

WE3F-4

Compact 12–18-GHz Bandpass Filter with Wide Stopband Using Hybrid Dual-Mode SIDGS/Microstrip Resonant Cell

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Outline

Motivation and Introduction

Hybrid Dual-Mode Resonant Cell

Filter Design

Fabrication and Experimental Results

Conclusion

Motivation and Introduction

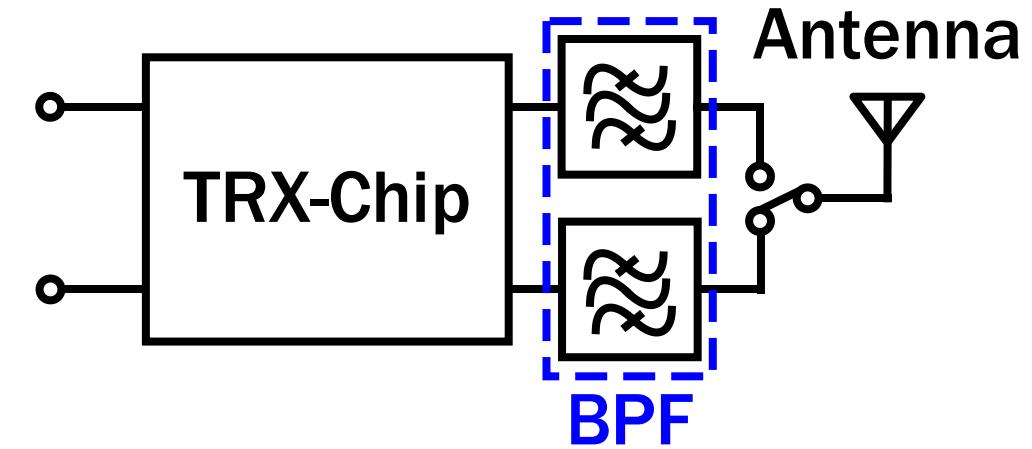
- Satellite systems can provide high-speed communication to more people:



In some remote areas, students must cross mountains to access education during the pandemic because the mobile phone signal in their villages is too weak.

Motivation and Introduction

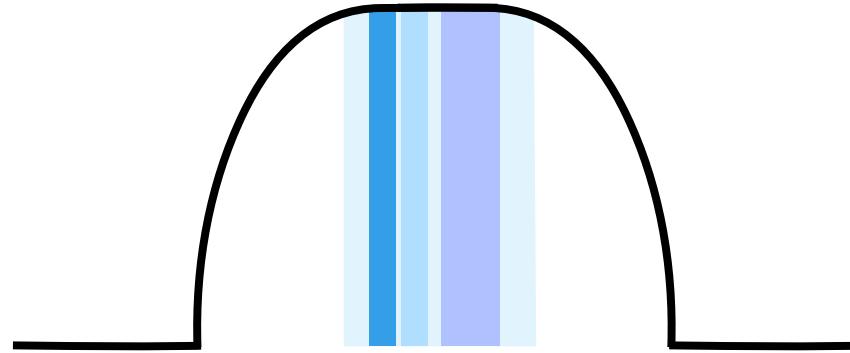
- Bandpass filter (BPF) in satellite communication systems:



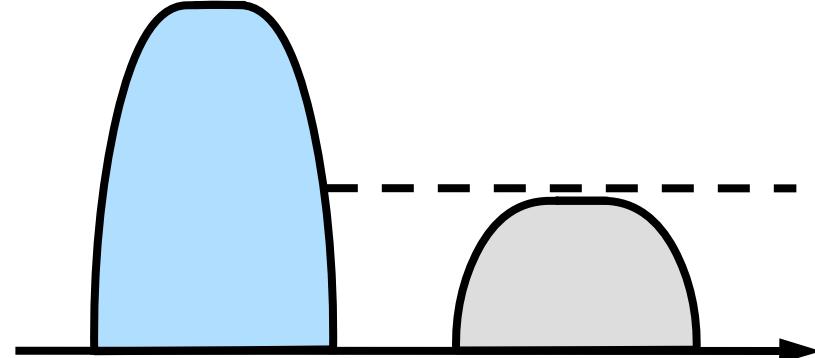
Transmit/Receive front-end

Motivation and Introduction

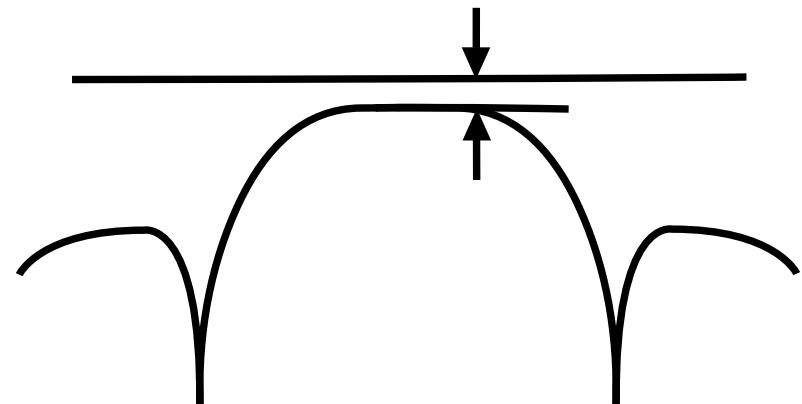
- Ku-band BPF design specifications:



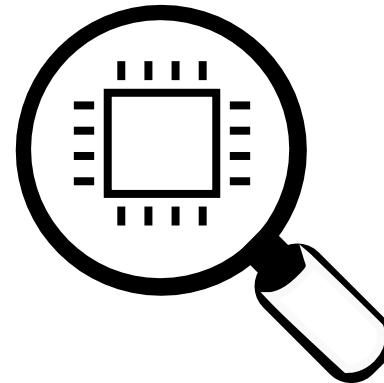
Operating at 12-18 GHz



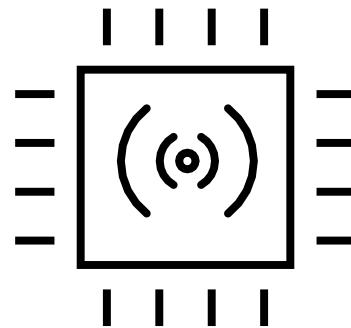
Stopband rejection up to 60 GHz



Insertion loss lower than 2dB



Miniaturized

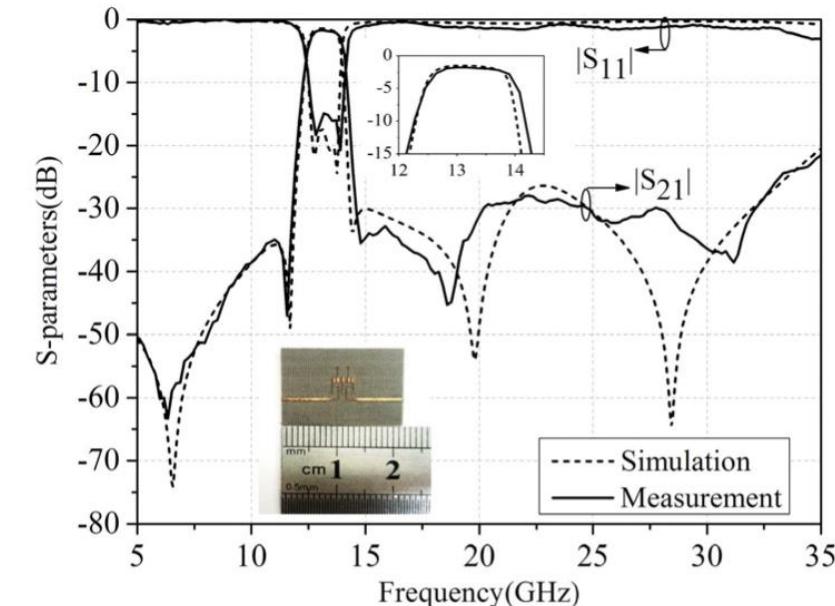
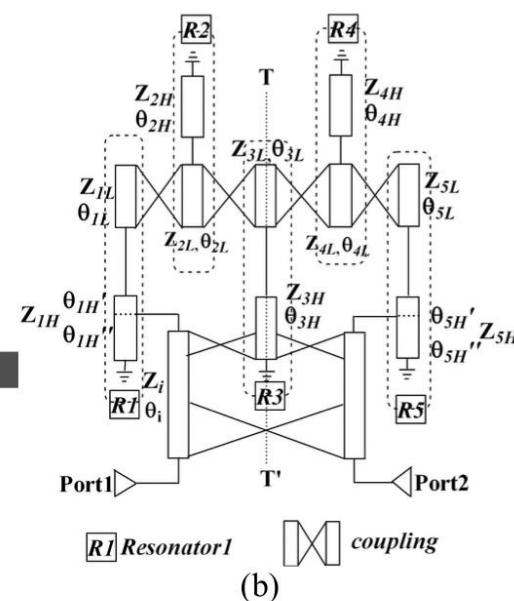
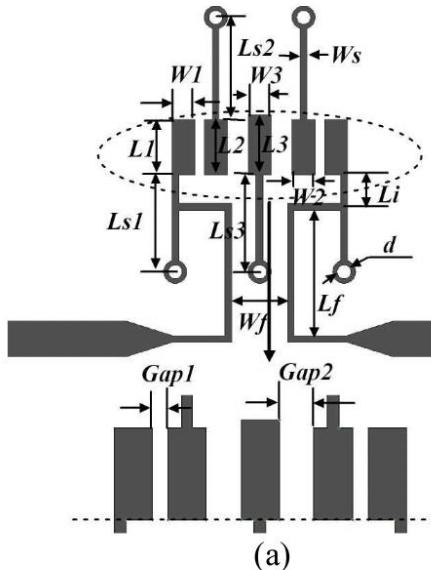


Low radiation leakage

- **BPF using microstrip resonators:**

- 😊 Relatively compact size
- 😊 High selectivity

- 😢 Limited passband bandwidth

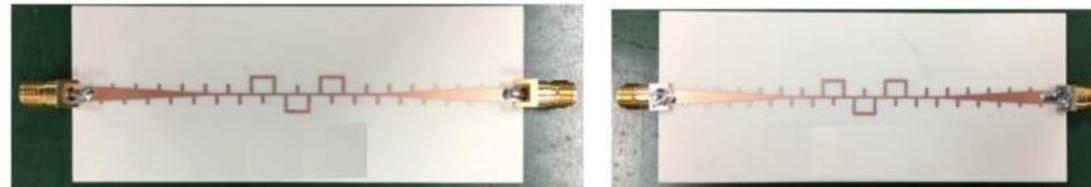
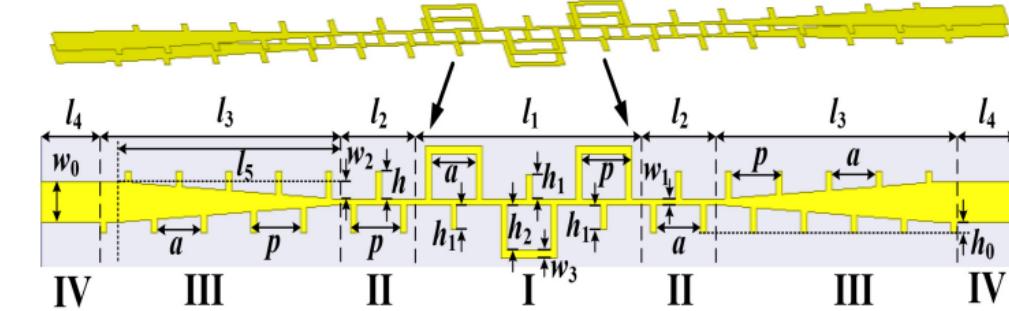


[1] J. Xu, W. Hong, H. Zhang, and H. Tang, "Compact bandpass filter with multiple coupling paths in limited space for Ku-band application," *IEEE Microw. Wireless Compon. Lett.*, vol. 27, no. 3, pp. 251–253, Mar. 2017.

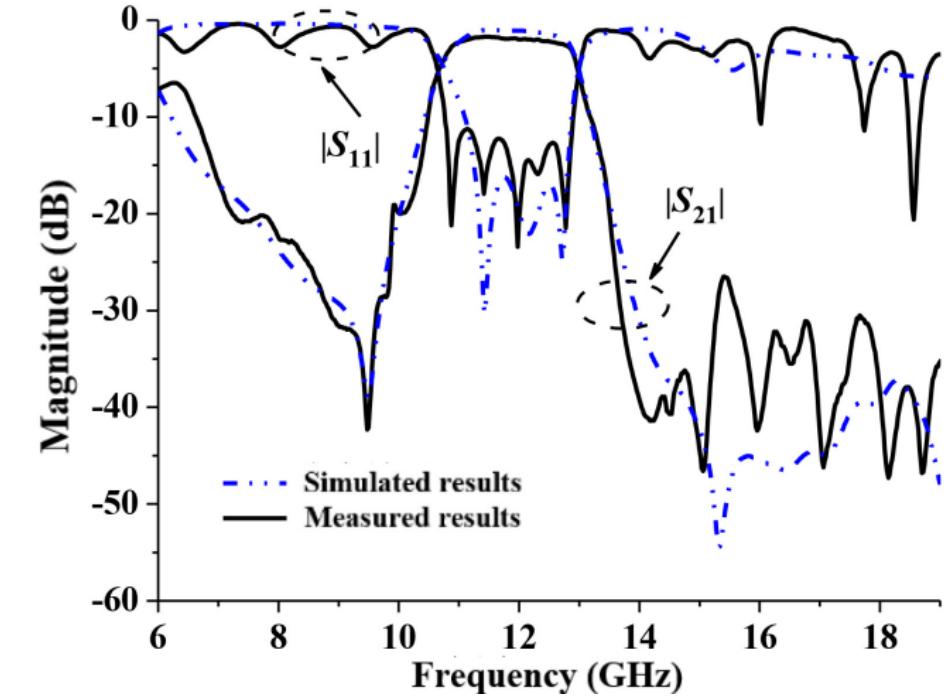
Motivation and Introduction

- BPF using double-sided parallel-stripline:

 High selectivity



 Limited stopband bandwidth

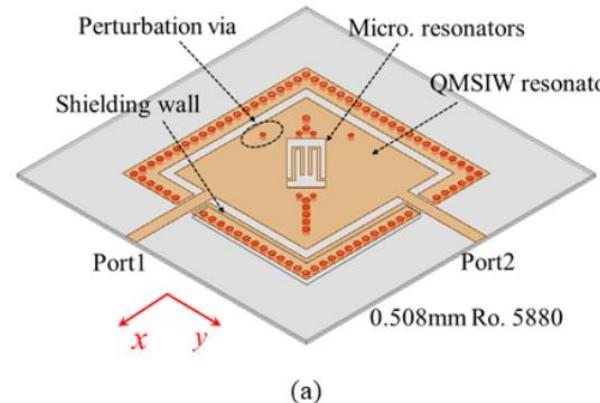


[2] W. Feng et al., "Novel wideband bandpass filters using double-sided quasi-SSPPs transmission line," *IEEE Trans. Circuits Syst. II*, vol. 69, no. 7, pp. 3174–3178, Apr. 2022.

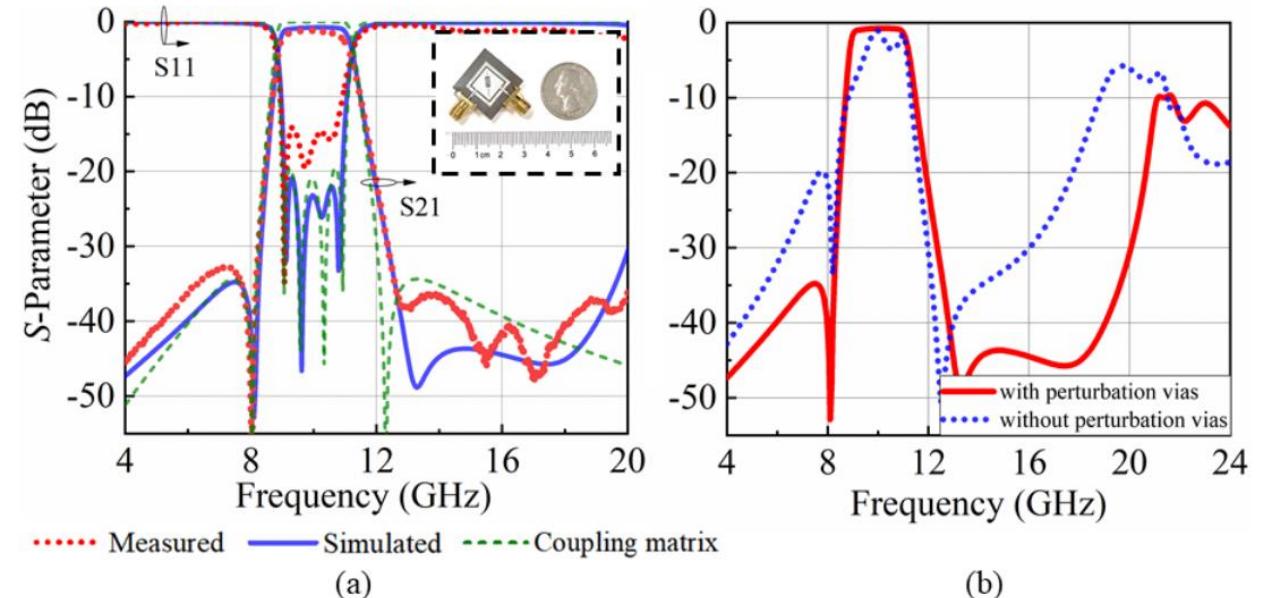
Motivation and Introduction

- BPF using substrate integrated waveguide (SIW) and microstrip line resonators:

 High selectivity



 Relatively large size

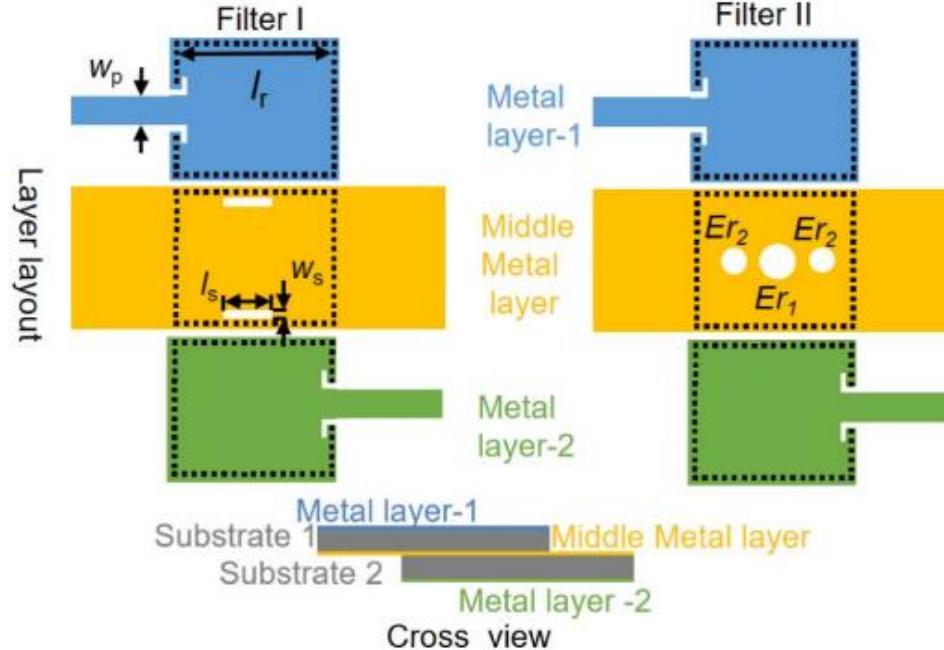


[3] Y. Zheng, Y. Zhu, Z. Wang, and Y. Dong, “Compact, wide stopband, shielded hybrid filter based on quarter-mode substrate integrated waveguide and microstrip line resonators,” *IEEE Microw. Wireless Compon. Lett.*, vol. 31, no. 3, pp. 245–248, Mar. 2021.

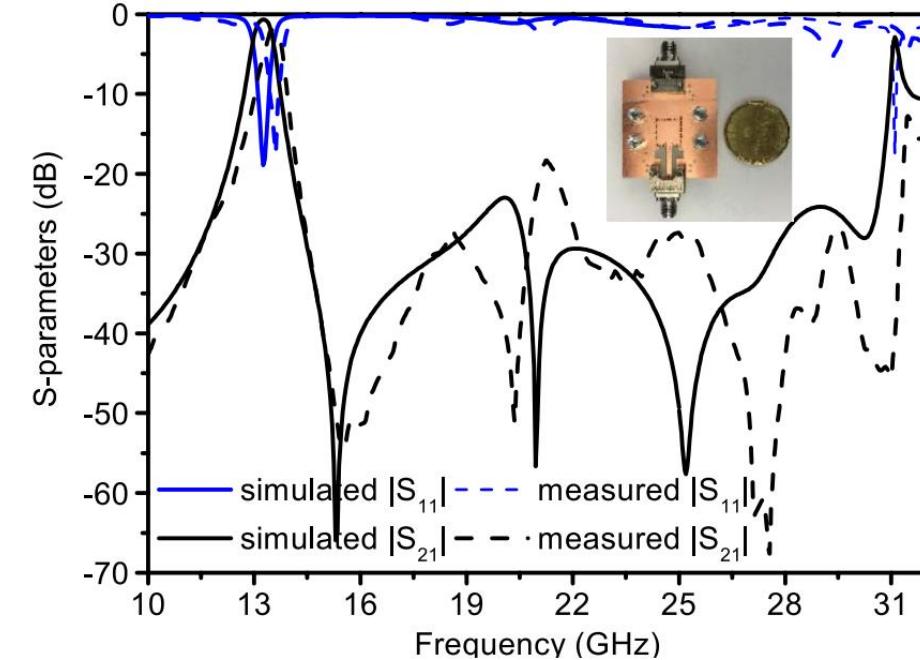
Motivation and Introduction

- **BPF using multilayer SIW:**

- 😊 Relatively compact size
- 😊 Relatively wide stopband



- 😢 Limited passband bandwidth

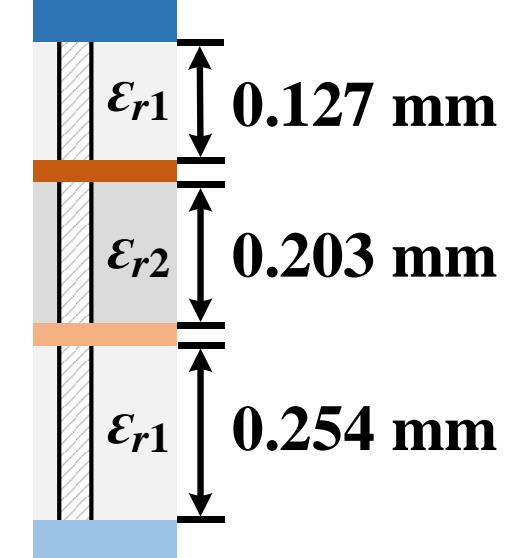
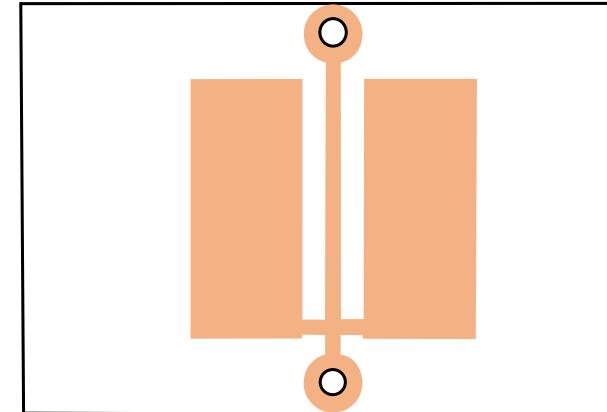
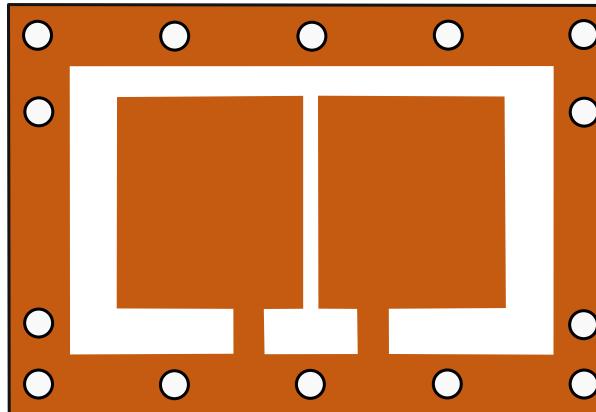
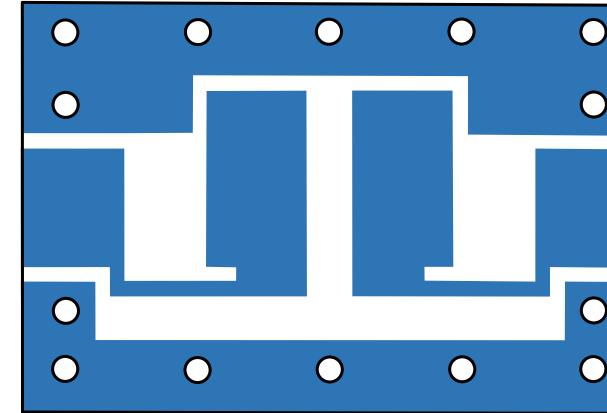
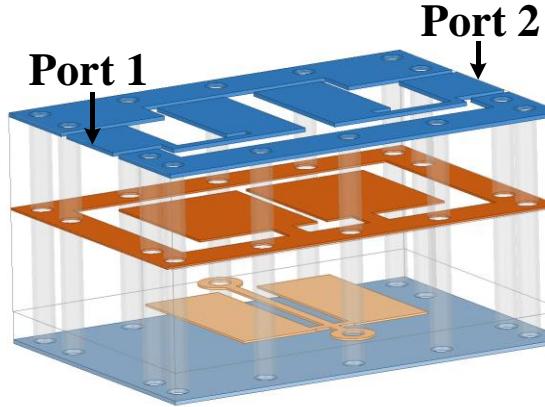


[4] D. Jia, Q. Feng, Q. Xiang, and K. Wu, “Multilayer substrate integrated waveguide (SIW) filters with higher-order mode suppression,” *IEEE Microw. Wireless Compon. Lett.*, vol. 26, no. 9, pp. 678–680, Sep. 2016.

Motivation and Introduction

- Configuration of the proposed BPF and layer diagram:

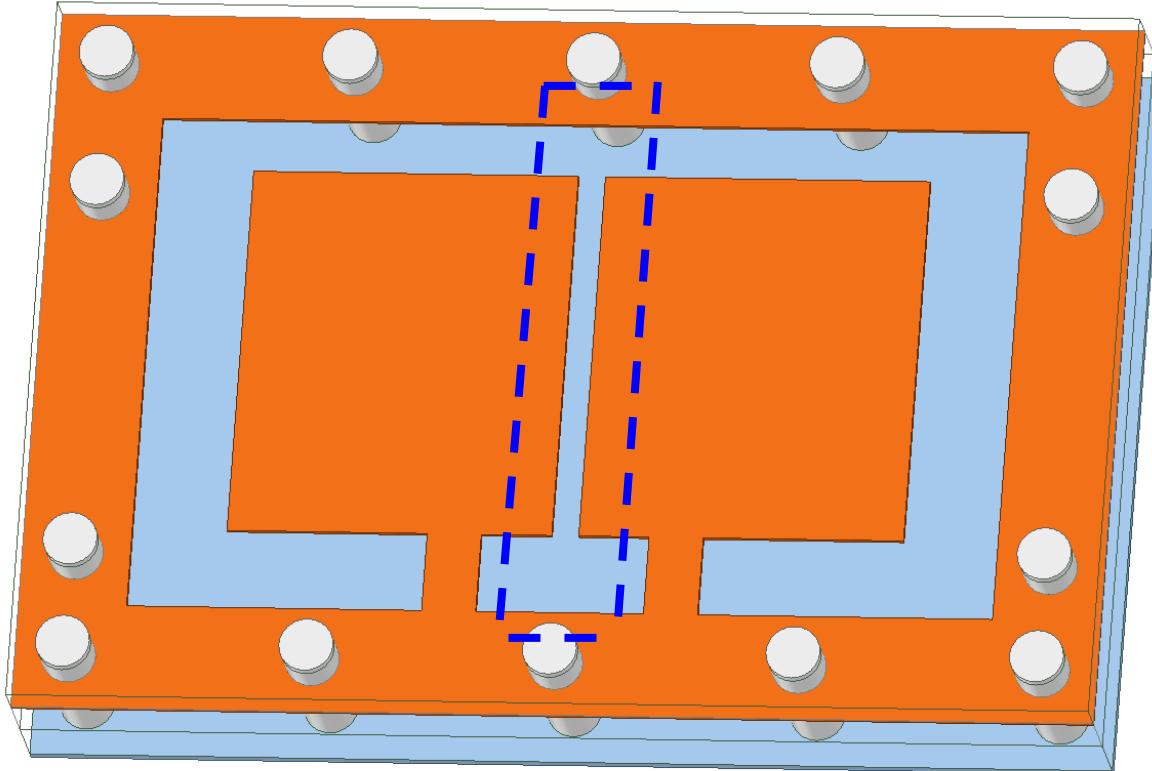
█ CPW █ Ground I █ Microstrip █ Ground II ○ Metal-Via



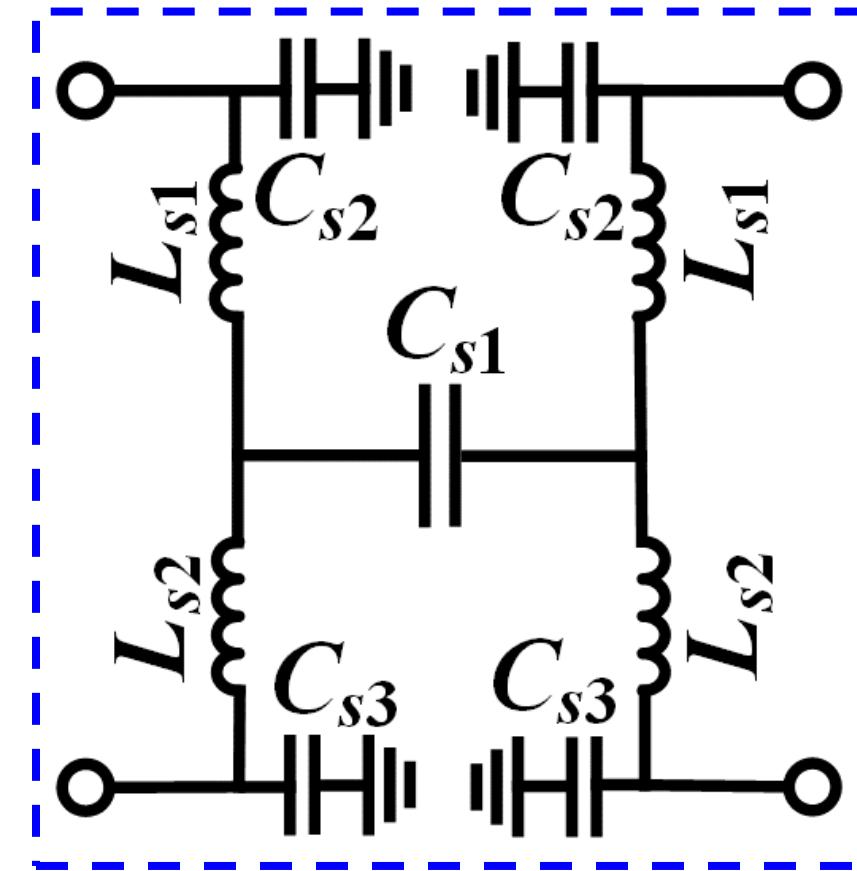
Taconic TLY-5, $\epsilon_{r1} = 2.2$

R04450F, $\epsilon_{r2} = 3.52$

- SIDGS dual-mode resonant cell:

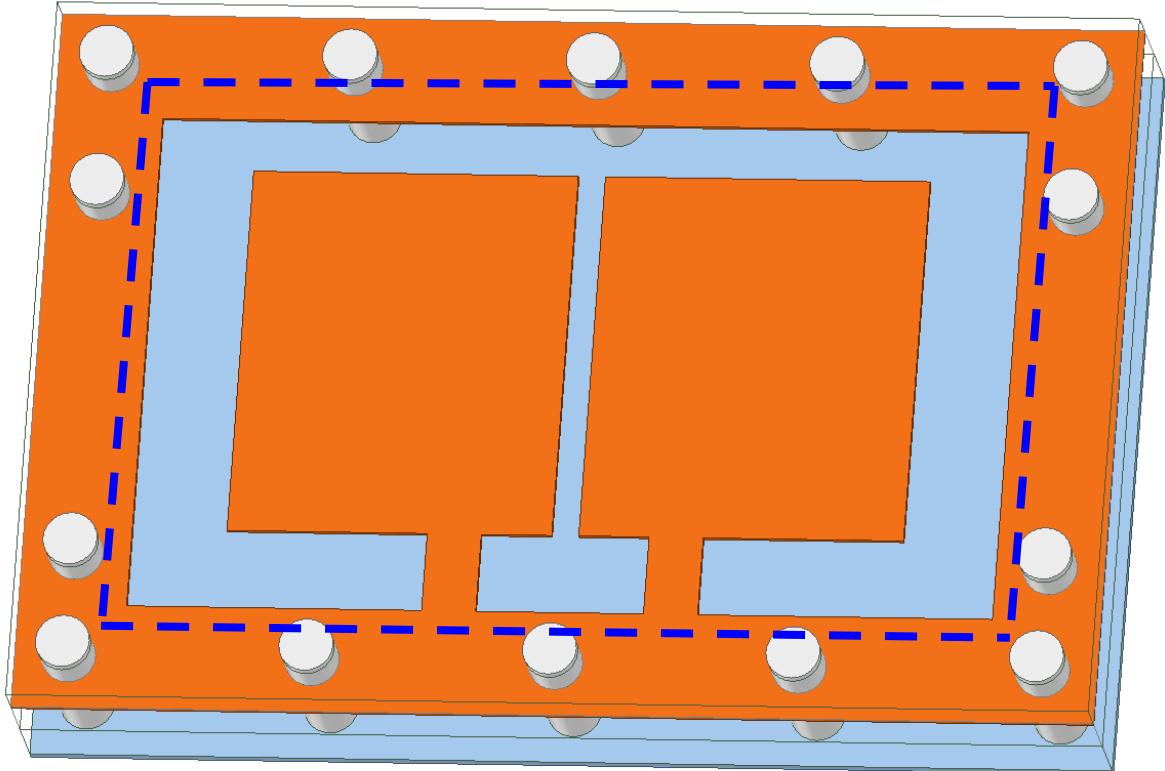


Simplified equivalent circuit
of the marked etch

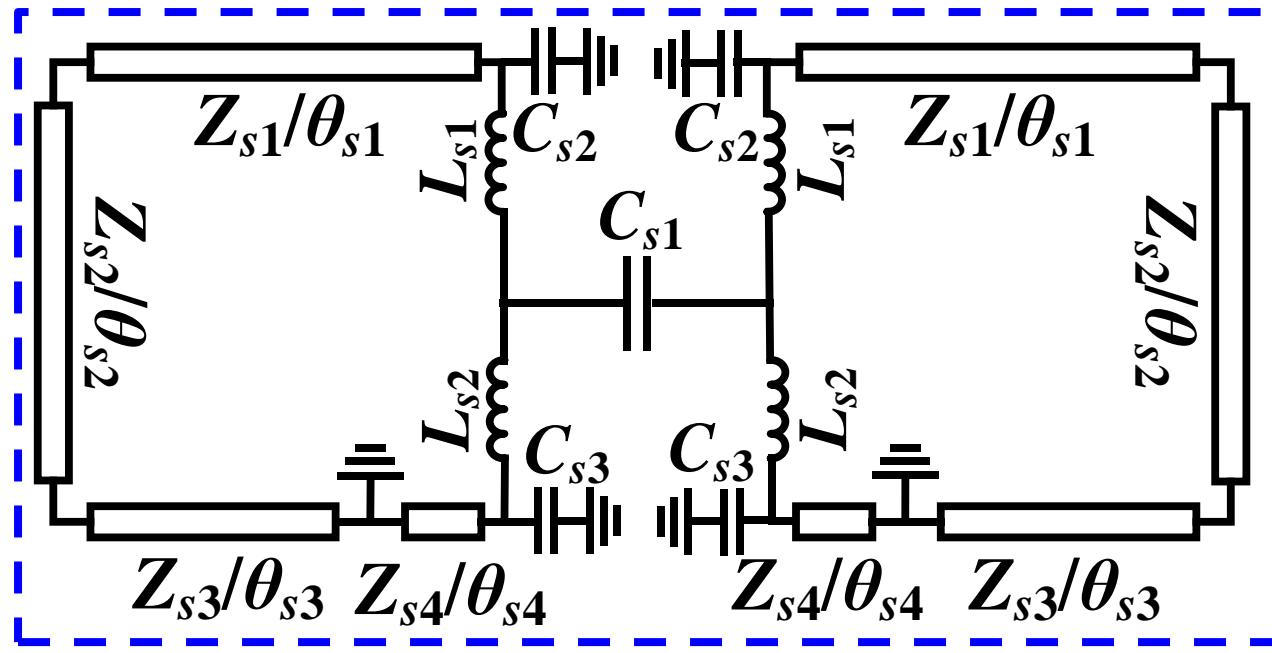


[5] J. Zhou, Y. Rao, D. Yang, H. J. Qian, and X. Luo, "Compact wideband BPF with wide stopband using substrate integrated defected ground structure," *IEEE Microw. Wireless Compon. Lett.*, vol. 31, no. 4, pp. 353–356, Apr. 2021.

- SIDGS dual-mode resonant cell:



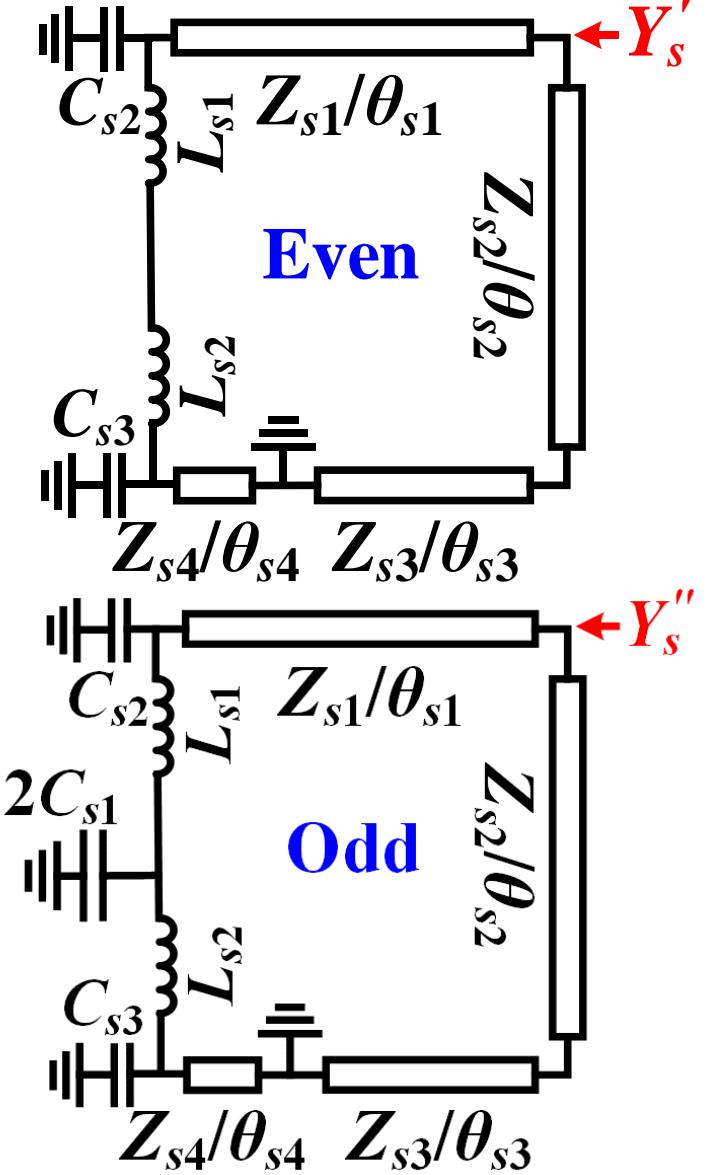
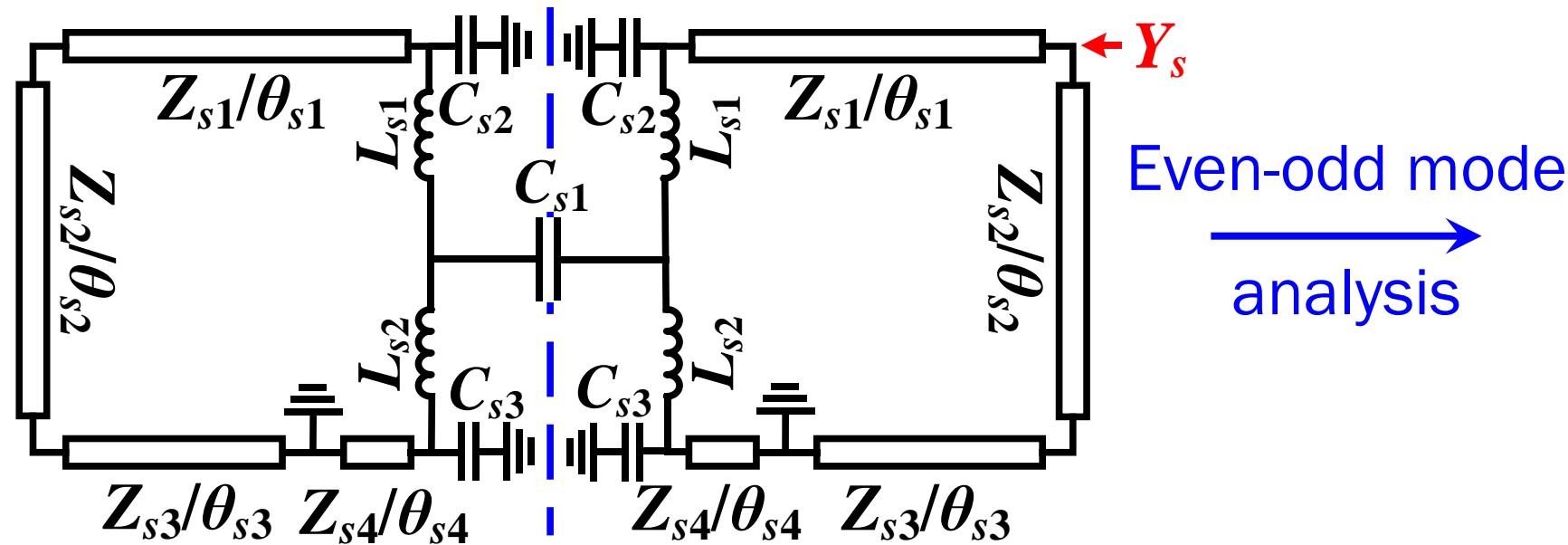
Simplified equivalent circuit
of the SIDGS resonant cell



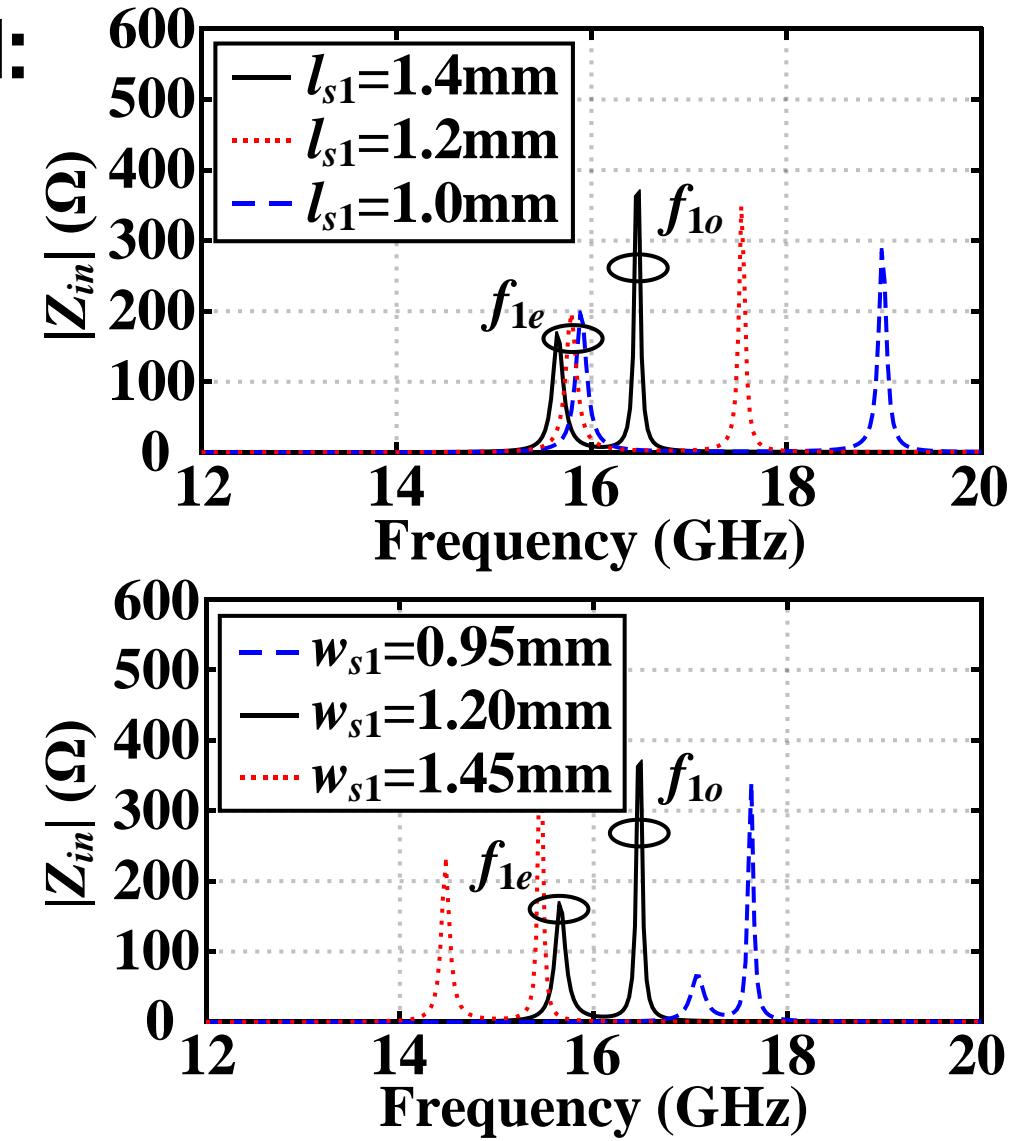
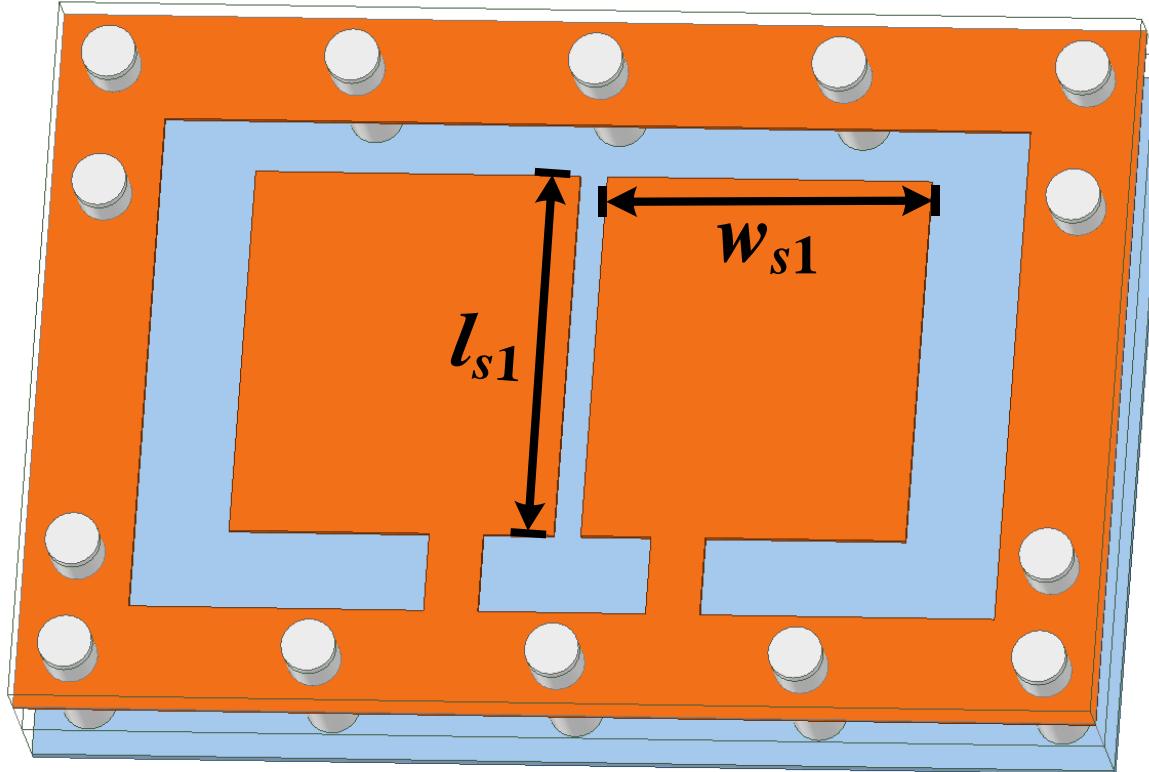
[6] D. Tang, C. Han, Z. Deng, H. J. Qian, and X. Luo, "Substrate-integrated defected ground structure for single- and dual-band bandpass filters with wide stopband and low radiation loss," *IEEE Trans. Microw. Theory Techn.*, vol. 69, no. 1, pp. 659–670, Jan. 2021.

Hybrid Dual-Mode Resonant Cell

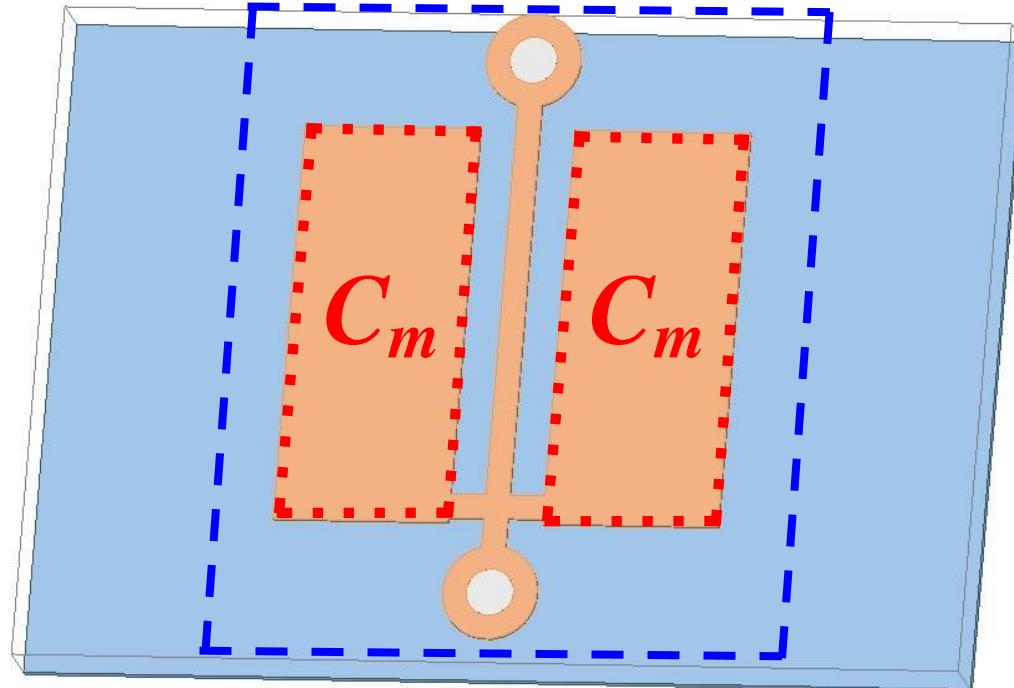
- SIDGS dual-mode resonant cell:



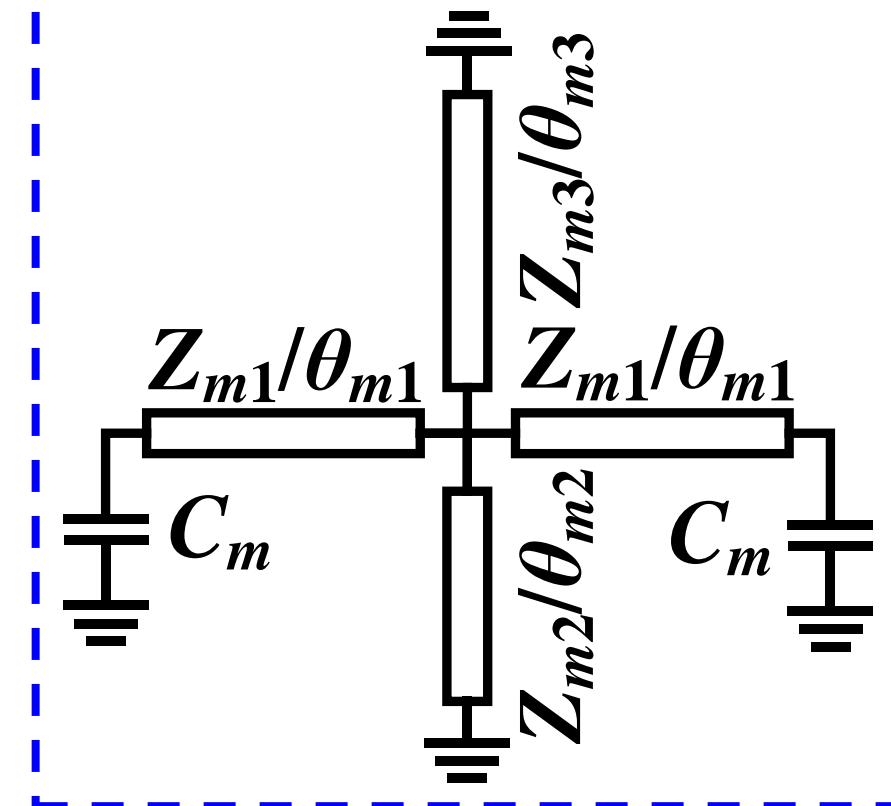
- SIDGS dual-mode resonant cell:



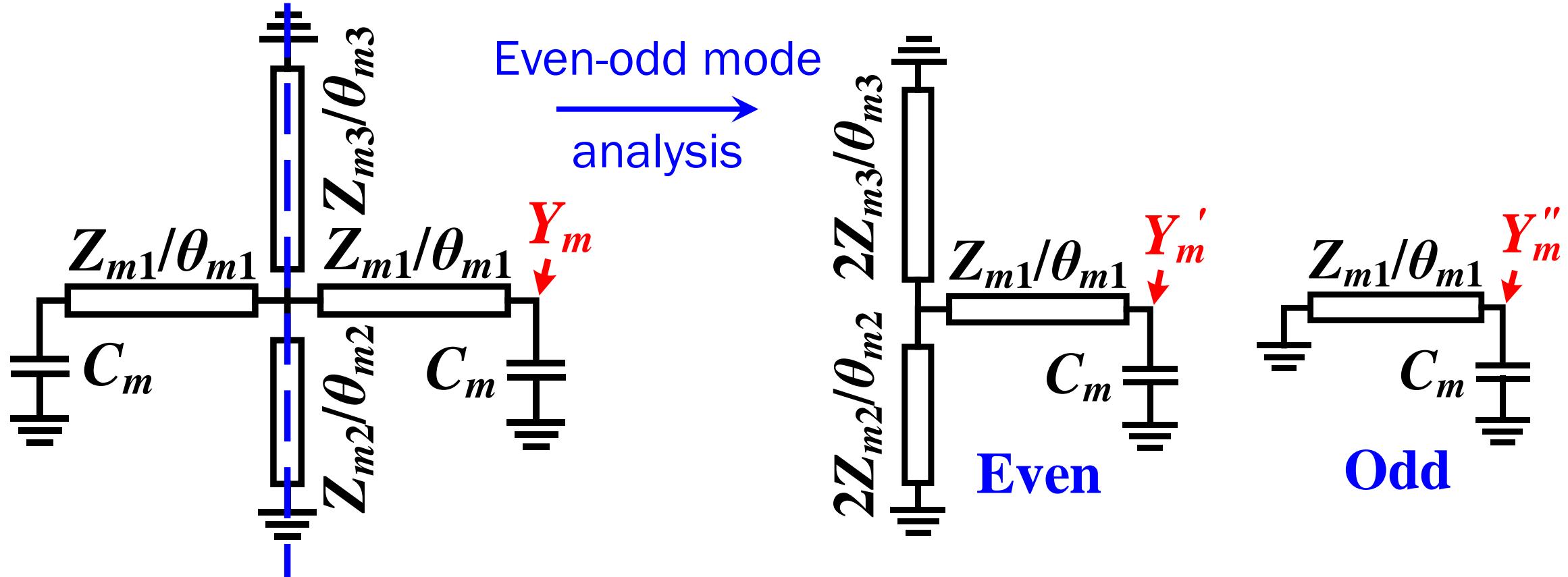
- Microstrip dual-mode resonant cell:



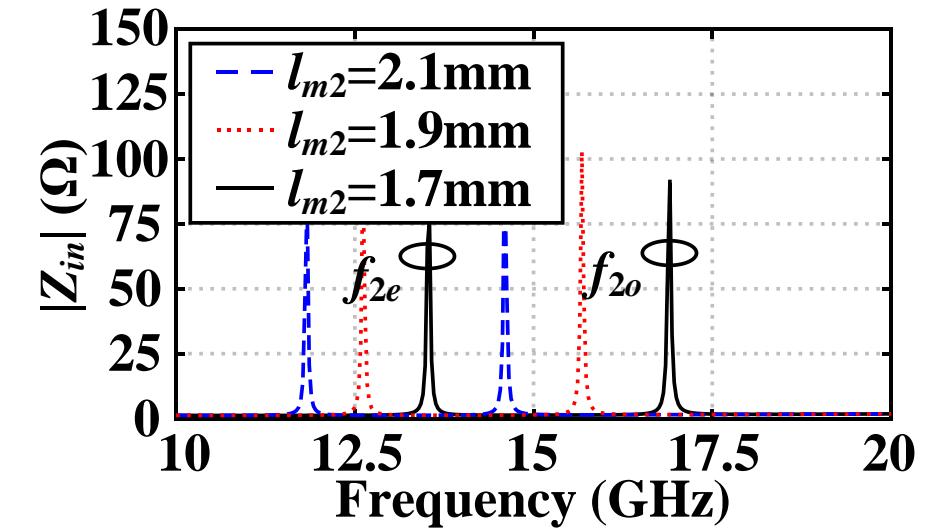
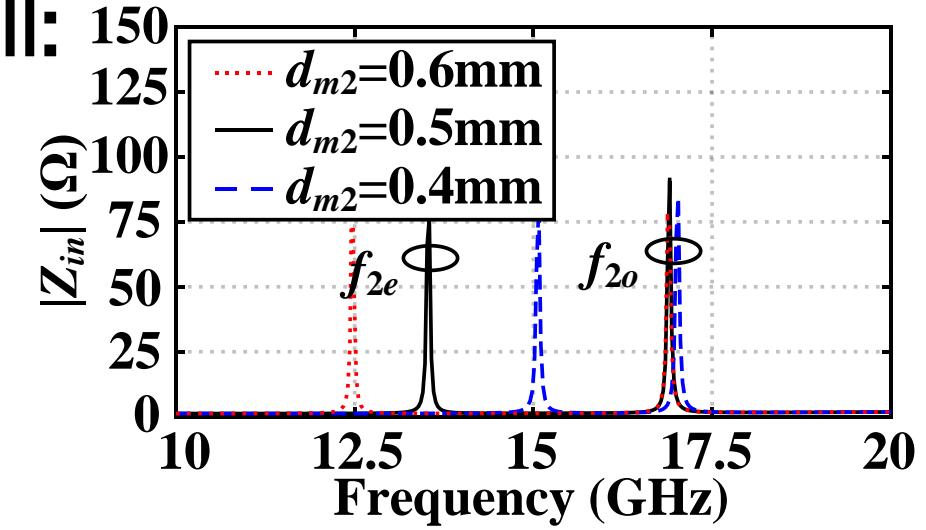
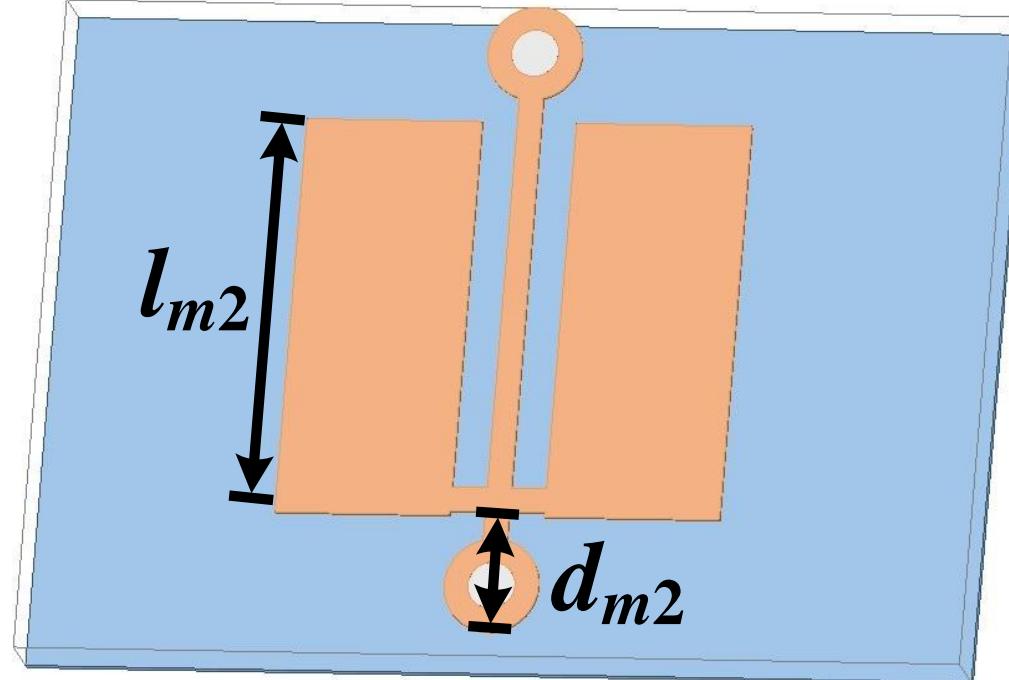
Simplified equivalent circuit
of the microstrip resonant cell



- Microstrip dual-mode resonant cell:

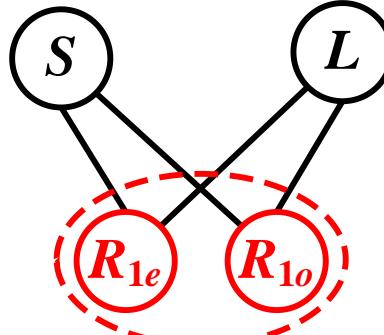


- Microstrip dual-mode resonant cell:

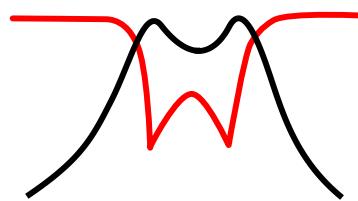


Filter Design

- Coupling scheme:



Dual-Mode Resonant Cell



Case I

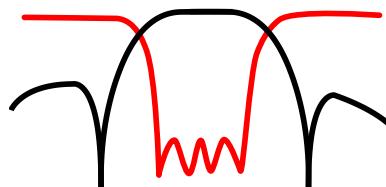
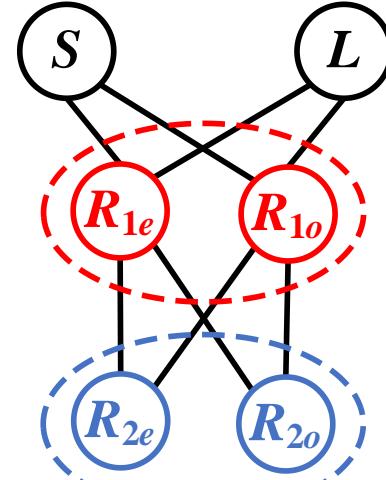


Narrow passband



Low selectivity

— Strong Coupling - - Weak Coupling



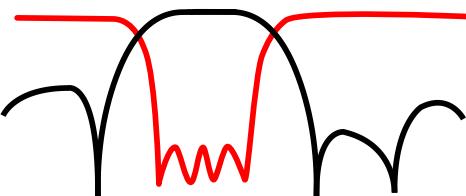
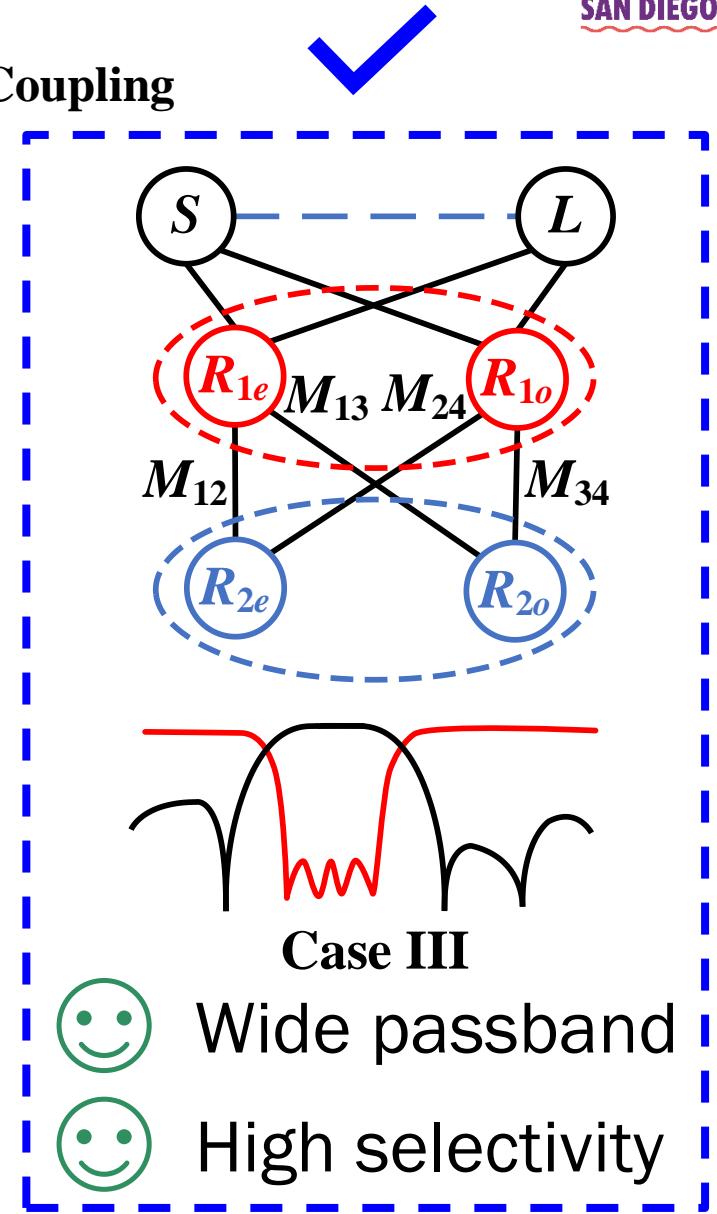
Case II



Wide passband



Low selectivity



Case III

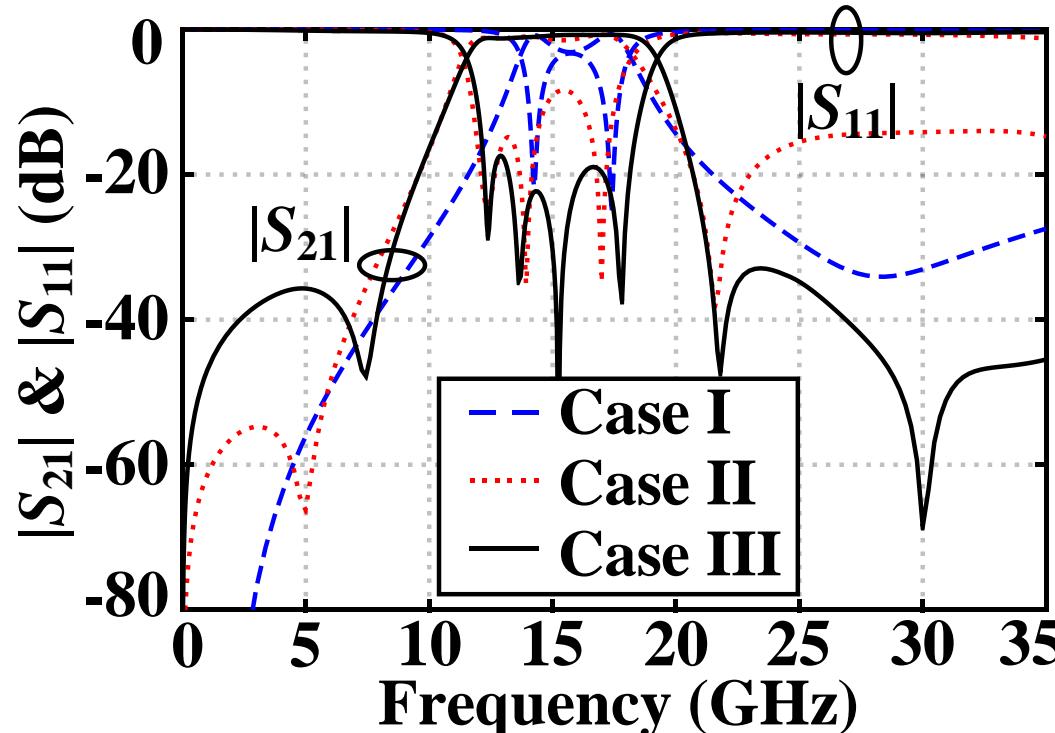


Wide passband



High selectivity

- Coupling scheme:



Simulated S-parameters with various coupling topologies (i.e., Case I–III)

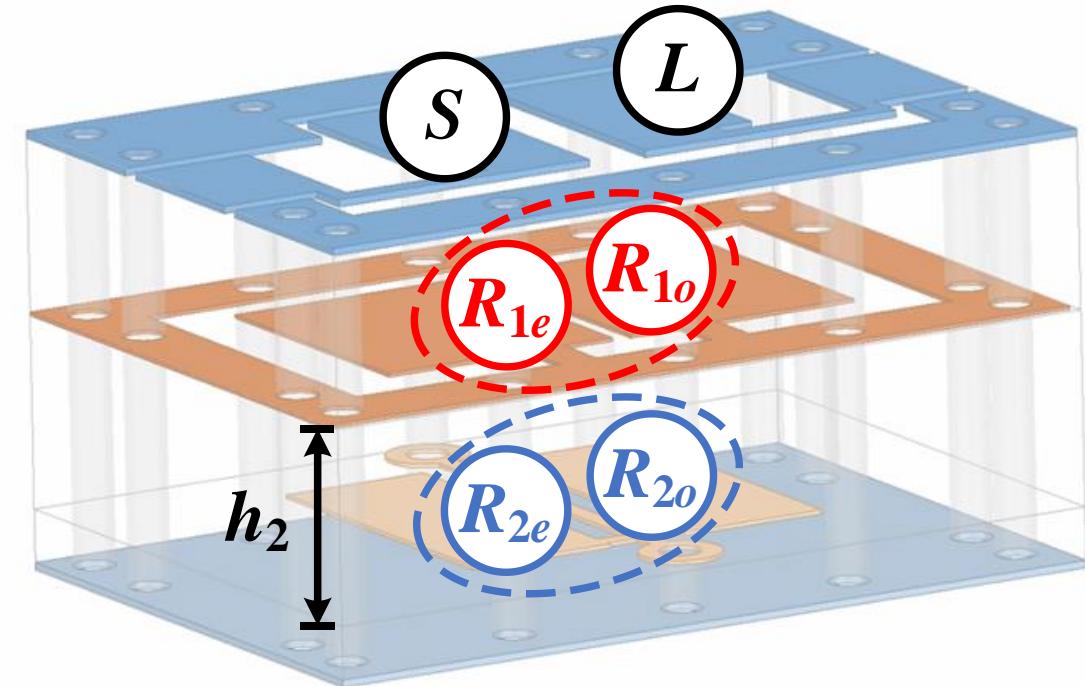


Diagram of resonant cells in the proposed BPF

- **Coupling scheme:**

The frequency transformations of the dual-mode resonant cells and the proposed BPF can be obtained by:

$$\Omega_i = (\omega/\omega_i - \omega_i/\omega)/B_i, i = 1e, 1o, 2e, 2o$$

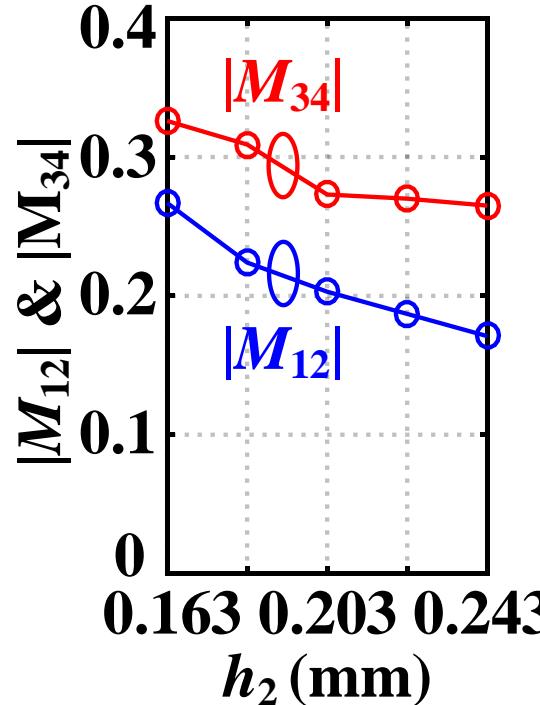
$$\Omega_0 = \begin{vmatrix} \Omega_{1e} & M_{12} & M_{13} & 0 \\ M_{12} & \Omega_{2e} & 0 & M_{24} \\ M_{13} & 0 & \Omega_{2o} & M_{34} \\ 0 & M_{24} & M_{34} & \Omega_{1o} \end{vmatrix}.$$

Good agreement is achieved between calculated results (i.e., 12.4, 14.2, 16.8, and 18.9 GHz) and EM-simulated results (i.e., 12.2, 13.6, 16.2, and 18.8 GHz).

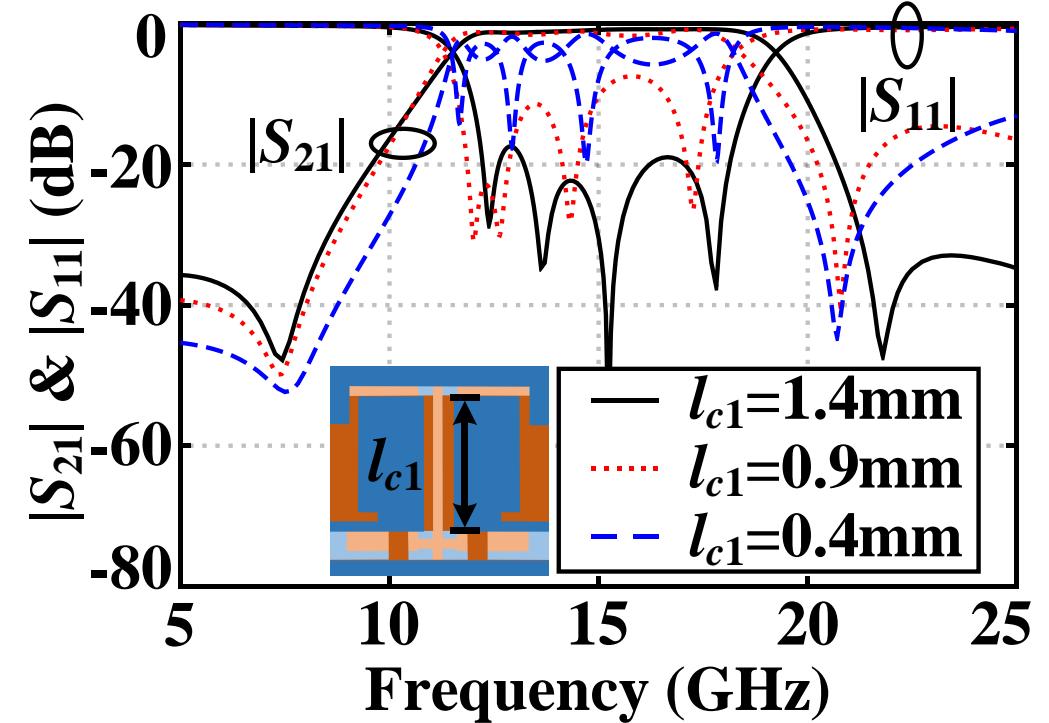
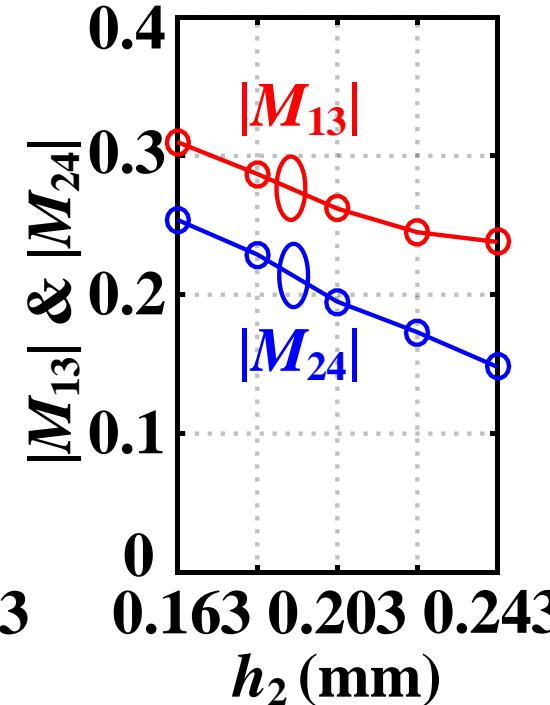
[7] J. Xie, D. Tang, Y. Shu, and X. Luo, “Compact UWB BPF with broad stopband based on loaded-stub and C-shape SIDGS resonators,” *IEEE Microw. Wireless Compon. Lett.*, vol. 32, no. 5, pp. 383–386, May 2022.

Filter Design

- Coupling scheme:

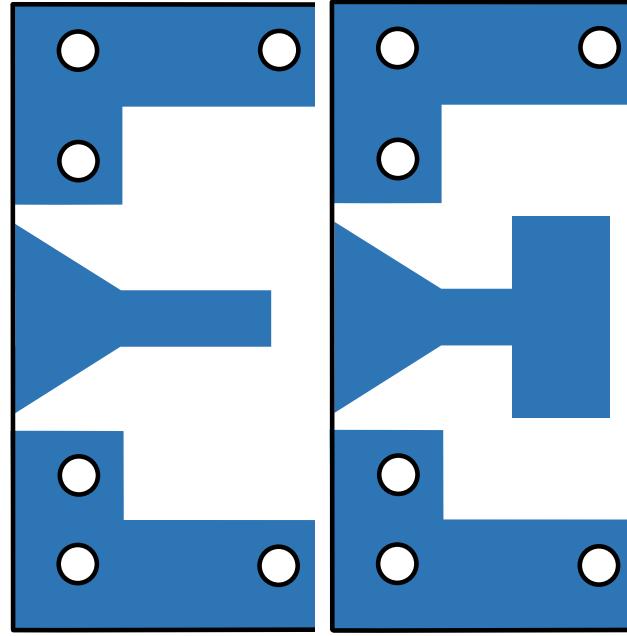


Simulated effect of h_2 on the coupling coefficients.



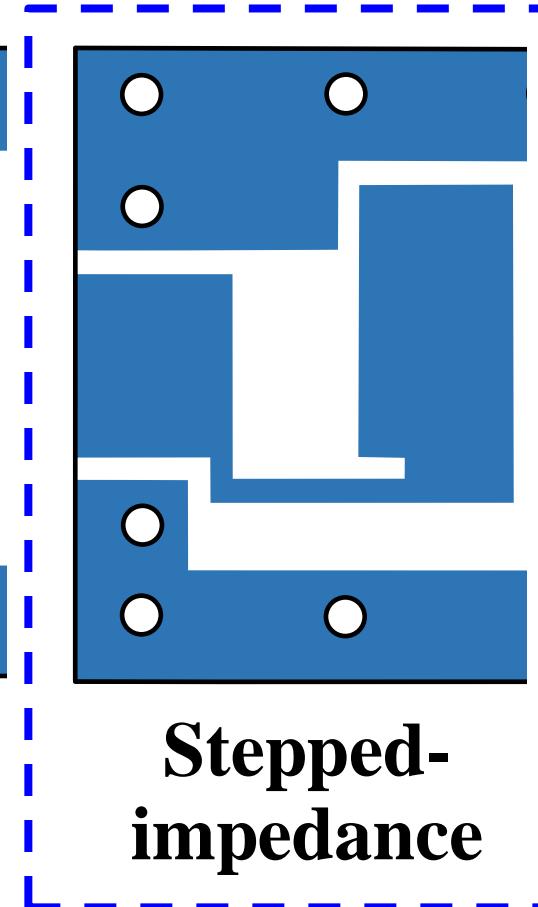
Simulated results with different lengths of l_{c1} .

- Stopband suppression:

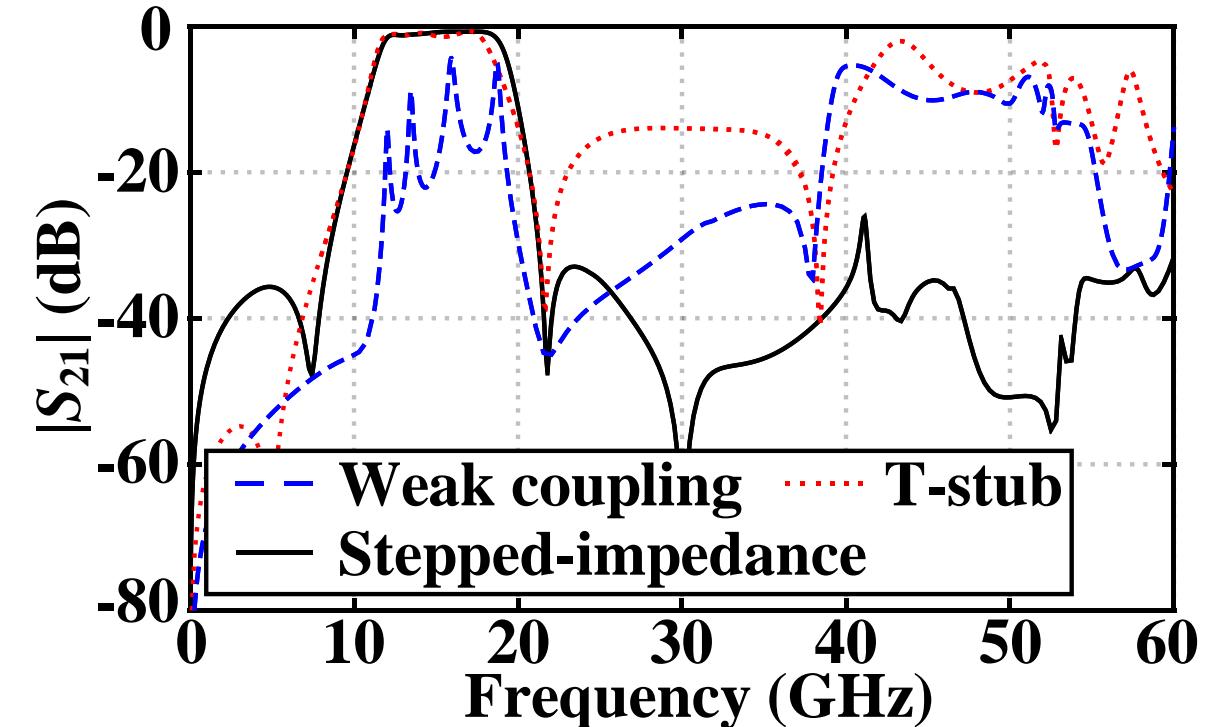


Weak
Coupling

T-stub

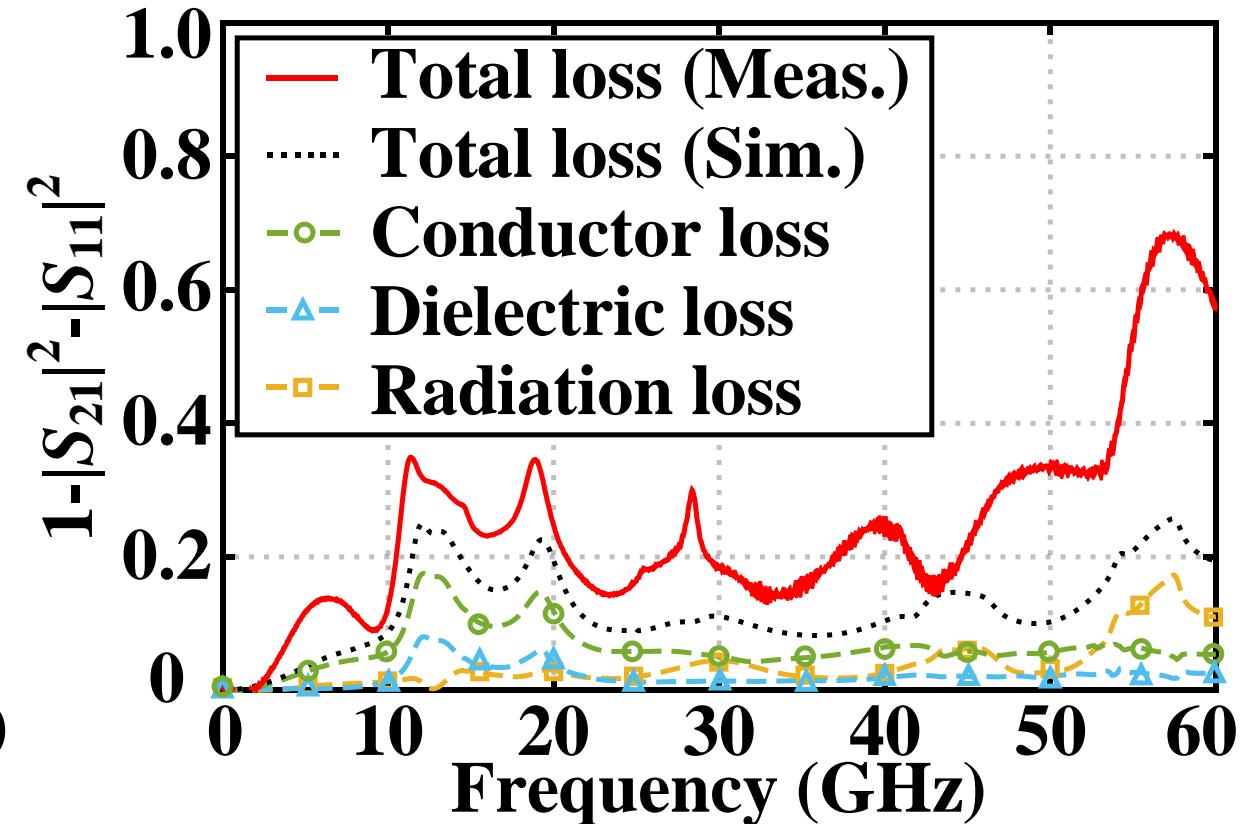
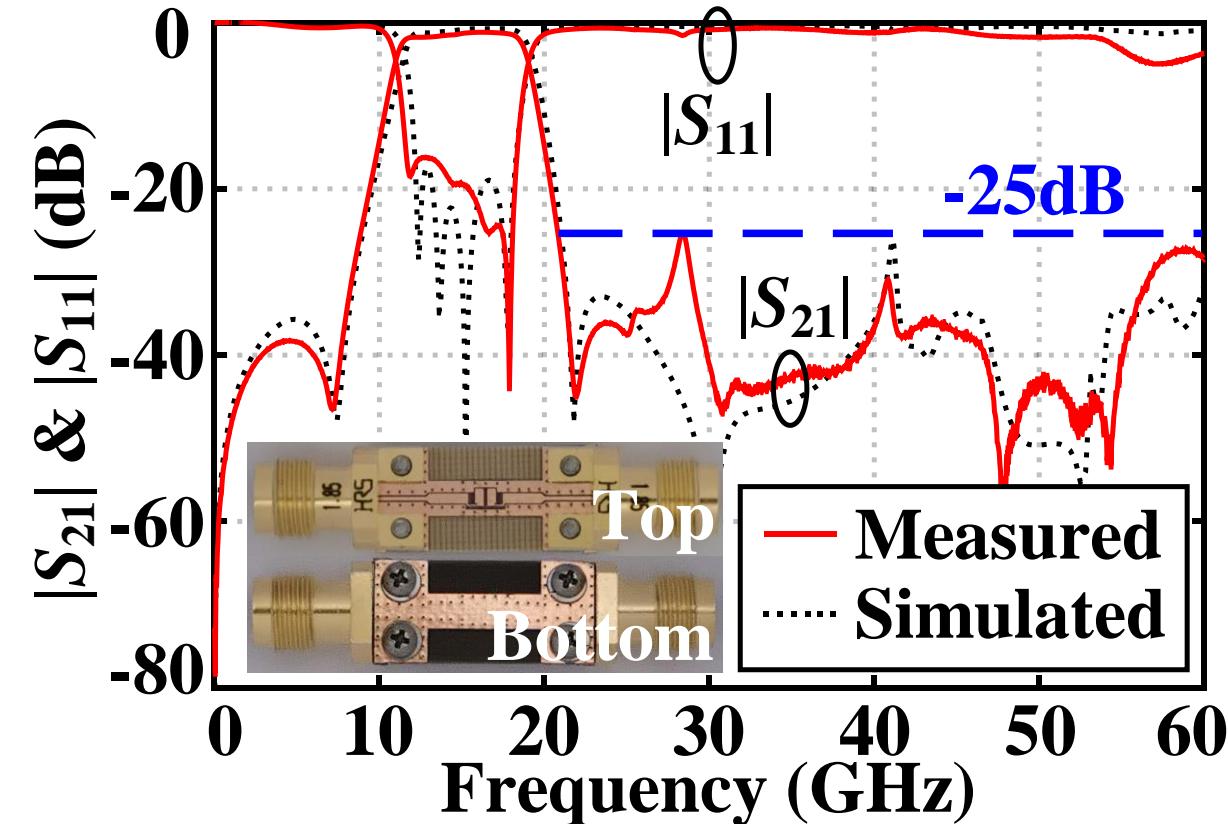


Stepped-
impedance



Simulated S-parameters

- Photograph and simulated & measured results:



- Comparison table:

Ref.	MWCL[1]	TCAS-II[2]-A	MWCL[3]	MWCL[4]-II	This work
Tech.*	Microstrip	DSPSL	SIW	SIW	Hybrid
Q_u	N/A	N/A	199.8	N/A	237.7/147.4/ 101.8/122.8#
f_0 (GHz)	13.2	11.85	10	13.2	15
IL**(dB)	1.75	2.0	1.2	1.5	1.18
RL \triangle (dB)	15	11.2	14 $^\diamond$	15 $^\diamond$	16
FBW(%)	7.6	18.6	22.7	4.5	52
Stopband Rejection	>28 dB up to $2.5f_0$	>25 dB up to $1.6f_0$	>36 dB up to $2f_0$	>20 dB up to $2.3f_0$	>25 dB up to $4f_0$
Core Size (mm^2)	27.6	N/A	123.7	82.8 $^\diamond$	10.8

- ✓ Wide passband
- ✓ Wide stopband
- ✓ Compact size

*: Technology. **: Insertion loss. \triangle : Return loss. $^\diamond$: Estimated from the paper.

#: R_{1e} , R_{1o} , R_{2e} , and R_{2o} .

Conclusion

Proposed: BPF using hybrid dual-mode SIDGS/microstrip resonant cell.

Advantage: Compact, operating at 12–18 GHz, wide stopband.

Application: Ku-band satellite communication.

Q & A time!

Thanks for your attention!!!