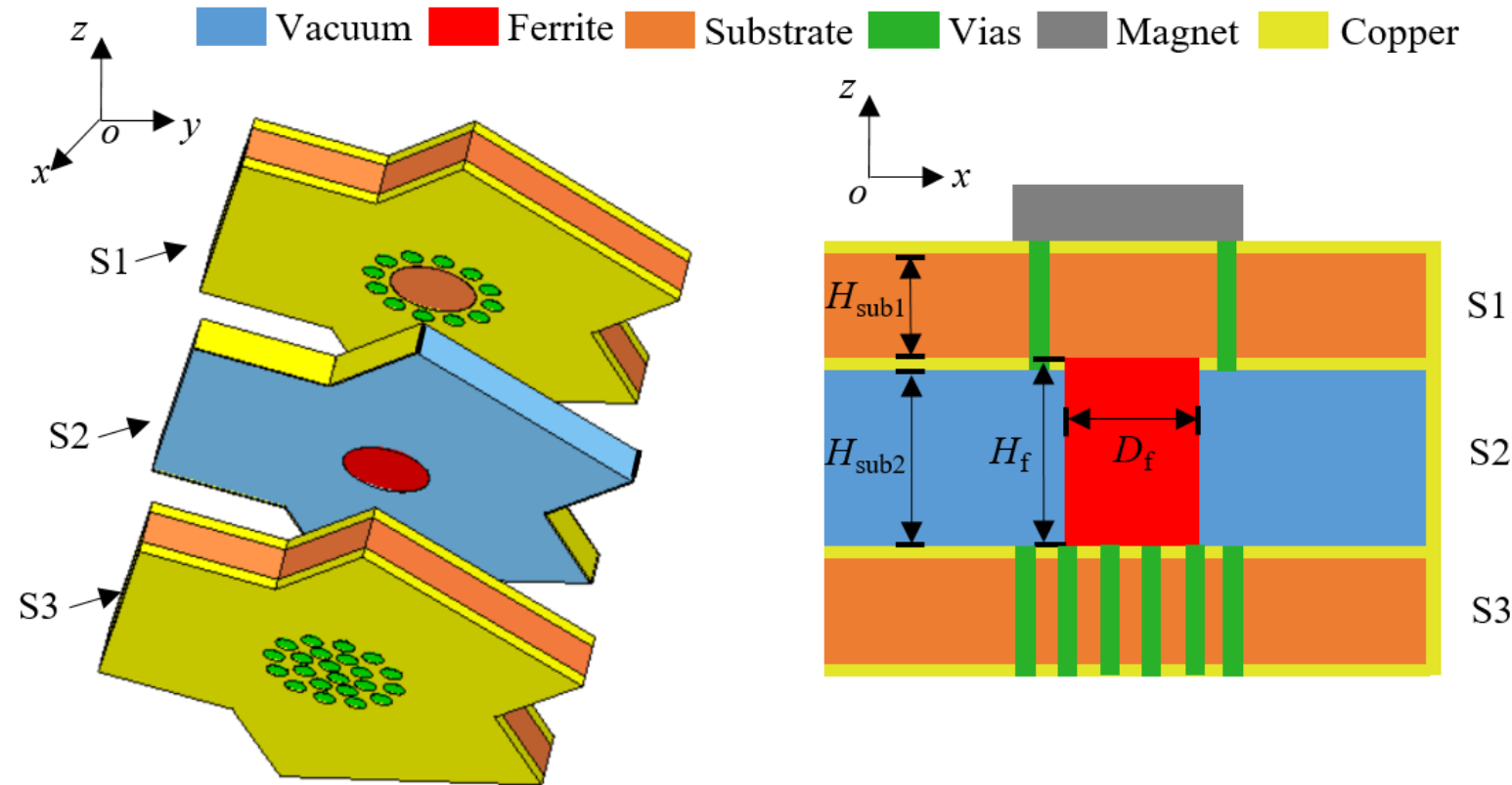
- Small ferrite radius
- Large ferrite Height
- Bad thermal behavior

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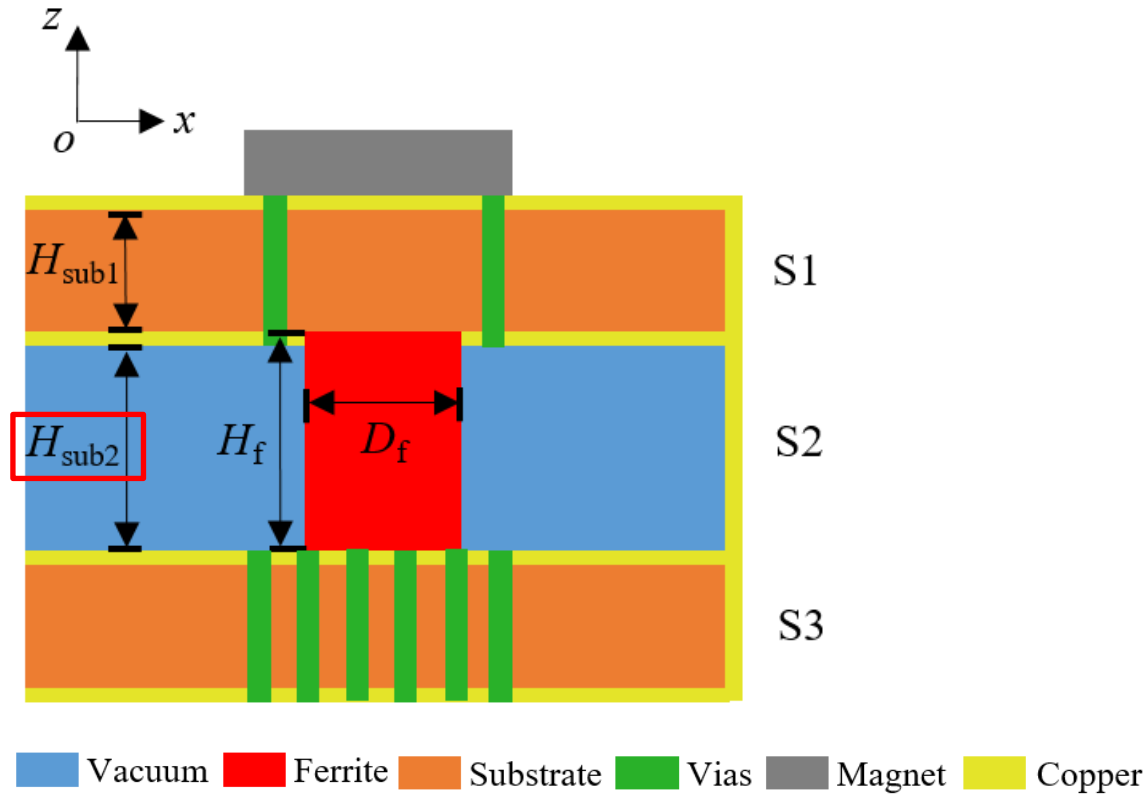
Proposed AFSIW Design

PATENTED

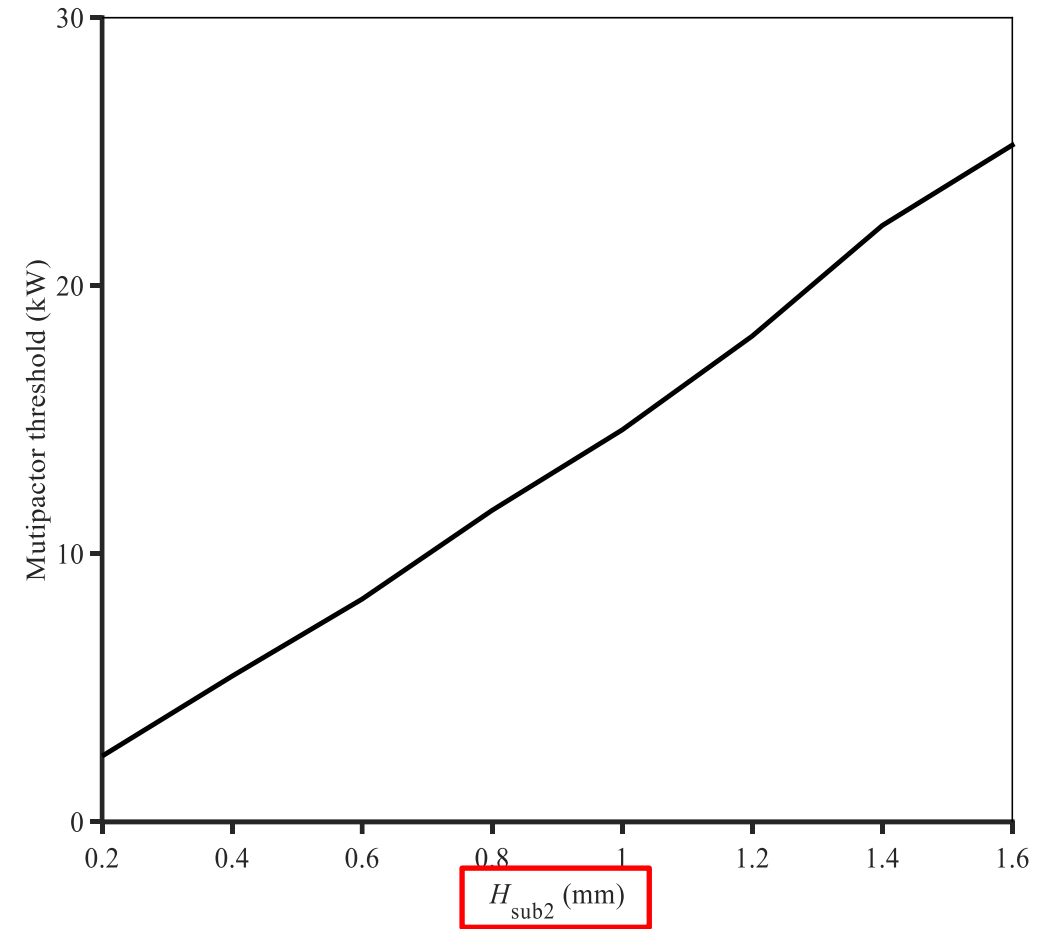


- Stacked 3 layers PCB
- Fully filled junction with ferrite
- Ferrite cylinder coupled to SIW S1 cavity

Power Handling Evaluation

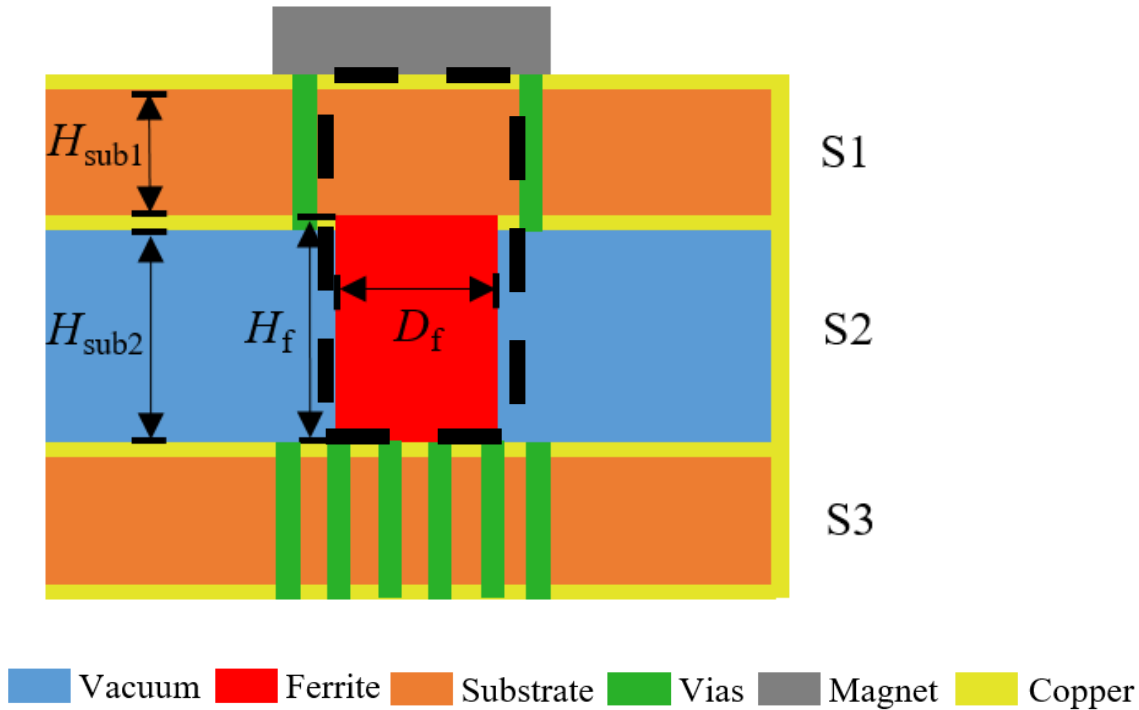


Vacuum gap removed in the critical region



Fully ferrite filled junction increases multipactor margin

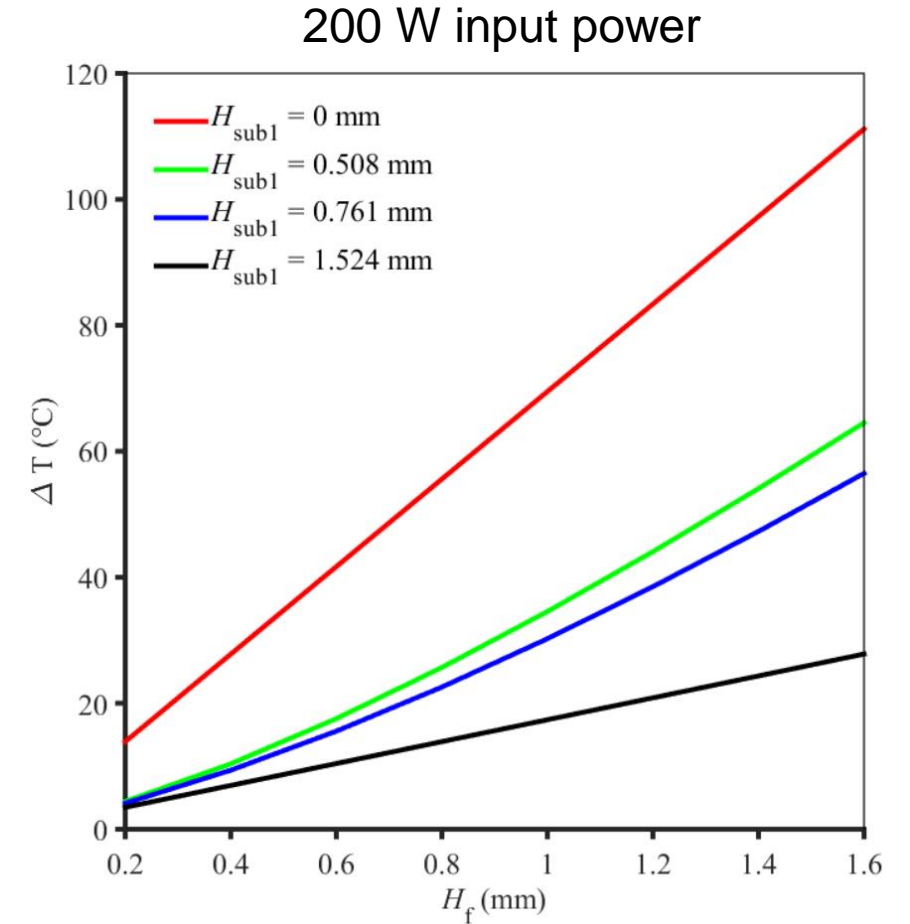
Power Handling Evaluation



$$k_0 D_f \sqrt{\epsilon_{eff}} = 1.84$$

$$\Delta T = \frac{4P_{dis}H_f}{k_f\pi D_f^2}$$

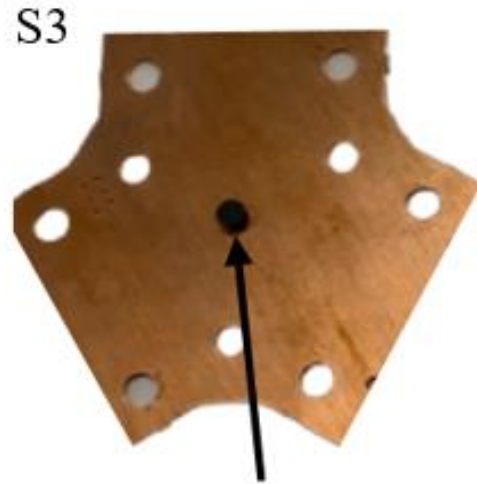
Use of substrate 1 increases thermal performance by increasing the ferrite diameter



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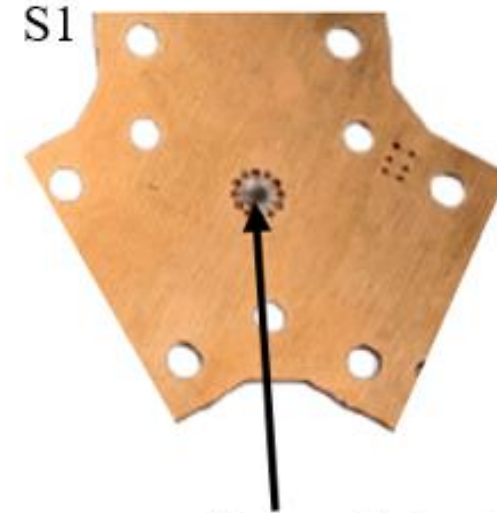
Manufactured AFSIW Circulator



Ferrite



.....Reference planes



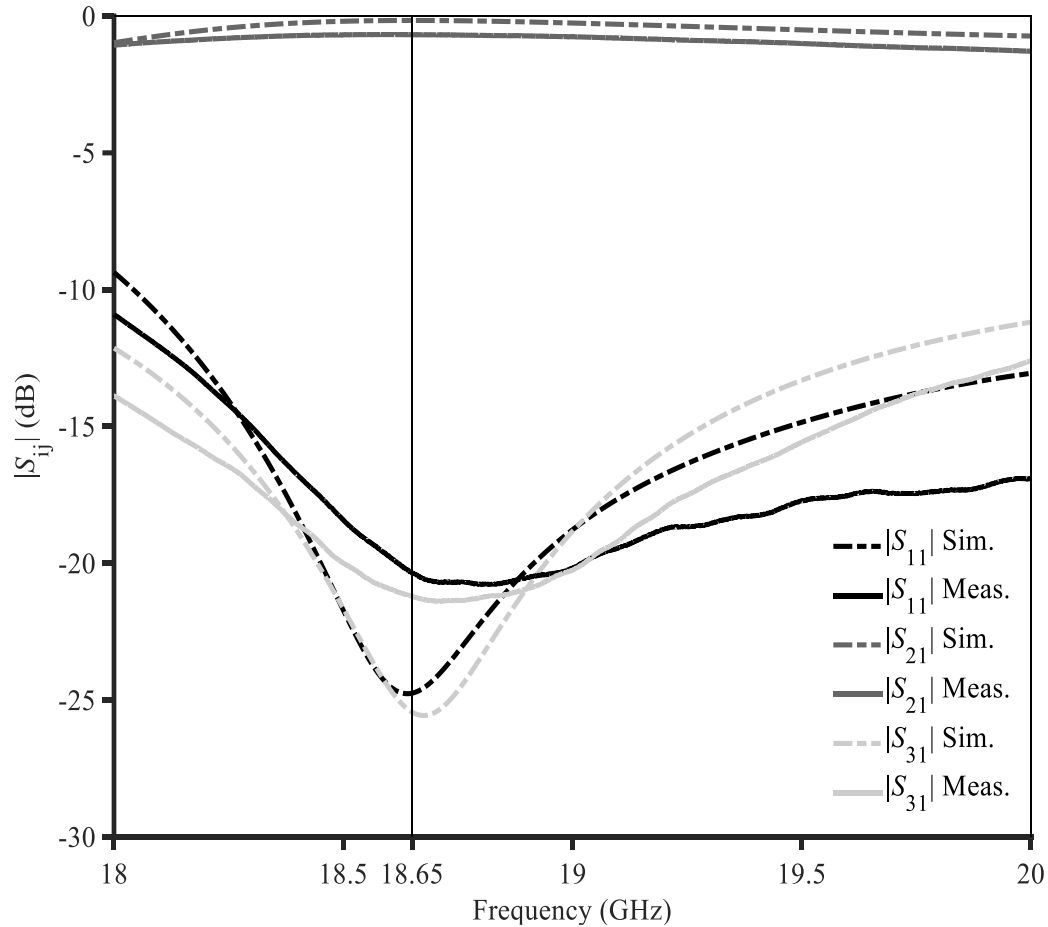
Resonator dielectric loading

Low cost FR-4

Spinel ferrite

SmCo5 magnet

Manufactured Circulator

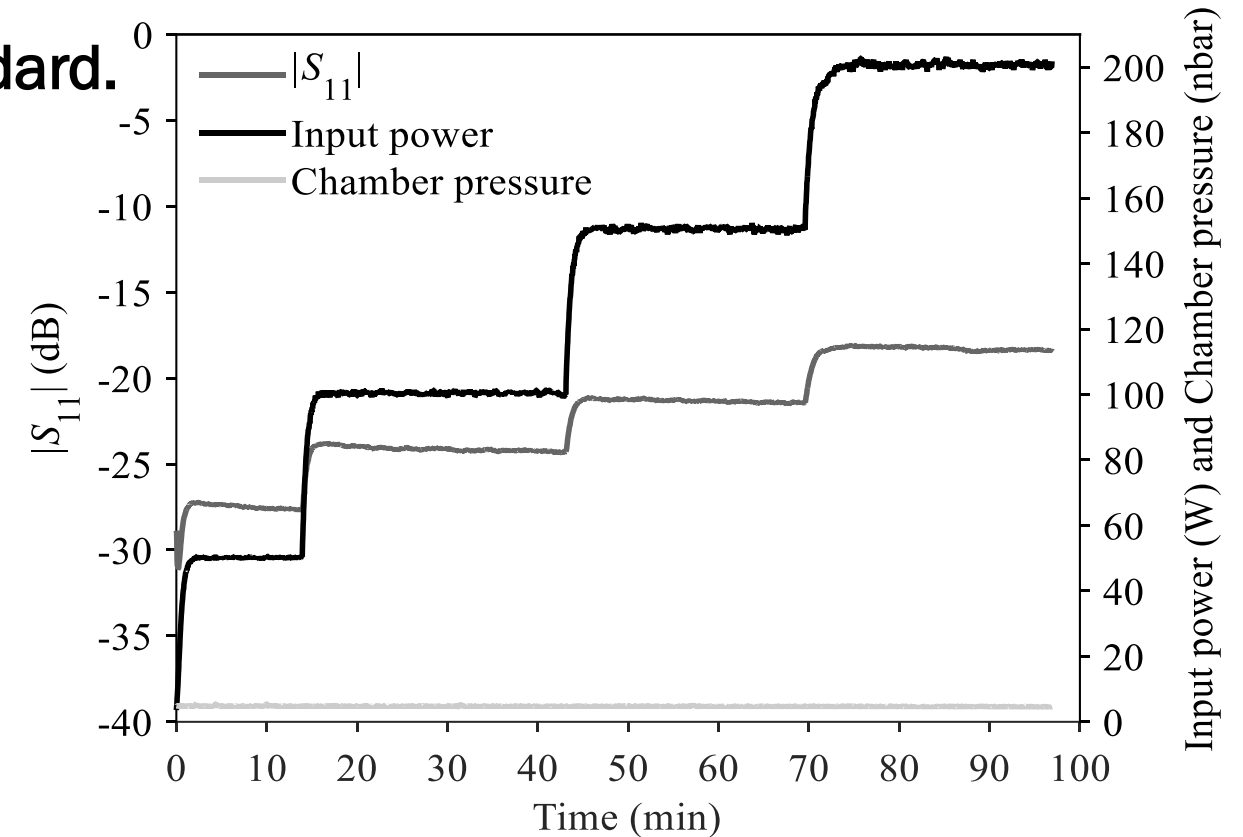
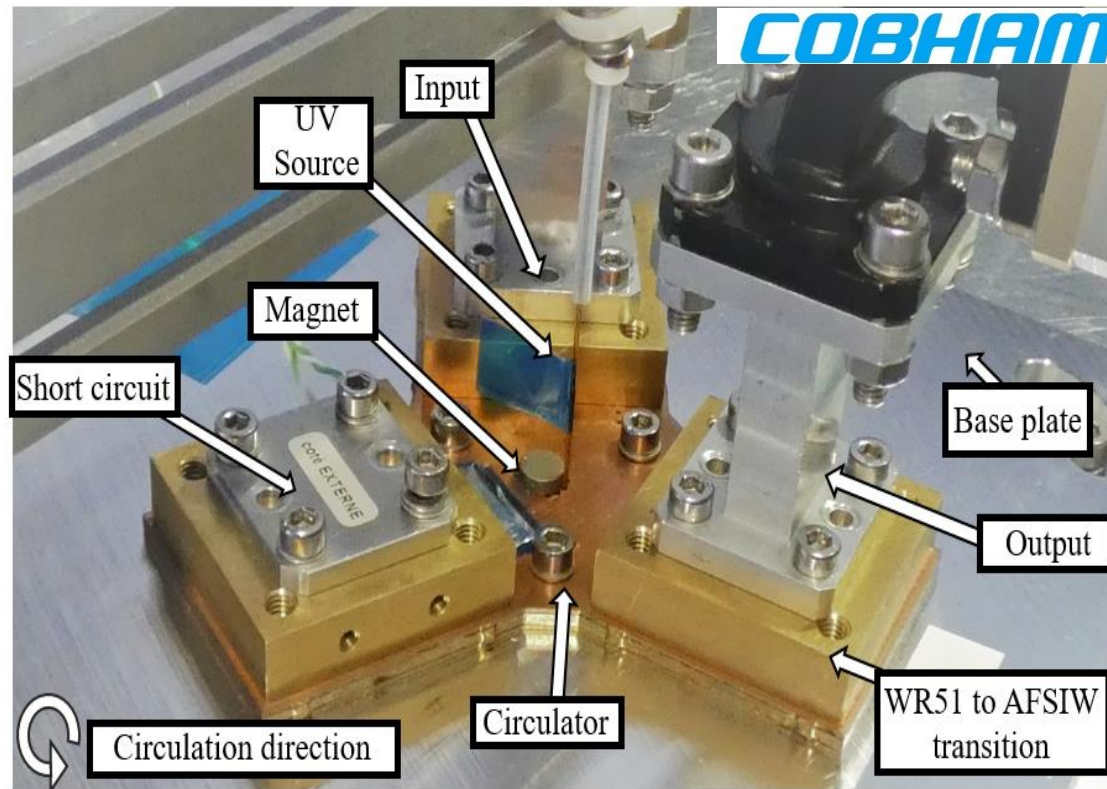


- Frequency : 18.65 GHz Ka-band downlink
- Insertion < 0.68 dB using FR-4 dielectric
- Return > 20 dB
- Isolation > 21 dB

Positive correlation between the simulation and the measurement

Multipactor Test

- The multipactor according to ESA ECSS standard.
- 3rd Harmonic and phase nulling detection



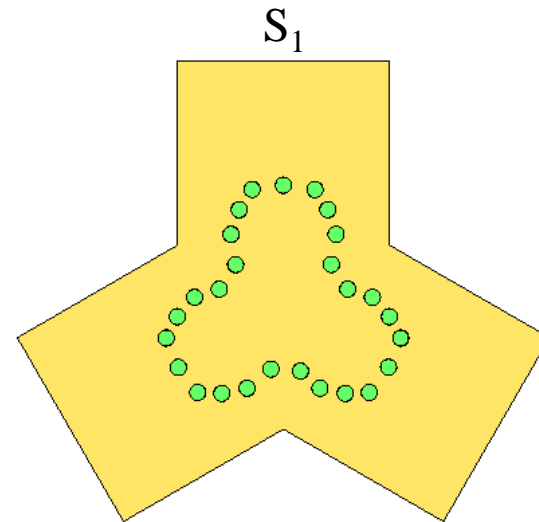
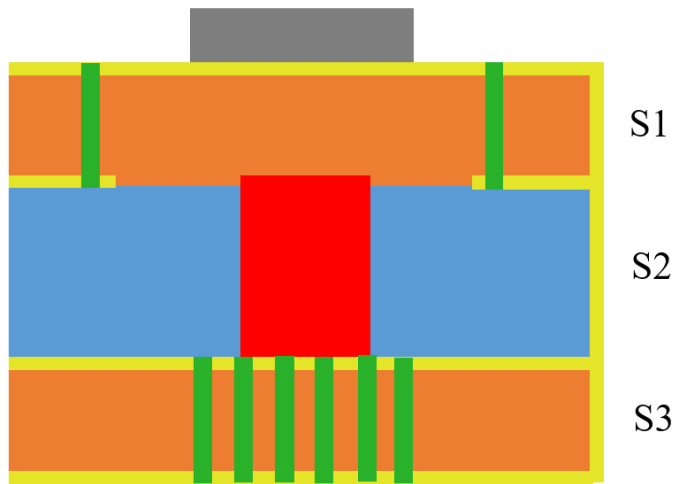
- The circulator can handle at least 200 W in short circuit TVAC

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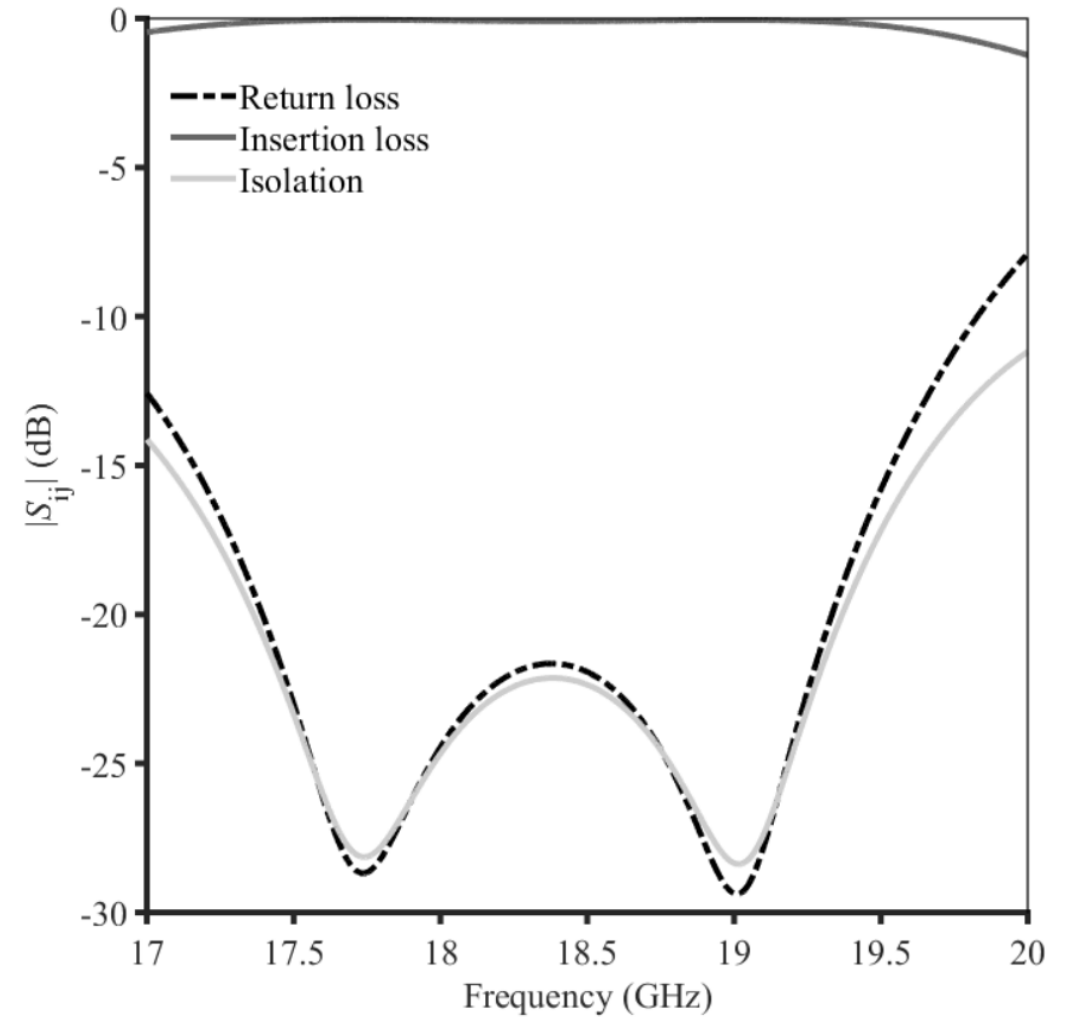
Further Work

Bandwidth Improvement



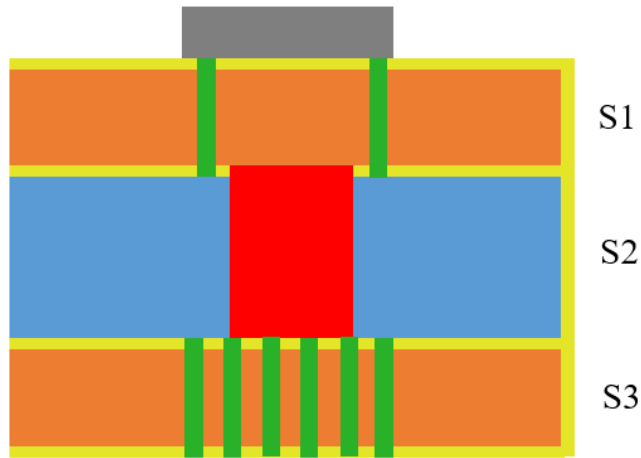
■ Vacuum
 ■ Ferrite
 ■ Substrate
 ■ Vias
 ■ Magnet
 ■ Copper

Complex transformer allow wide band impedance matching




Further Work

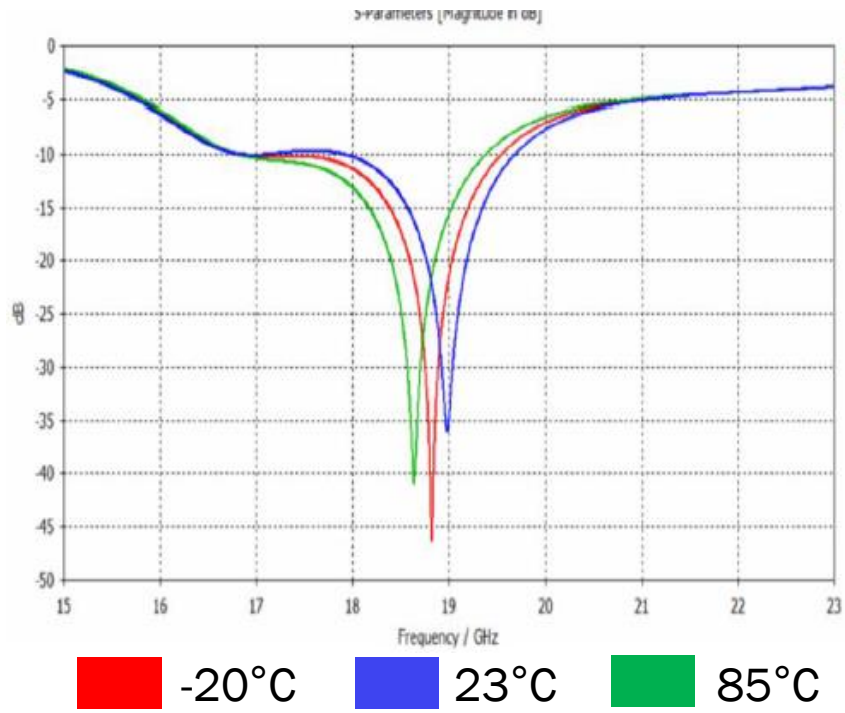
Thermal Compensation




$$k_0 D_f \sqrt{\epsilon_{eff} \mu_{eff}} = 1.84$$

if Temperature 

$$k_0 D_f \sqrt{\epsilon_{eff} \mu_{eff}} = 1.84$$

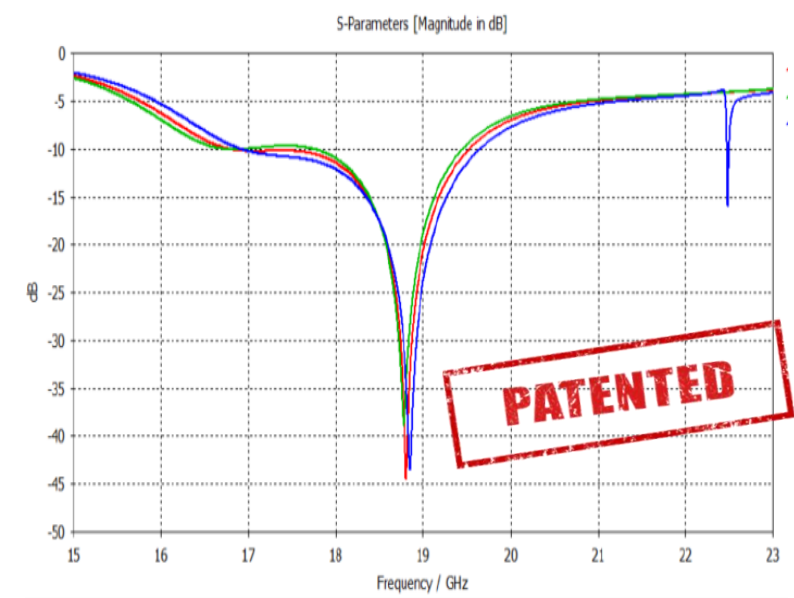


Frequency shift

if Temperature 

Cte

$$k_0 D_f \sqrt{\epsilon_{eff} \mu_{eff}} = 1.84$$



Self compensation is obtained

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Conclusion

- ☐ New AFSIW design high power Y-junction circulator is presented
- ☐ To increase the multipactor margin the junction has been completely filled
- ☐ In order to improve the thermal behaviour the substrate 1 has been used
- ☐ A theoretical and experimental study of the proposed design is demonstrated
- ☐ The proposed circulator can hold at least 200 W in short circuit and in Ka downlink band

Thank you for your attention

Questions?

issam.marah@cobham.com