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# MINITUARIZATION OF PASSIVE MICROWAVE COMPONENTS FOR LEO PAYLOADS

14/12/2023

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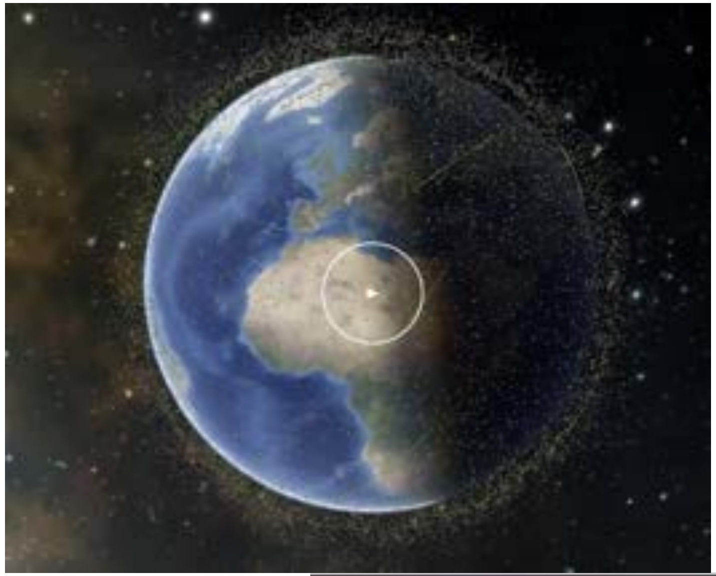
# What is a SmallSat?

- Generally speaking, a satellite is any small object orbiting about a larger object in space.
- In everyday use, the word “satellite” refers to artificial objects launched into orbit around the Earth or other worlds in the Solar System.
- A satellite’s orbit is a balance between its speed and the planet’s gravitational pull.
- Low-orbiting satellites circle the Earth several times a day.



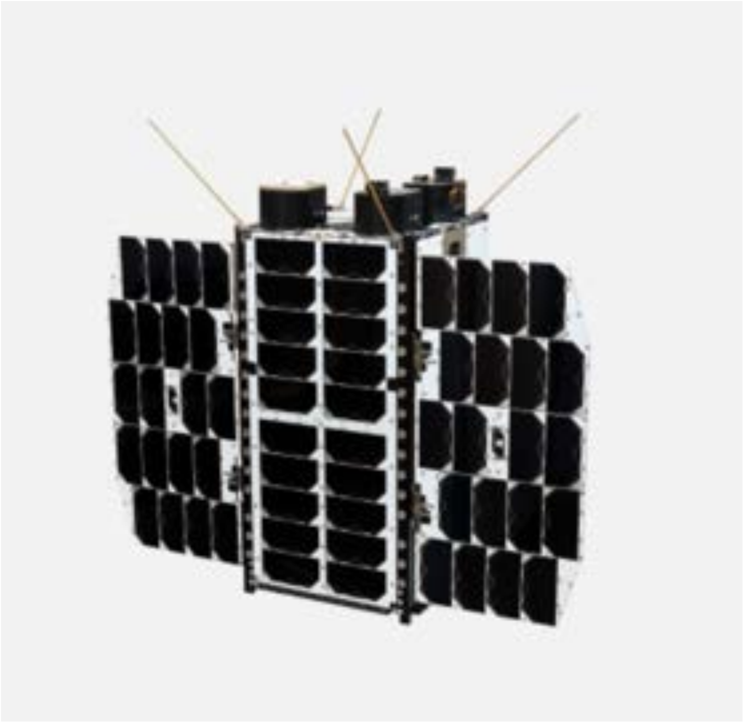
# What does a SmallSat do?

- **Communications:**Satellites cover more ground than any radio tower, letting them detect radio signals, provide connectivity, and link industrial internet of things from anywhere.
- **Navigation:**Satellite navigation helps people plan their everyday journeys and optimize the transportation of goods through lands, sea, and air, reducing their environmental footprint.
- **Earth Observation (EO):**Low-orbiting small satellites can make high-resolution observations of the planet below. An EO constellation's many satellites can return real ime video of earth's surface and support environmental and asset monitoring
- **Research & Development:** Going beyond theory and laboratory testing, innovators can affordably evaluate new technologies in orbit. In situ testing reduces development cycles and brings futuristic technologies such as interplanetary solar sails closer to reality.




# What are the benefits of SmallSats?

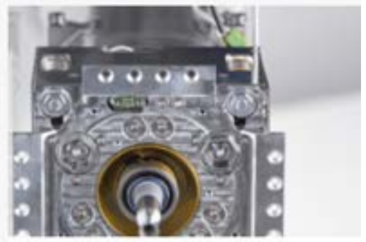
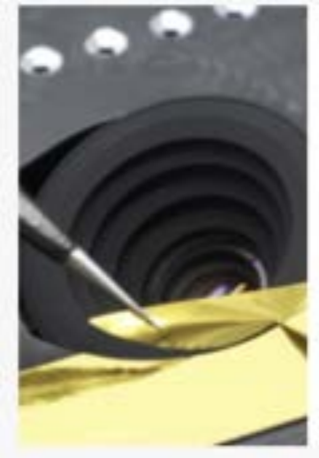
- 01. Reduced costs
- 02. Shorter development cycles
- 03.Rapid technological improvement
- 04.New operating models

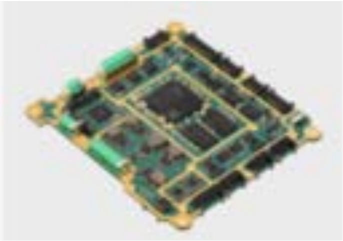


These benefits will continue to drive the adoption of small satellites over the next decade. As sensors, propulsion, and other satellite systems become smaller and more performant, small satellites will create new opportunities in education, commerce, government, and science.

# What are the main systems used in a SmallSat?

- **Attitude Control and Propulsion:** Thrusters, star trackers, magnetorquers and reaction wheels, combined with computers to control them, move and position satellites in space.
- **Telemetry and Communications:** Transceivers, repeaters, and antennas let satellites receive commands, transmit performance metrics, and download payload data.
- **Power Management:** Electric power systems distribute electricity from solar panels to satellite systems and payloads.
- **Payload Interfaces:** Payload controllers let scientific and commercial systems communicate with the satellite bus and its communications systems.
- **Thermal Management**: Insulation and cooling subsystems protect satellites from the 300°C temperature swings between Earth's dayside and nightside.
- **Structure:** Modular, standardized structures optimize small satellites for the best size and shape to achieve mission success without sacrificing affordability.

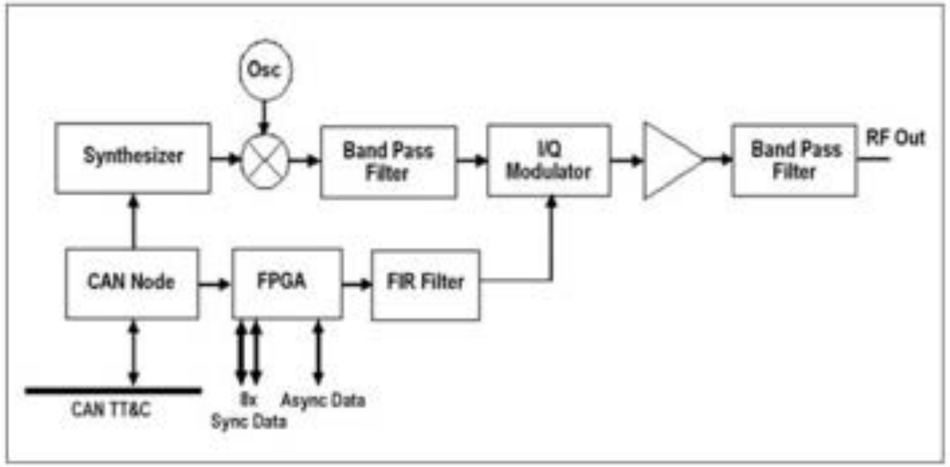


# What type of RF/Microwave Components Used in Small Sats?

**Telemetry and Communications:**

- Transceivers,
- Repeaters,
- Antennas  etc.

in various frequency bands from UHF to X band.




# How big is a Small Sat?

MiniSatellite

100-500 KG

Micro Satellite

10-100 KG

Nano Satellite

1-10 KG

Pico Satellite

1-10 KG

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# How a Passive RF Component can be designed for compact size?

- Different transfer functions
- Different topologies
- Different Elecromagnetic Structures
- Different Materials

A component can be size efficient by applying one or a combination of all above..

# RF Filter Example

- Different transfer functions

Butterworth Polynomial

Chebyshev Polynomial

Cauer-Chebyshev Polynomial

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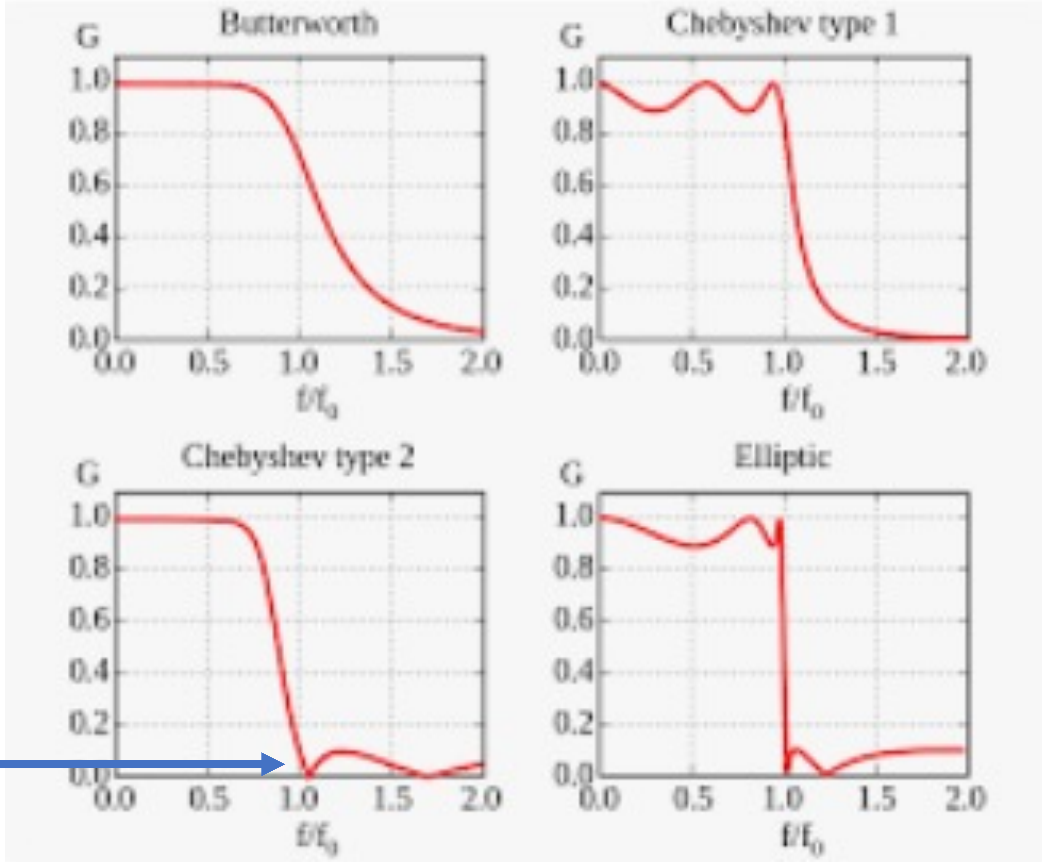
.

.

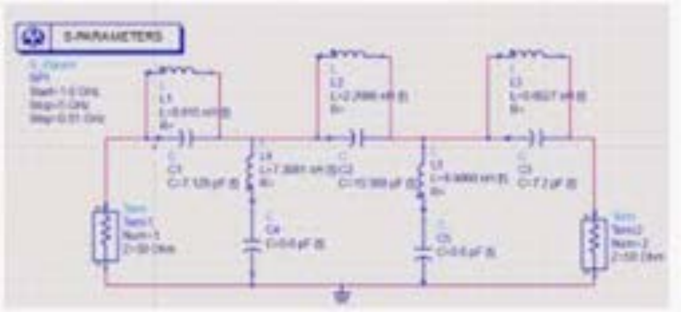
Elliptical Ploynomial

Generates finite transmission zeros, save up number of stages hence similar performance less size and insertion loss



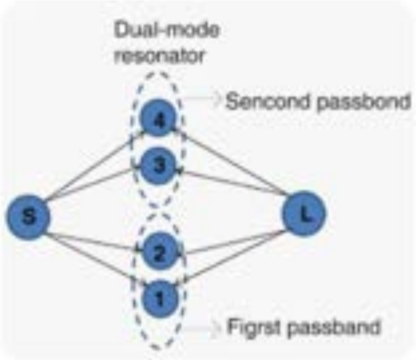
# RF Filter Example

- Different Coupling Topologies

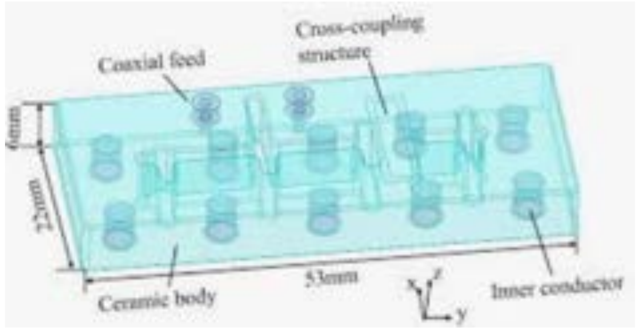



Generation of Finite Transmission zeros:

Inline



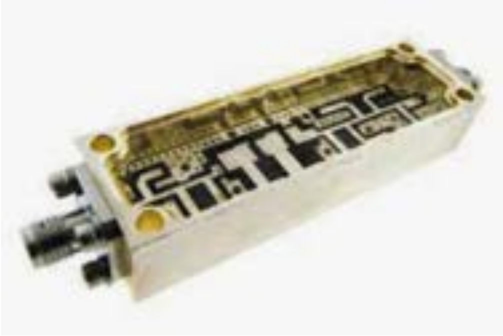

Multi -Mode  Resonators




Cross Couplings

# RF Filter Example

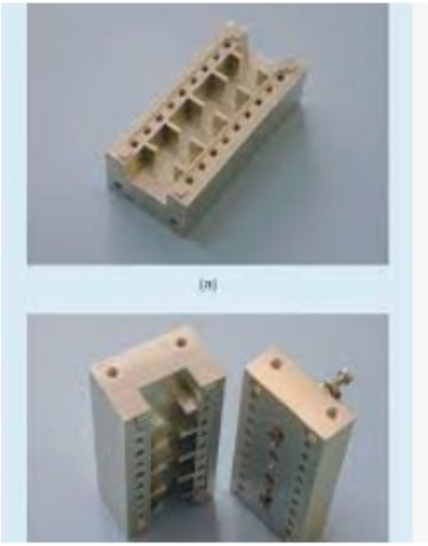
- Different Elecromagnetic Structures



Lumped

Cavity

Stripline



Waveguide

Etc.

# RF Filter Example

- Different Materials

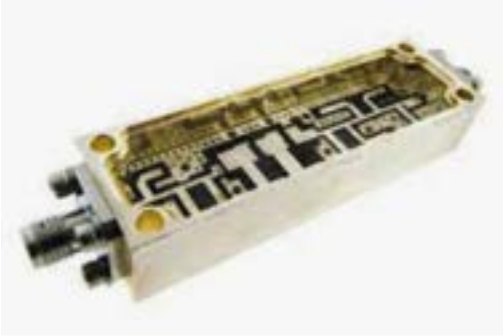
Air Filled

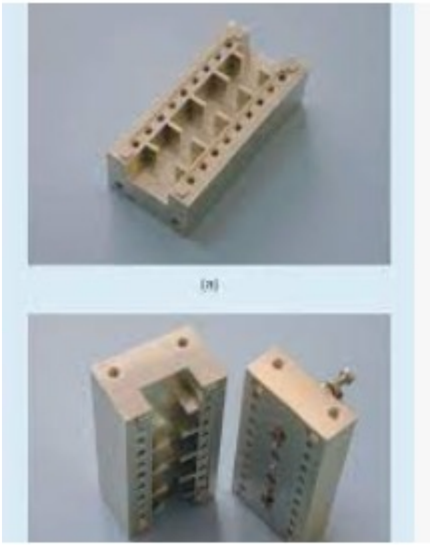
Ceramic

Partially filled

LC

Etc.

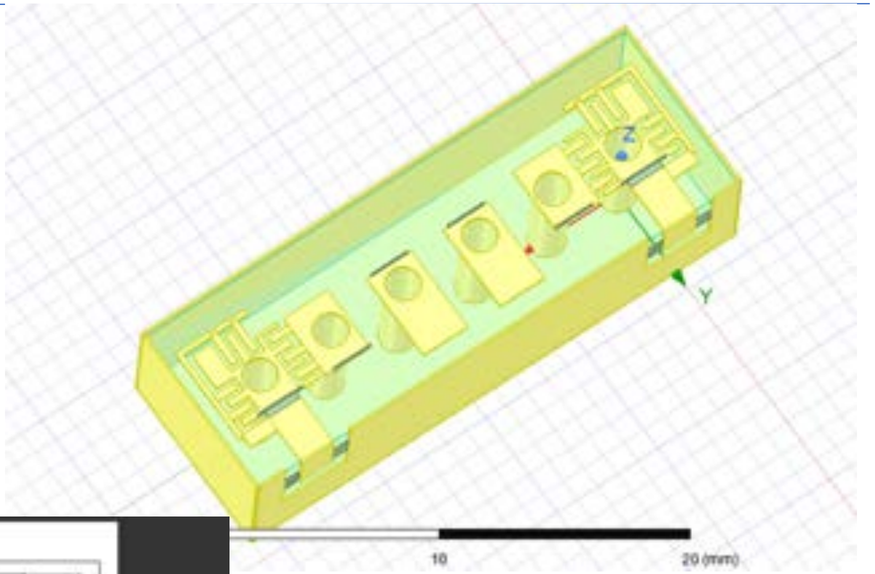


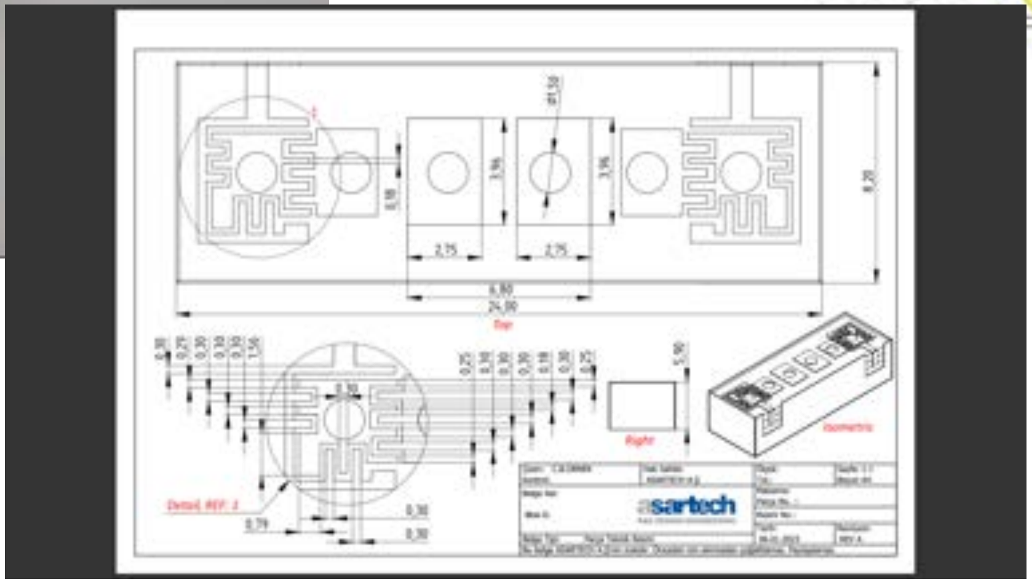


# RF Filter Example

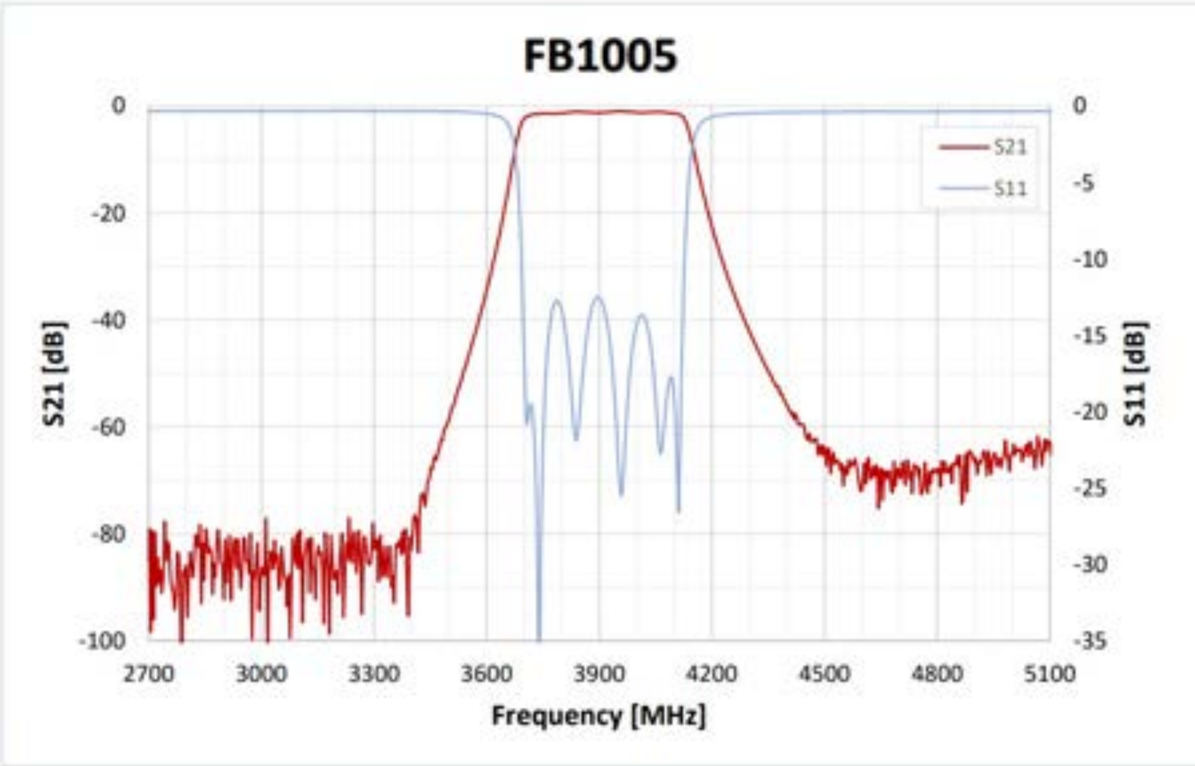
- Based on above considerations nowadays the most size and cost effictive solution is MonoBlock filters.
- These are in fact cavity comlibe filter setup in ceramic blocks.
- Inline coupling can easiy be made for finite transmissiın zero generation near the passband to increase selectivity with the same insertion loss level.
- Examples of designed and manufactured filters of this type are given in the following slides.
- Both filter and ceramic material are realized in full domestically.

# RF Filter Example- C band Filter

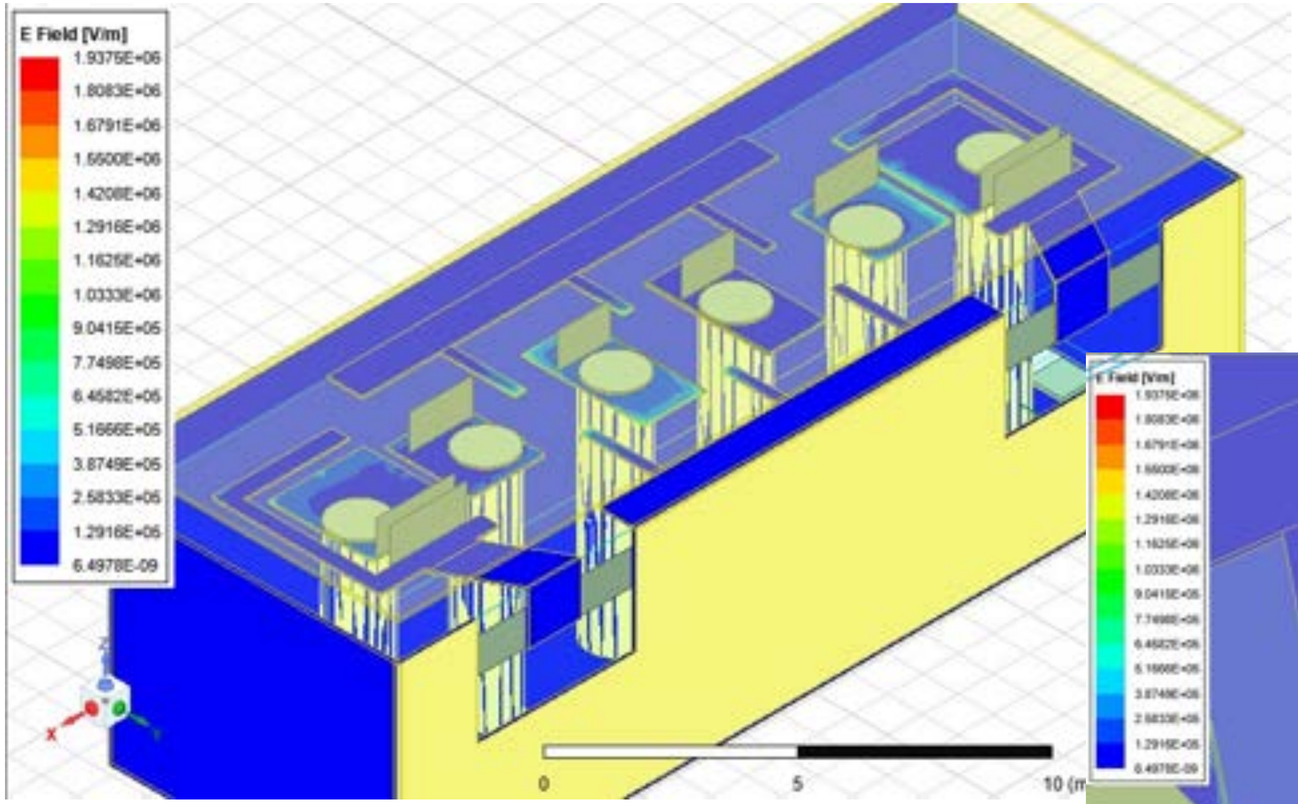


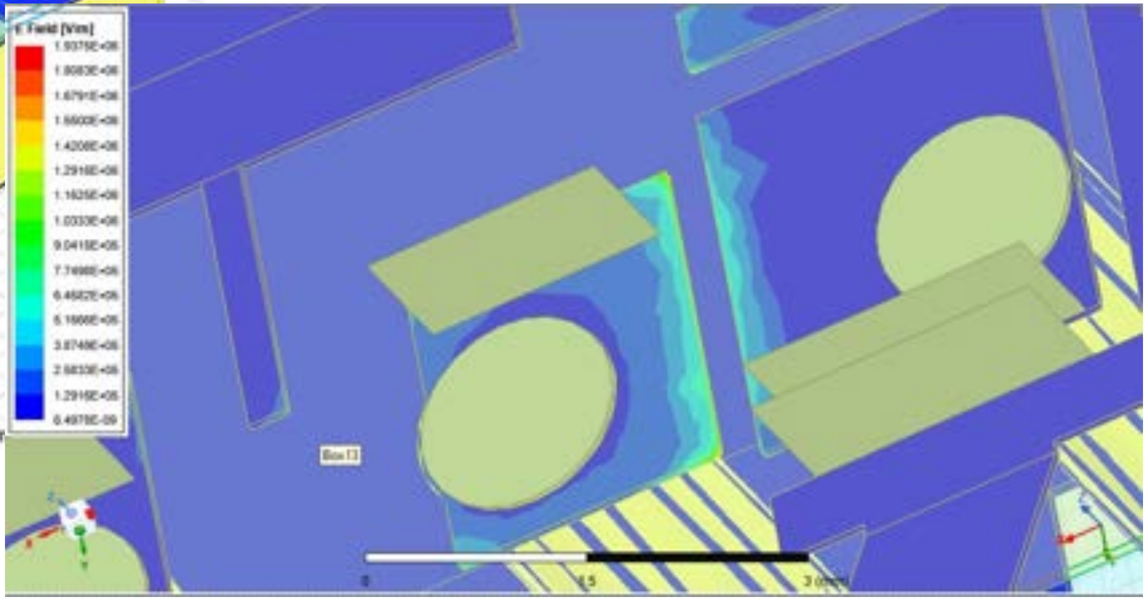
# RF Filter Example- C band Filter



# RF Filter Example- S band Filter




| 1.0 ELECTRICAL SPECIFICATION | | | | |
|---|---|---|---|---|
| ITEMS | | Room Temp. | Full Temp. | UNIT |
| 1.1 Center Frequency [fo] | | 3100.0 | | MHz |
| 1.2 Bandwidth [BW] | | fo ± 225.0 [ 2875.0 ~ 3325.0 ] | | MHz |
| 1.3 Insertion Loss in BW | | 0.7 0.5 TYP | 0.9 | dB max. |
| 1.4 Ripple in BW | | 0.5 | | dB max. |
| 1.5 Return Loss in BW | | 14.0 | | dB min. |
| 1.6 Attenuation | @ 2200.0 ~ MHz | 30.0 | | dB min. |
| Absolute Value | @ 2690.0 ~ MHz | 20.0 | | dB min. |
| ☑ Relative Value | @ 3600.0 ~ 4200.0 MHz | 20.0 | - | dB min. |
| ☐ | @ 5700.0 ~ 6700.0 MHz | T.B.D | - | dB min. |
| | @ 8500.0 ~ 9300.0 MHz | T.B.D | | dB min. |
| 1.7 Group Delay Variation | | 0.15 | | ns max |
| 1.8 Input Power | | 15 W [ 100 W max. ] | | W max. |
| 1.9 In/Out Impedance | | 50 | | Ω |
| 1.10 Operation Temp. Range | | -40 to +85 | | ℃ |
| 2.0 MECHANICAL SPECIFICATION | | | | |



# RF Filter Example- S band Filter

| 1.0 ELECTRICAL SPECIFICATION | | | | |
|---|---|---|---|---|
| ITEMS | | Room Temp. | Full Temp. | UNIT |
| 1.1 Center Frequency [fo] | | 3100.0 | | MHz |
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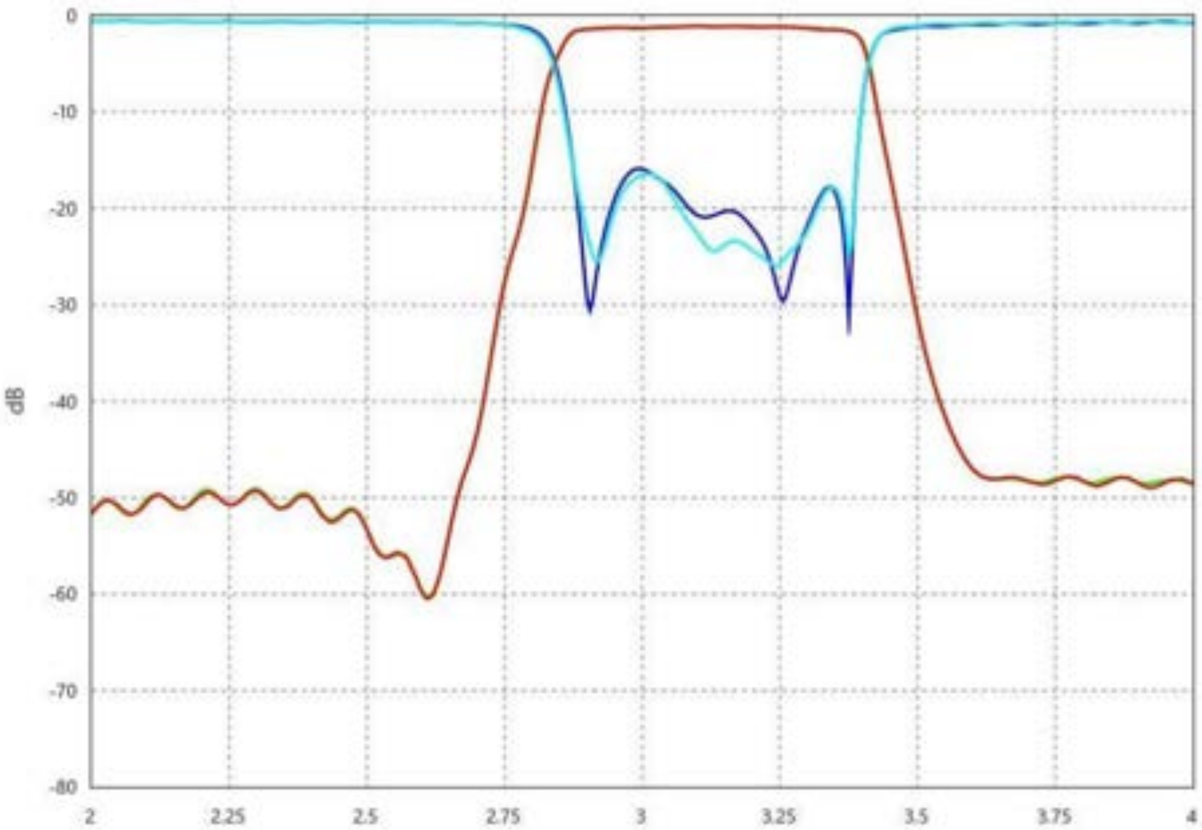

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# Thank YOU..

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