We1H-2

Dual-Mode Dielectric-Loaded Resonator for Satellite High-Power Filters

P. Vallerotonda[1,2], F. Cacciamani[1], L. Pelliccia[1], C. Tomassoni[2], and V. Tornielli di Crestvolant[3]

[1]RF Microtech Srl, Italy

[2]University of Perugia, Italy

[3]ESA ESTEC, The Netherlands

Outline

- Introduction: Problems and Challenges
- State of the Art: Dielectric-loaded resonators
- Proposed Higher order Dual-mode Dielectric-loaded Cavity
- Preliminary Second-order Ku-band filter prototype
- Measurements and Results
- Conclusions

Introduction: *Problems and Challenges*

- **Satellite payloads** are becoming more and **more complex**

- **Size** and **mass saving** of High-Q microwave filters in satellite communication is **essential**

- Lot of **effort** is devoted to **bulkiness** and **weight reduction**

https://www.esa.int/ESA

State of the Art: *Dielectric-loaded resonators*

Main Drivers for Satellite filters

- Size and mass reduction
- High Q-factor
- High-power handling in space environment

Dielectric based Solutions

- Most common approaches
  - ❑ TM_{010} mode dielectric
  - ❑ $TE_{01\delta}$ mode dielectric
  - ❑ $TM_{01\delta}$ mode dielectric
  - ❑ Dielectric-loaded combline

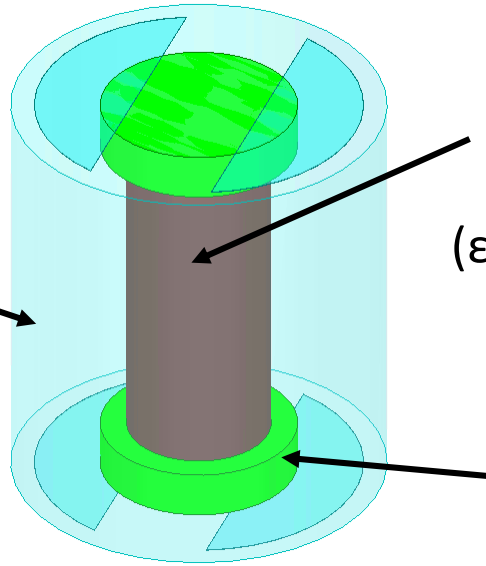
The best choice strongly depends on application!!!

Proposed solution: *higher order mode DR doublet*

A novel doublet is proposed where a ceramic high-permittivity dielectric cylinder (Barium Magnesium Tantalum oxide) is placed in the center of a circular metal cavity thanks to low-permittivity dielectric Supports (Teflon)

A pair of shaped irises placed on top and bottom surfaces of the cavity allows the control of the coupling to the adjacent cavities

3D-MODEL

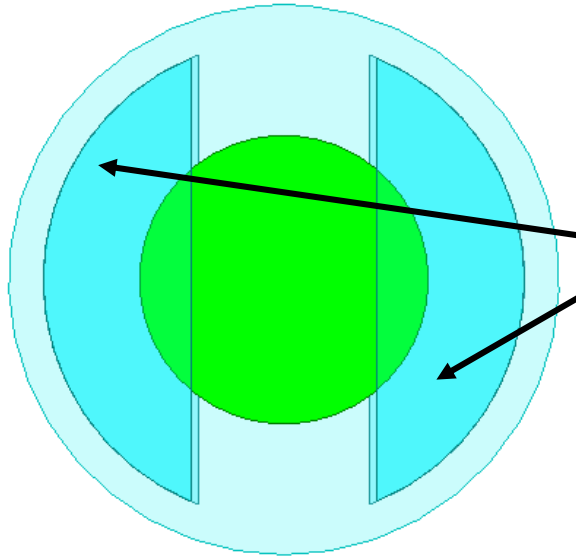


Metal cavity

High-permittivity Dielectric load (ε_r=24, Qxf=250000)

Low-permittivity Dielectric Support

TOP-VIEW



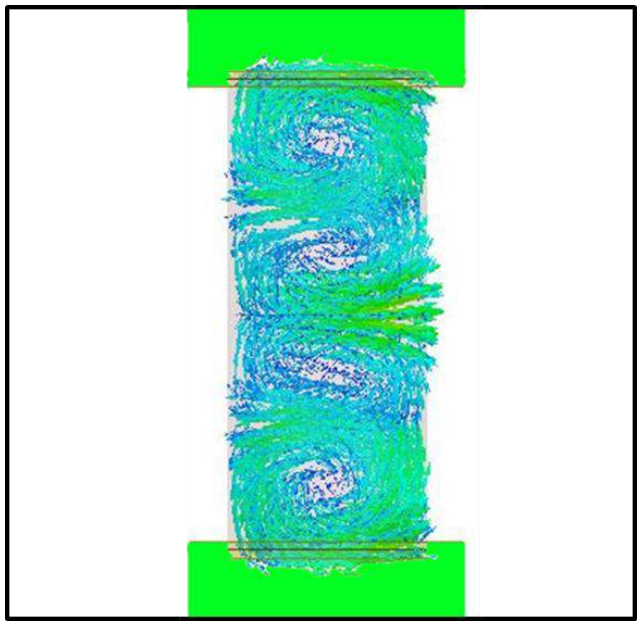
Coupling irises

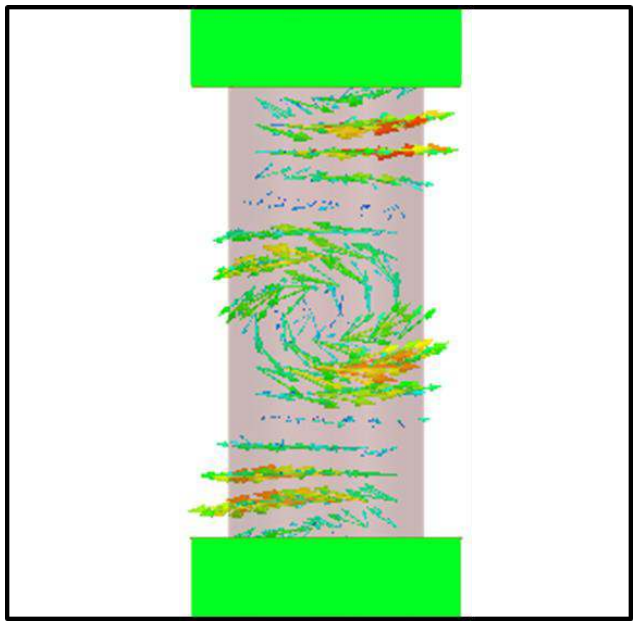
Proposed solution: *higher order mode DR doublet*

In order to ensure thermal dissipation capabilities suitable for the high power requirements (150 W CW in space environment), the dielectric cylinder cannot be too small

A higher order resonant mode has been proposed: 2 degenerate higher order modes are adopted as operating modes. These are mixed TE and TM modes

E-field



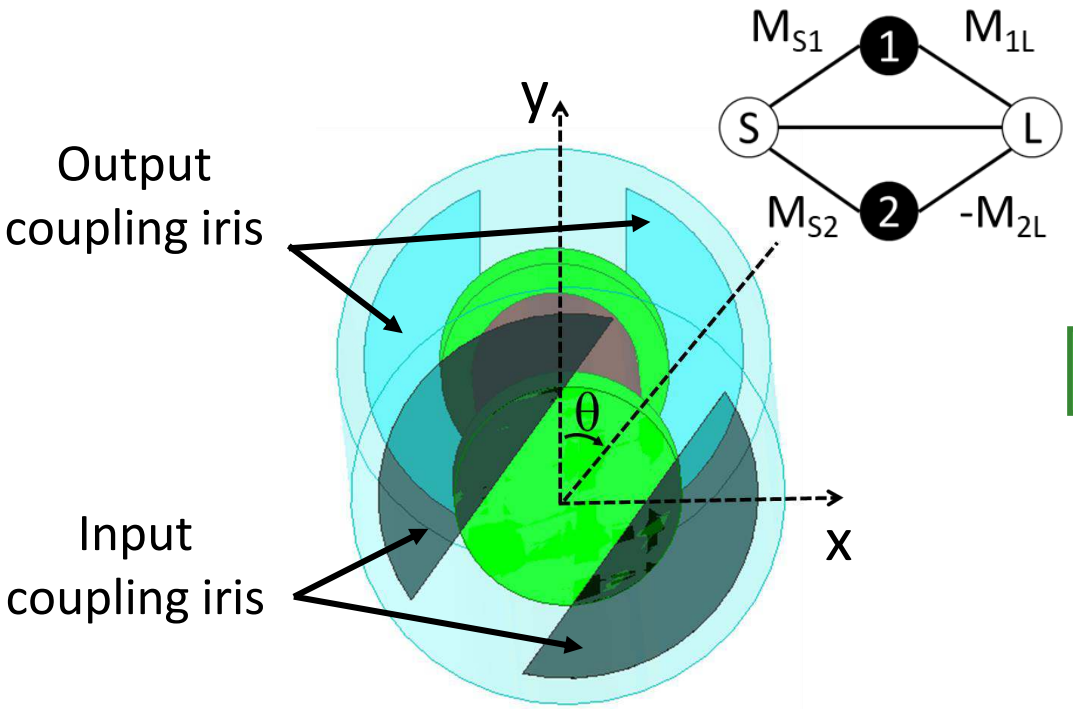


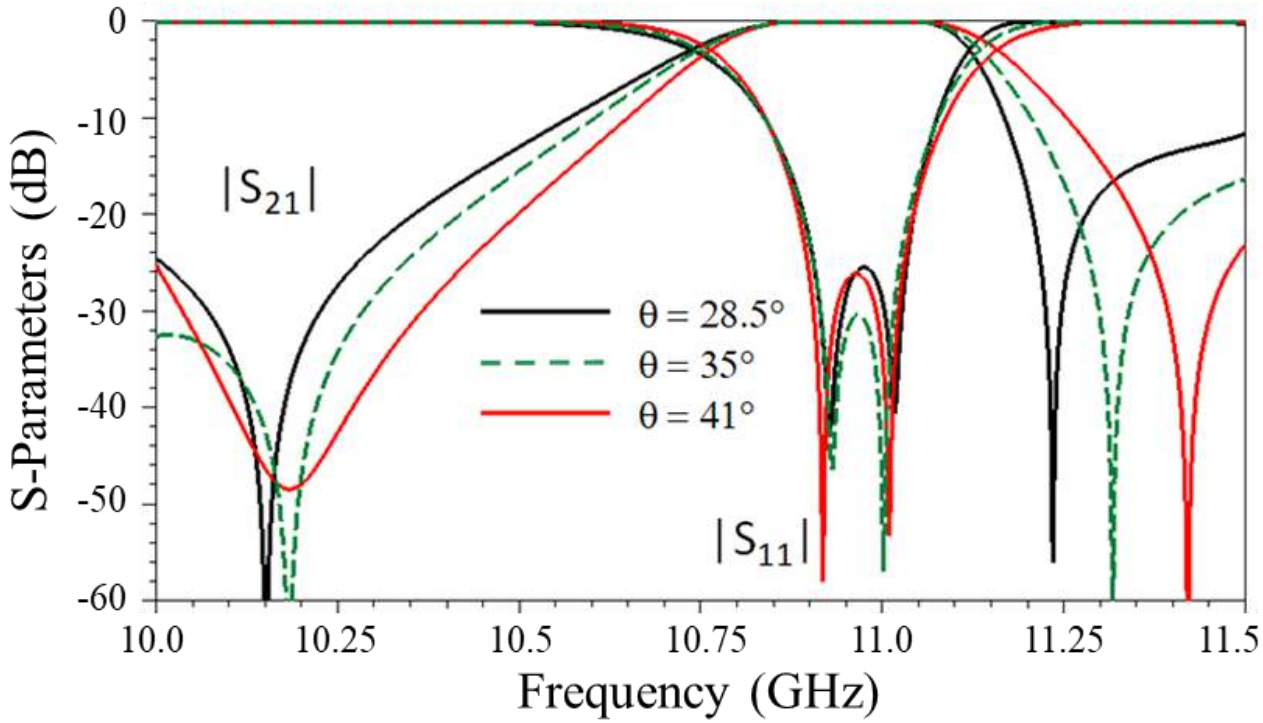
H-field

Proposed solution: *higher order mode DR doublet*

Varying the rotation angle (θ) of the irises, each doublet can provide a transmission zero (TZ) which can be moved above or below the passband

By changing the ratio of the coupling to the two resonant modes (MS1/MS2), the doublet allows control over the frequency position of only one TZ



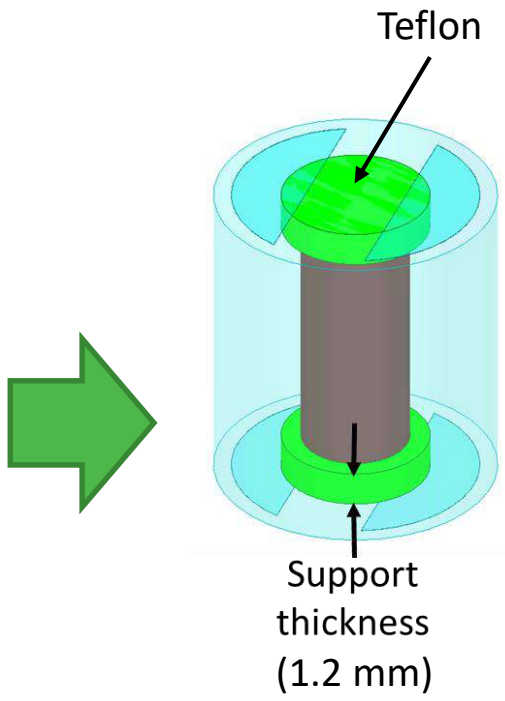


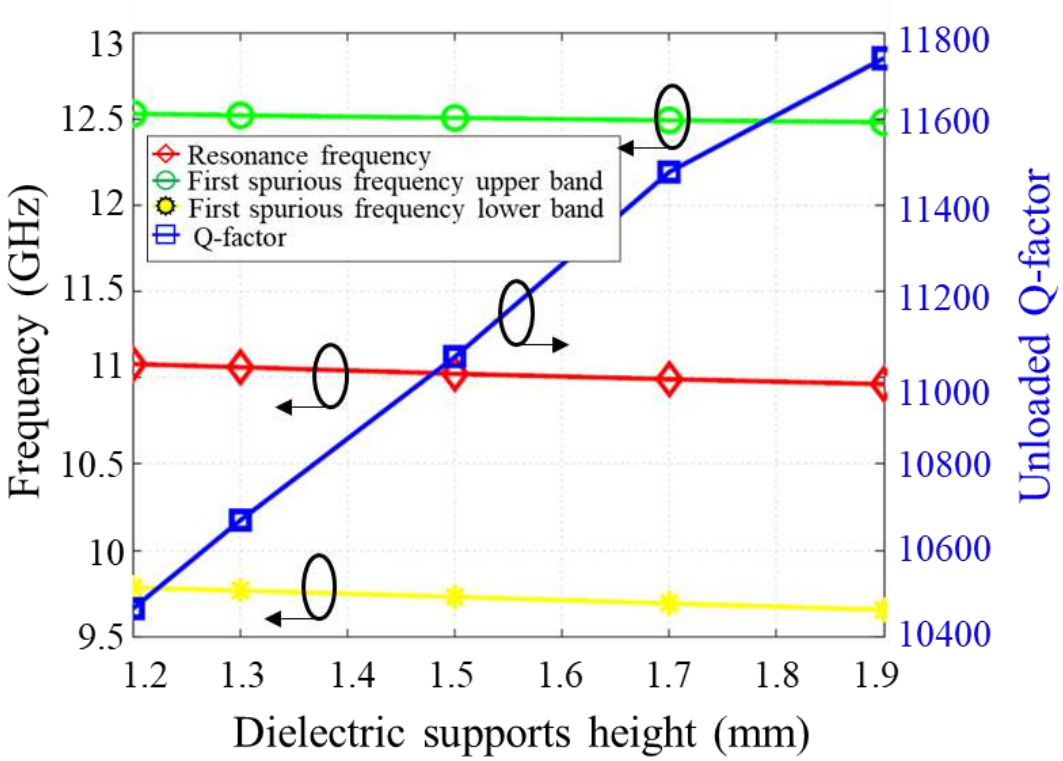
Proposed solution: *higher order mode DR doublet*

Geometries and materials have been carefully chosen in order to improve the robustness of the structure from mechanical and thermal points of view

Particular attention has been focused on the supports, which represent key elements for the correct behavior of the filter

- **Thermal point of view:** the material of supports has to be a good thermal conductor in order to ease the thermal flow
- **Thickness of the supports** affects Q-factor
- **Thickness between 1÷2 mm**: unloaded Q-factor always is above 10000, and the spurious-free range of roughly 1 GHz

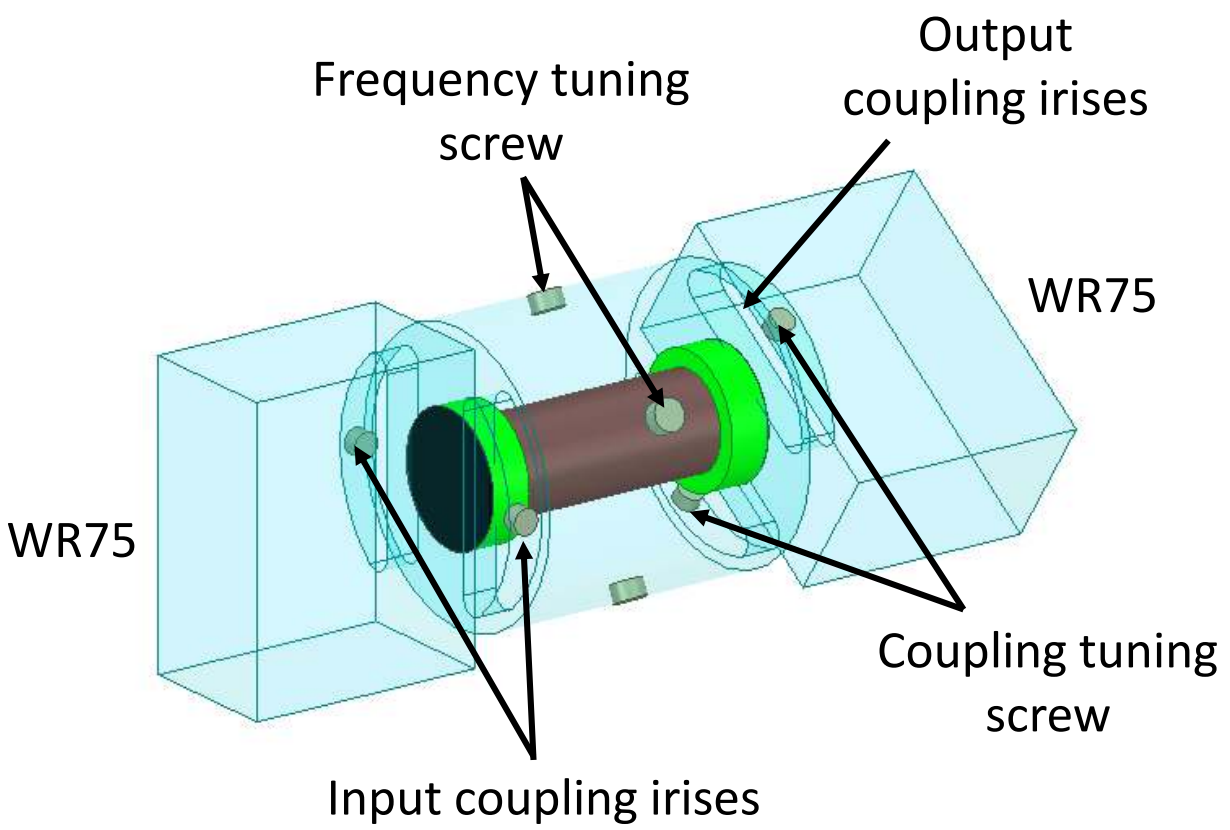




First Ku-band prototype: *3D model Design*

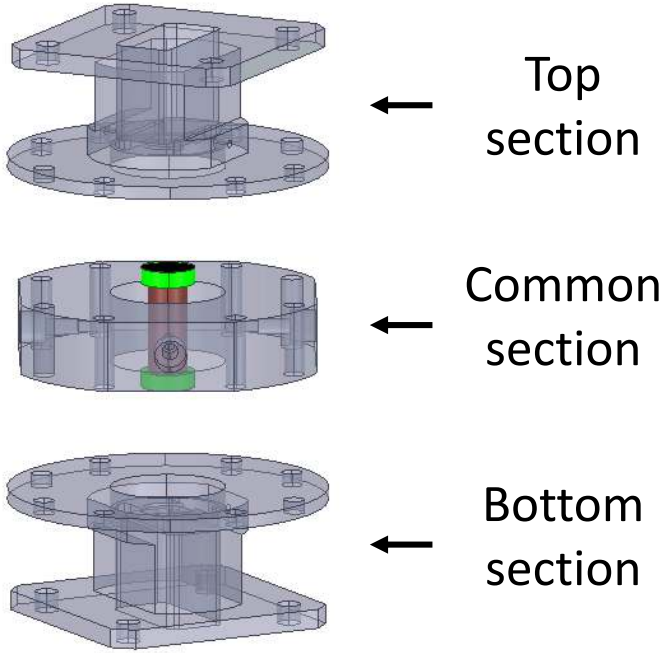
The feasibility of proposed design concept has been demonstrated through the preliminary measurements of a second-order filter which is centred at 11 GHz with a bandwidth (BW) of 240 MHz

3D-MODEL



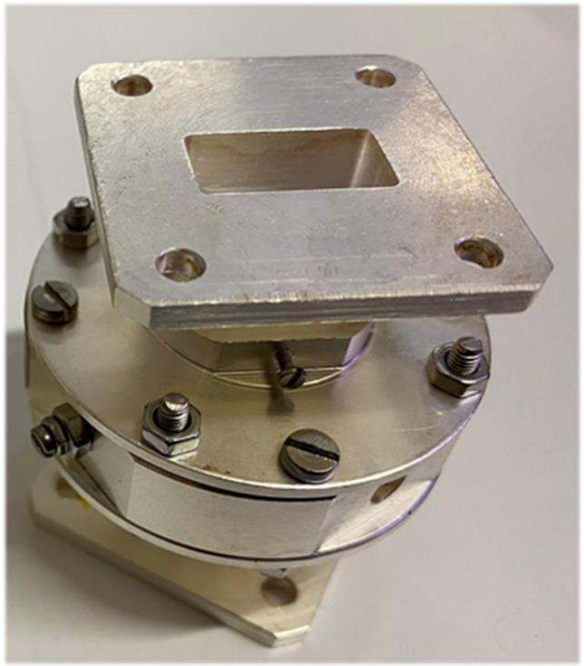
MECHANICAL MODEL

The filter is composed by three main silver-plated aluminium parts.



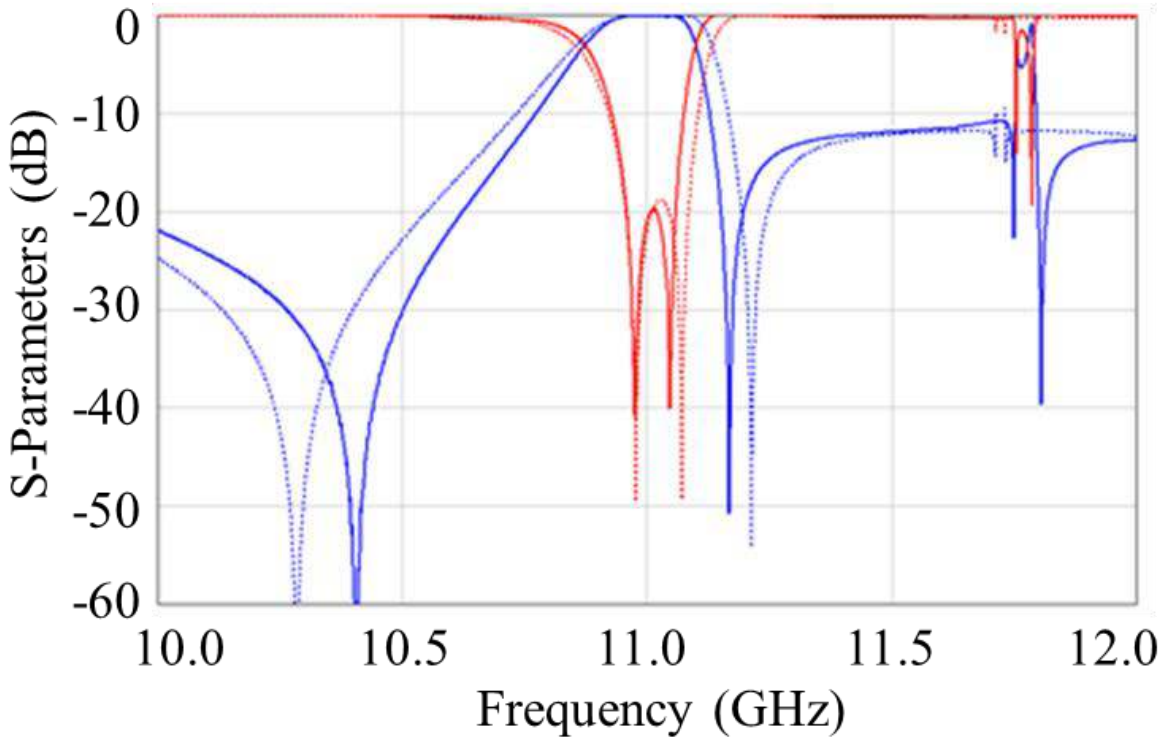
First Ku-band prototype: *Measured results*

The tuning process allows for an easy recovering of the manufacturing errors for both mechanical and ceramic permittivity tolerances.



Size (L x W x H):
52.7 mm x 50 mm x 50 mm

Mass: 118g

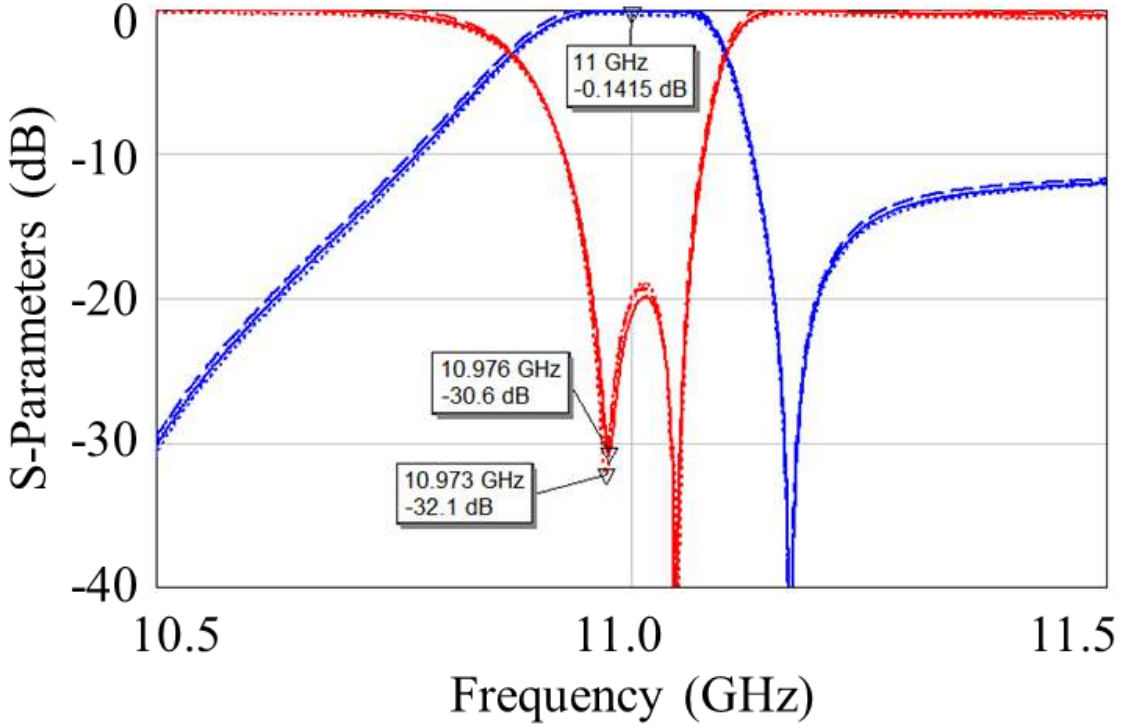


····· Simulation —— Measure

Measured Q-factor:
6000

First Ku-band prototype: *Thermal/Power results*

A very stable measured filter response is shows with respect to the temperature variation.



— 25°C ····· 70°C --- -35°C

- A maximum frequency shift of the response of roughly 3 MHz is observed in the range -35°C ÷ +70°C
- The equivalent τf (relative frequency shift per °C): < 3 ppm/°C

High-power performance:

- Multipactor analysis in Spark-3D shows no discharges above 1 KW
- Power handling analysis in ANSYS exhibits that the filter can handle up to 150 W CW in space environment

Conclusions

- A novel doublet resonator based on higher order dual-mode dielectric-loaded cavity has been presented as an alternative solution for compact high-power filters
- The proposed resonator can provide a transmission zero above or below the passband by changing the rotation angle of the coupling irises
- The feasibility of proposed solution has been demonstrated through the measurement of a preliminary second-order Ku-band filter, which highlights the good thermal stability of the architecture
- The requirements of European Space Agency (ESA) ARTES AT project called DOMUK (“Dielectric-loaded high-power Output de-Multiplexer at Ku/Ka-band”, ESA Contract Number: 4000125645/19/NL/NR), have been considered as a benchmark
- Thanks to the reduced number of physical cavities, compact higher order filter architectures can be realized by cascading multiple doublets

THANK YOU FOR YOUR ATTENTION !!!