Merlion RFID Forum 2022
Paper Sharing Series

Organized by IEEE Singapore RFID Chapter

16:00-17:00 19 September 2022 (Monday)

Suppression of Cross-Band Scattering in Multiband Antenna Arrays

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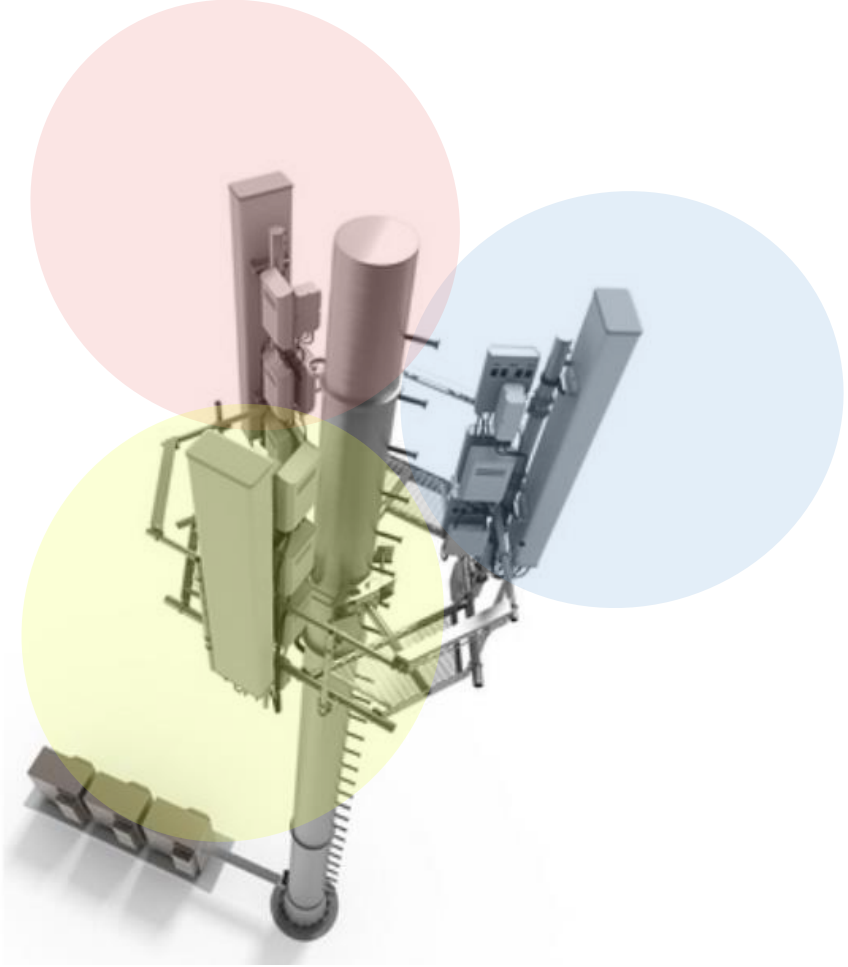
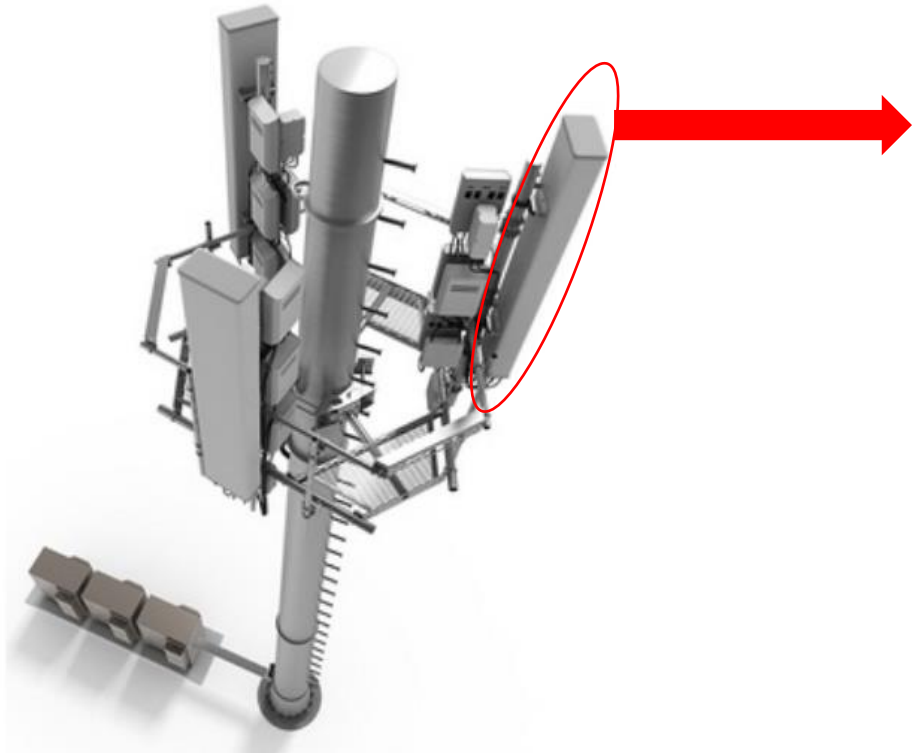
Presenter: Hai-Han Sun

INTRODUCTION: BASE STATION ANTENNAS

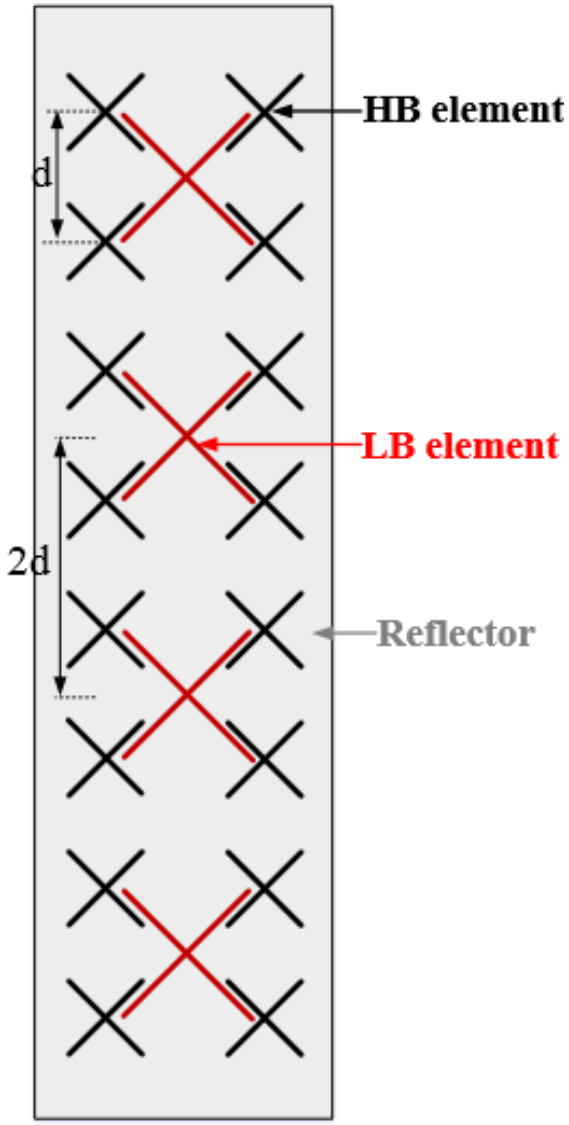


❑ *Typical three-sector cellular base station antennas*

INTRODUCTION: BASE STATION ANTENNAS

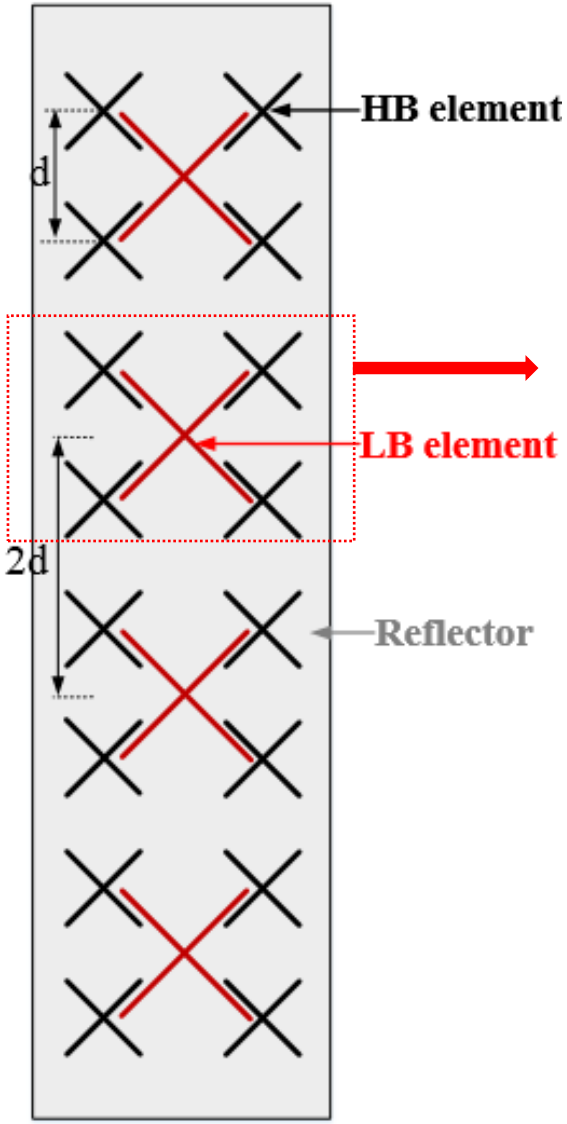


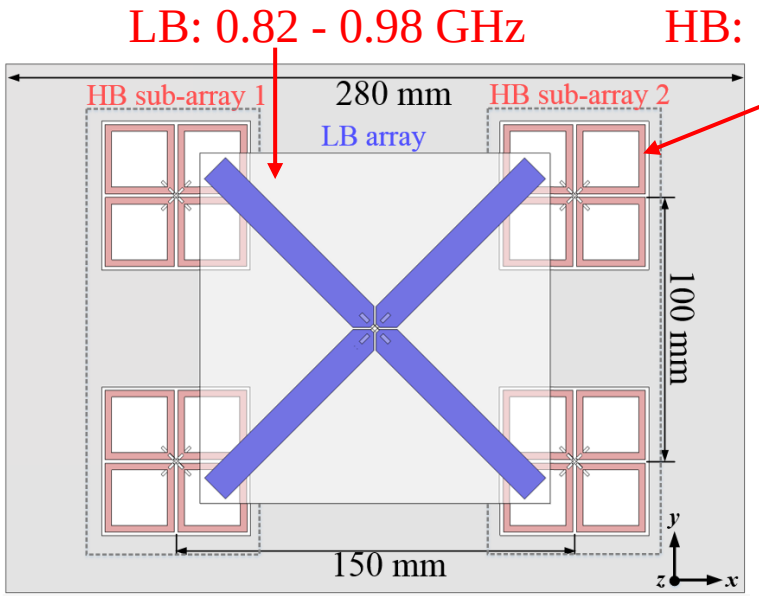
❑ *Three-sector base station antenna*

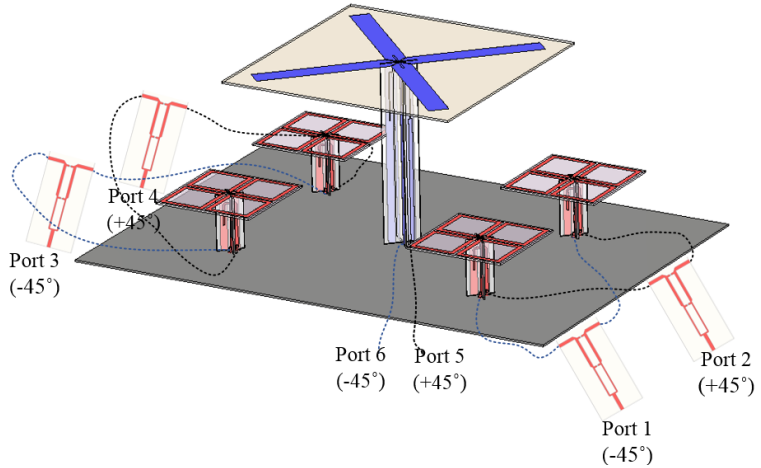


❑ *Dual-band base station antenna array configurations*

MOTIVATION: CROSS-BAND SCATTERING ISSUE







Close spacing

↓

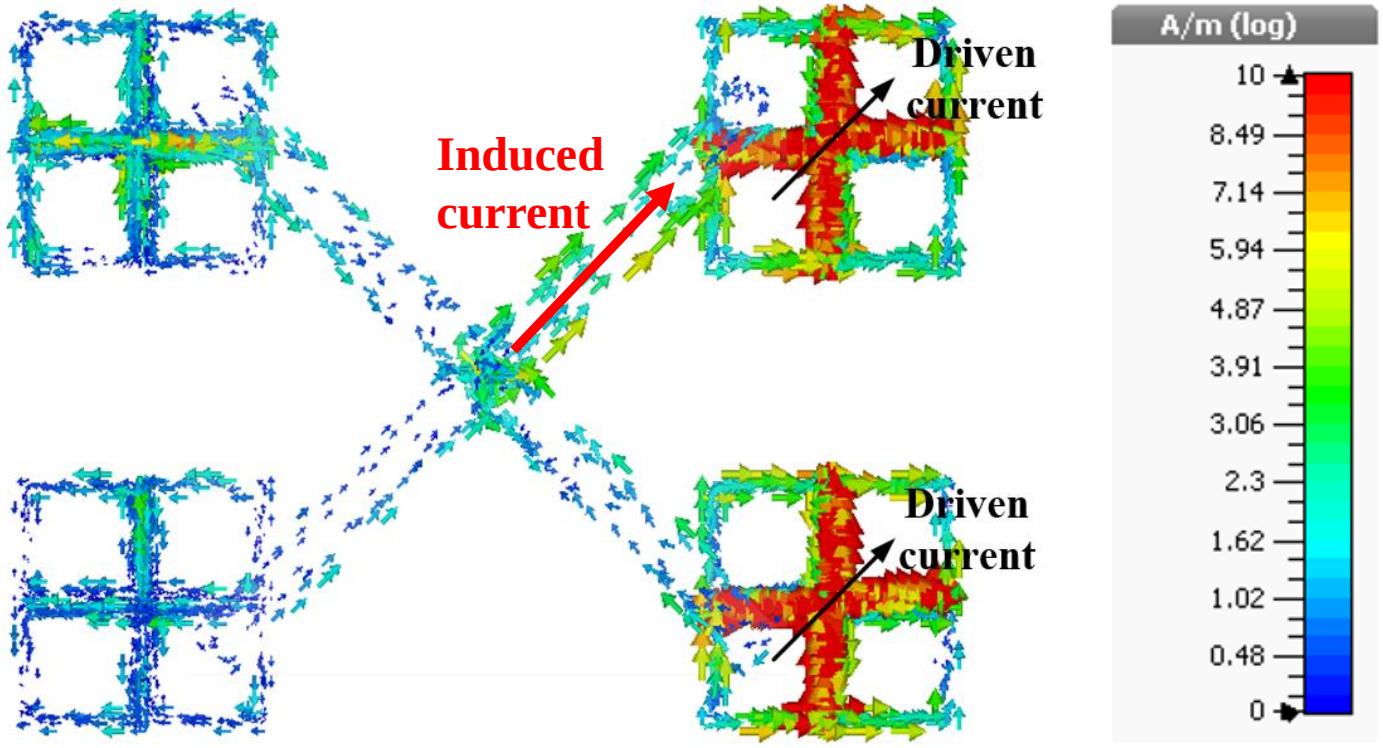
Cross-band scattering

↓

Destroy radiation performances

❑ *Configuration of an interleaved 3G and 4G BSA array section*

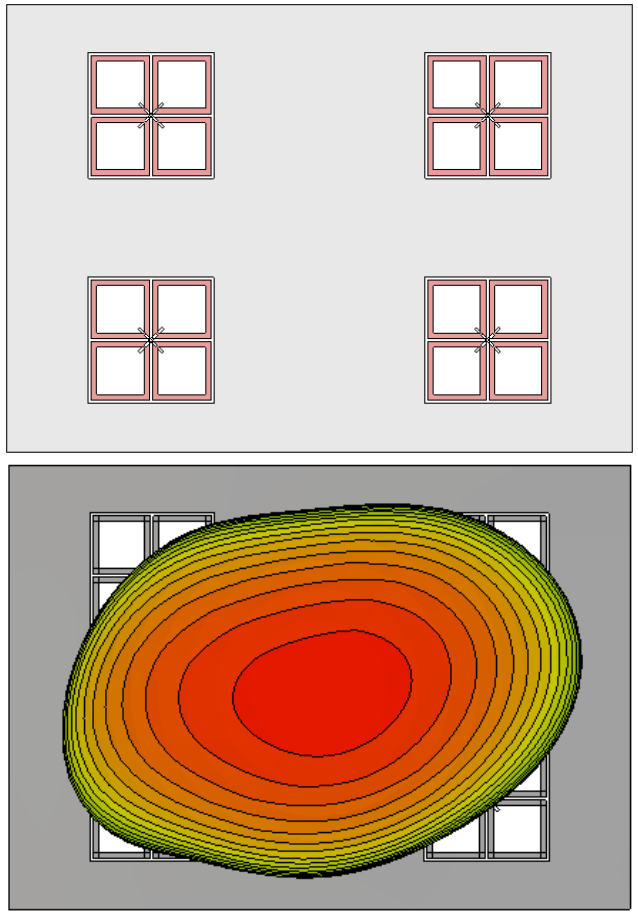
MOTIVATION: CROSS-BAND SCATTERING ISSUE



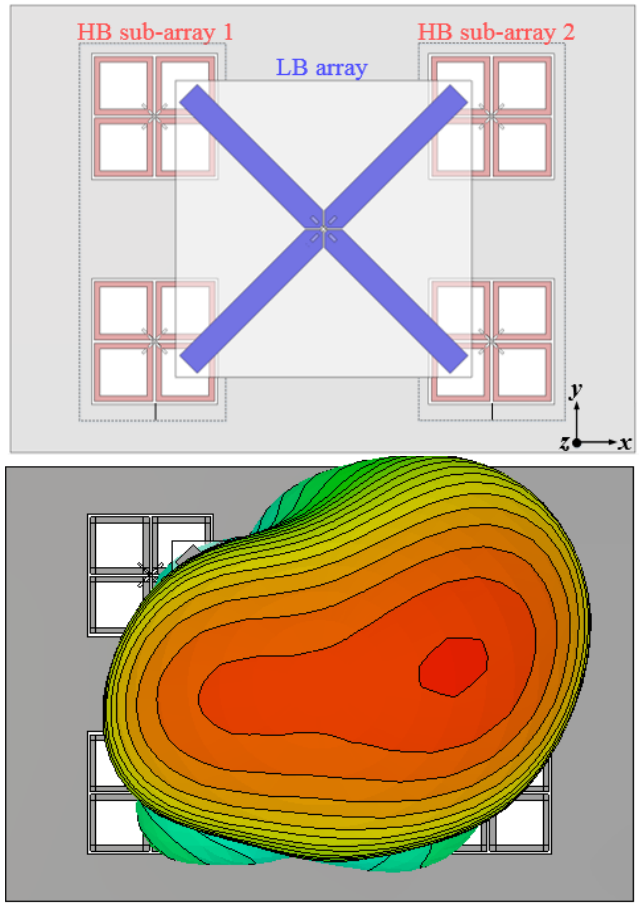
❑ *Current distribution when one HB array is excited at 1.7 GHz.*

MOTIVATION: CROSS-BAND SCATTERING ISSUE

Without LB element

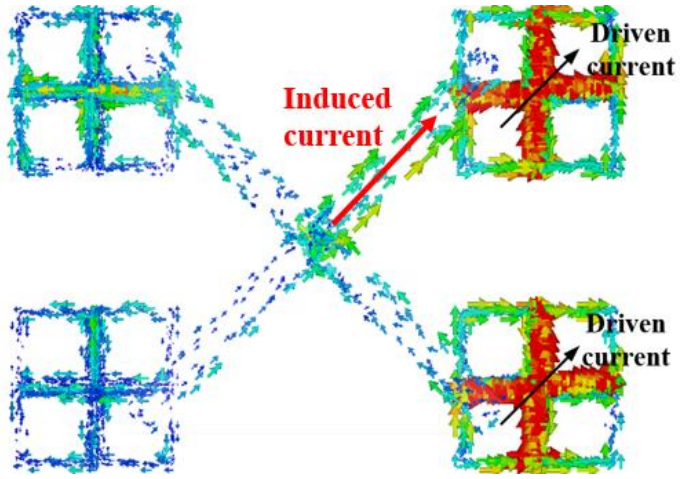


With LB element

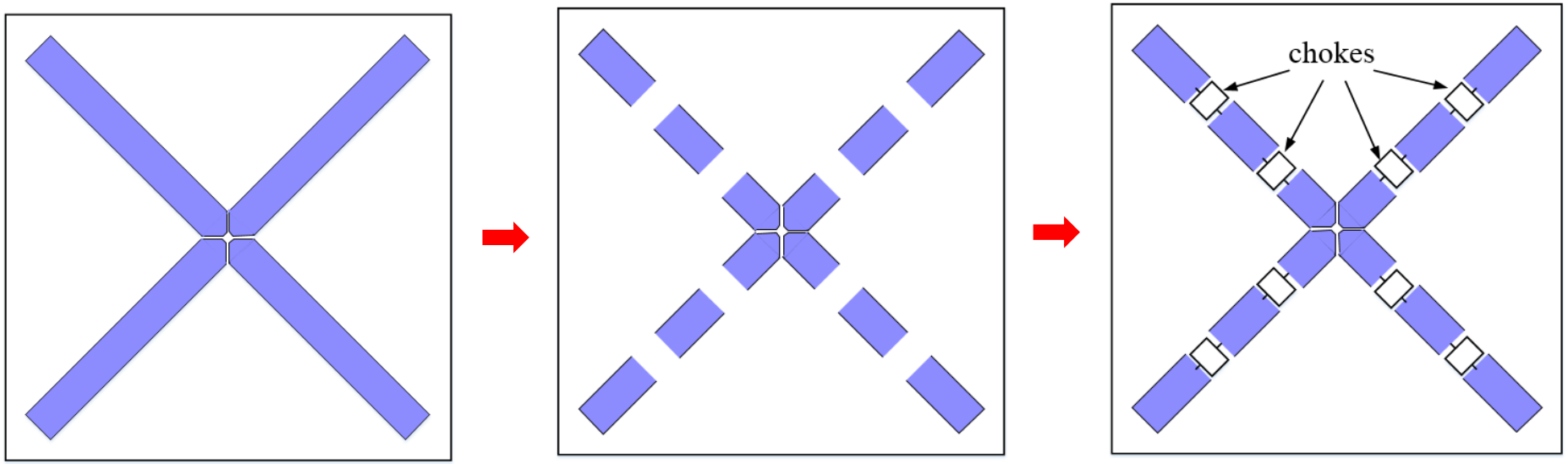


How to suppress the scattering and restore HB radiation pattern?

METHODOLOGY

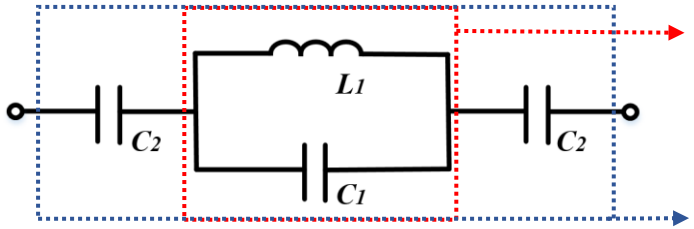


Chokes: open circuit at high band
short circuit at low band



METHODOLOGY

Design of chokes



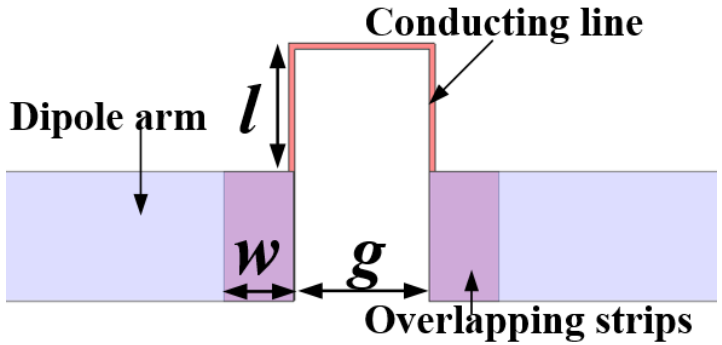
❑ *Circuit model of the choke*

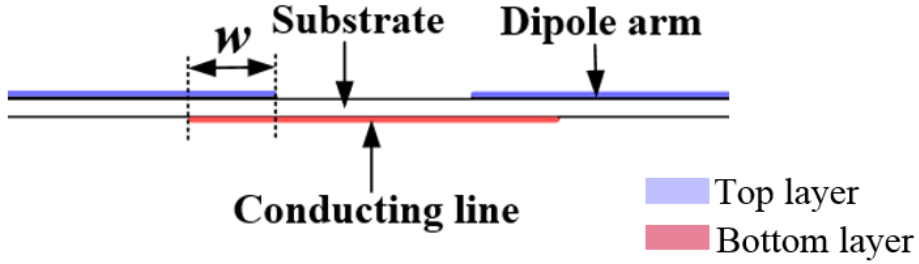
parallel resonance at HB (open circuit)

$$j2\pi f_h C_1 + \frac{1}{j2\pi f_h L_1} = 0$$

Series resonance at LB (short circuit)

$$\frac{2}{j2\pi f_l C_2} + \frac{1}{j2\pi f_l C_1 + \frac{1}{j2\pi f_l L_1}} = 0$$

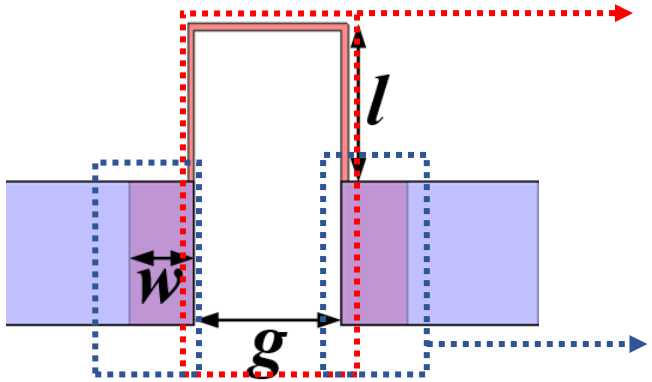




❑ *Configuration of realized choke*

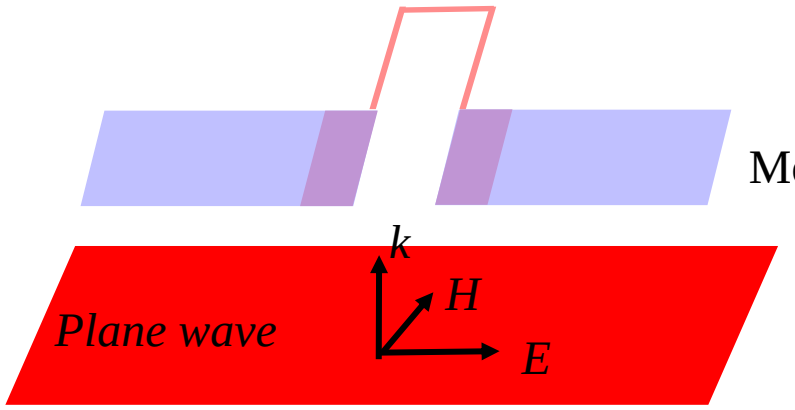
METHODOLOGY

Design of chokes



Suppress induced HB current

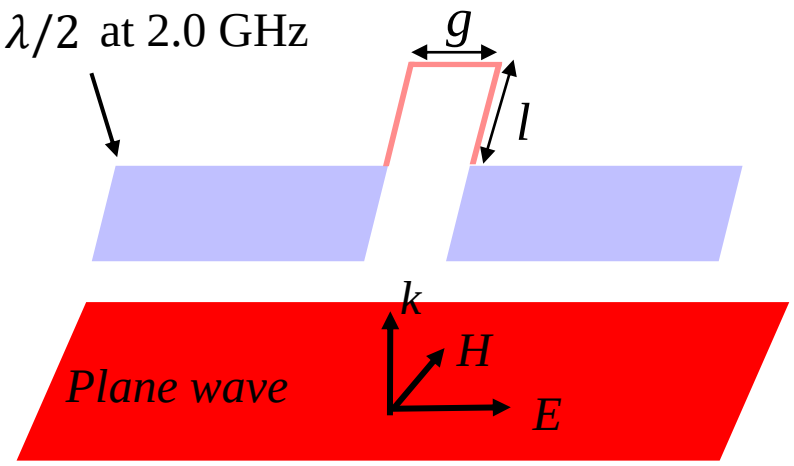
Create a pass band at LB

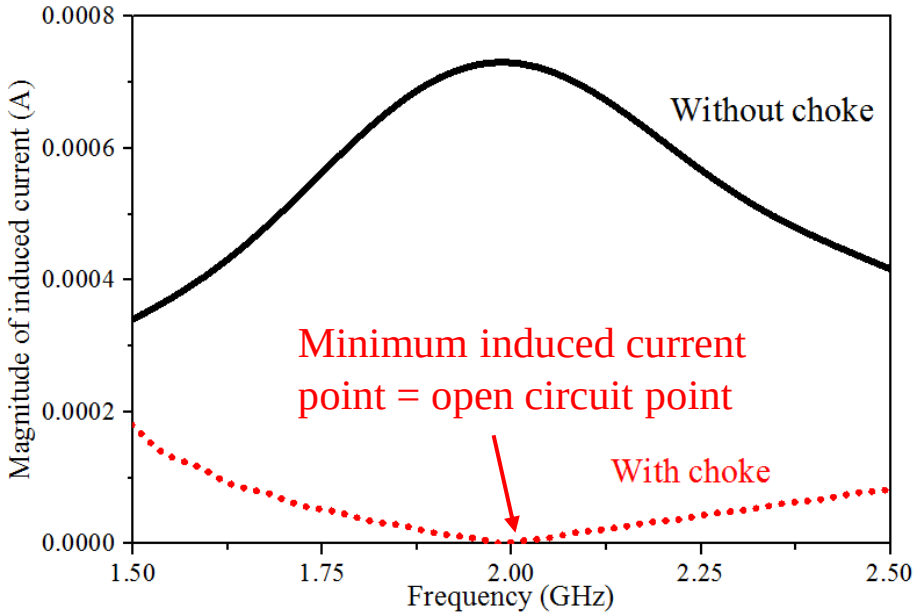


Monitor the maximum induced current

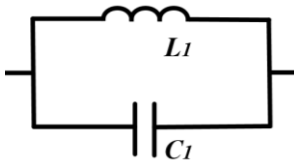
METHODOLOGY

Design of chokes – HB suppression (~2.0 GHz)





❑ Maximum induced HB currents

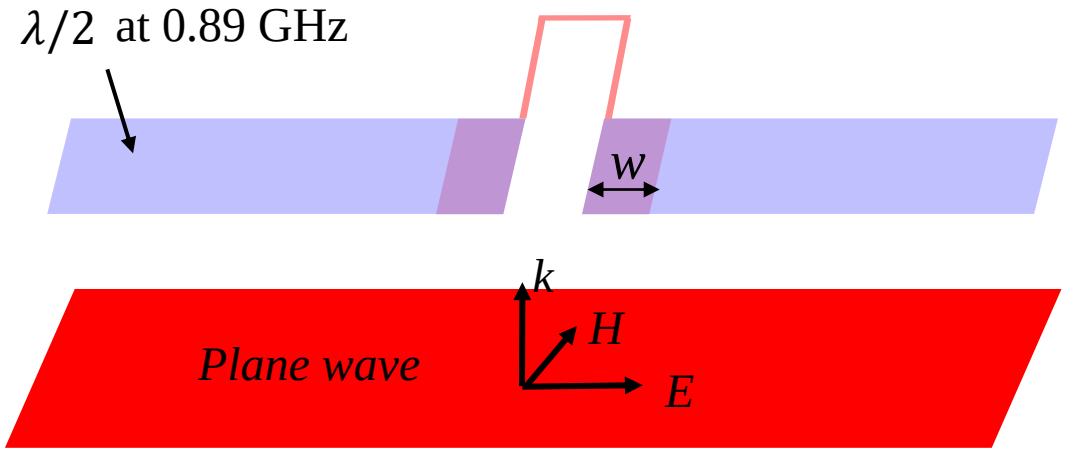


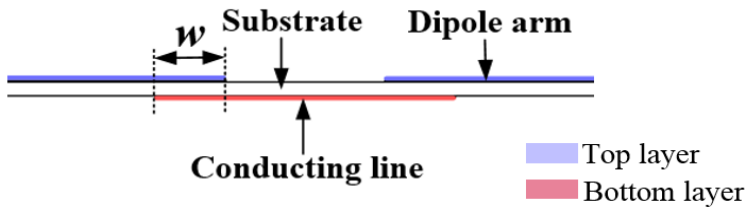
$$l \uparrow \rightarrow L1 \uparrow \rightarrow f_{open} \downarrow$$
$$g \uparrow \rightarrow C1 \downarrow \rightarrow f_{open} \uparrow$$

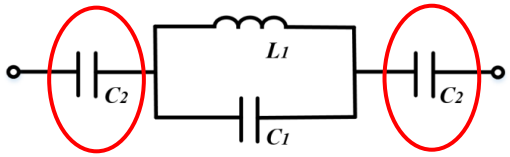
$$f_{open} = 2.0\ GHz$$

METHODOLOGY

Design of chokes – LB pass (~0.89 GHz)

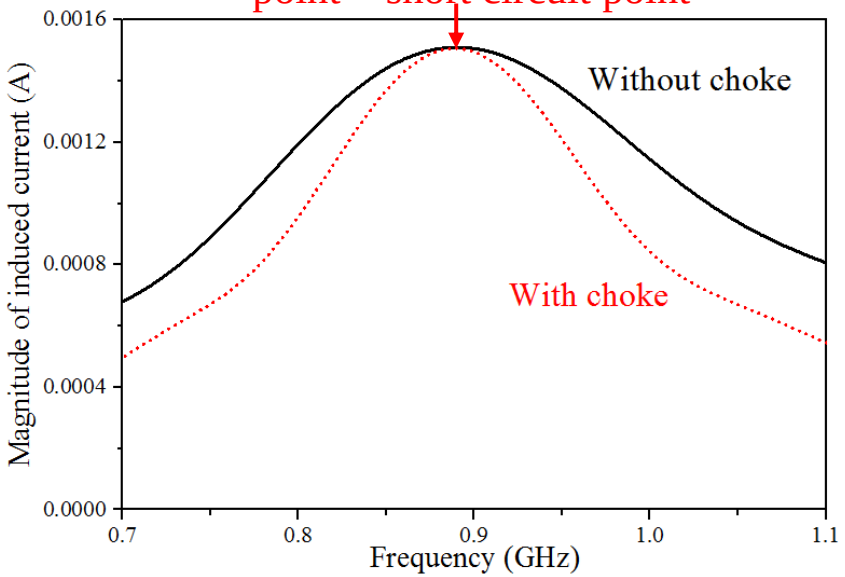






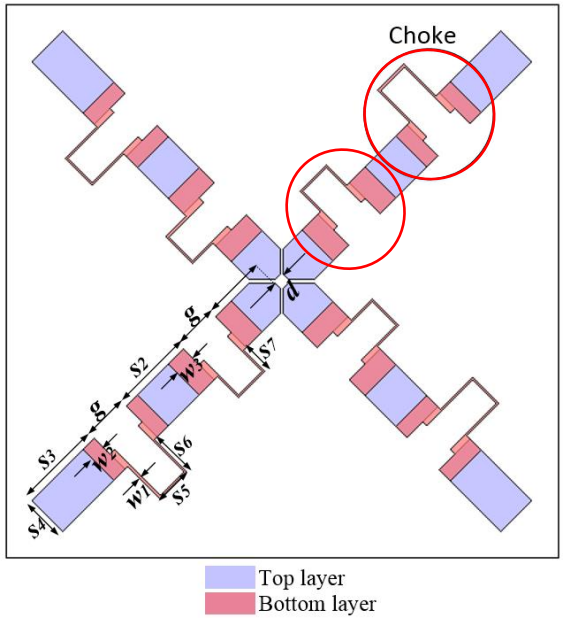
$w \uparrow \rightarrow C2 \uparrow \rightarrow f_{short} \downarrow \rightarrow f_{short} = 0.89\ GHz$

Maximum induced current point = short circuit point

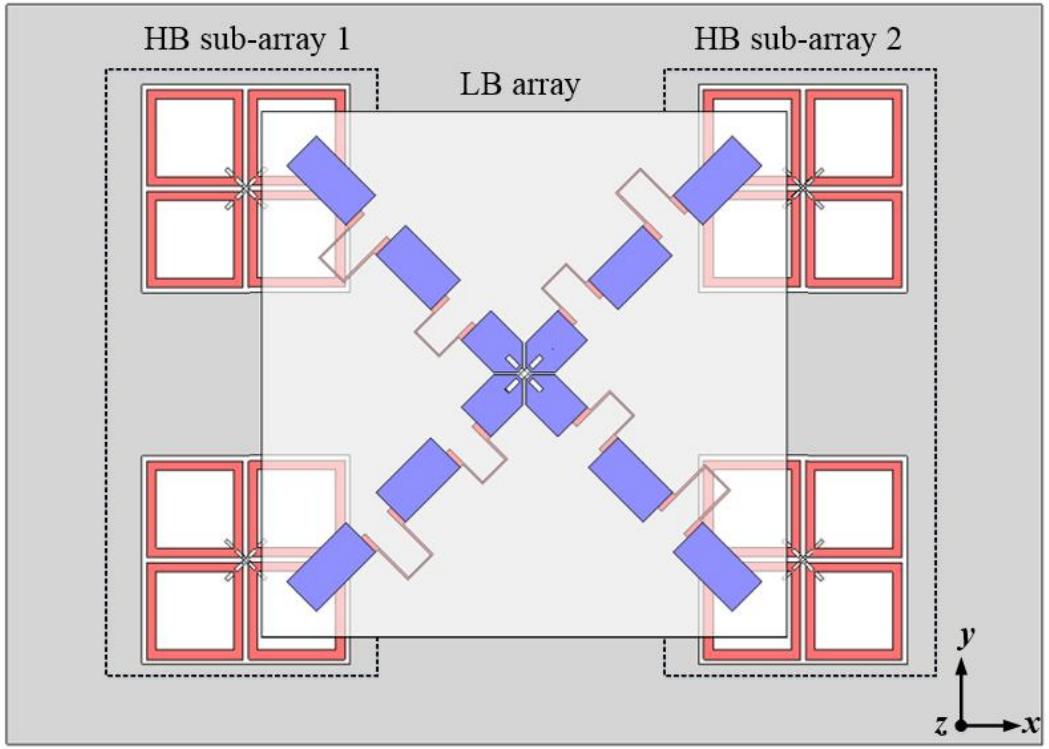


❑ Maximum induced LB currents

METHODOLOGY



❑ *Configuration of the choked radiator.*



❑ *Arrangement of the interleaved dual-band array with choked LB radiators.*

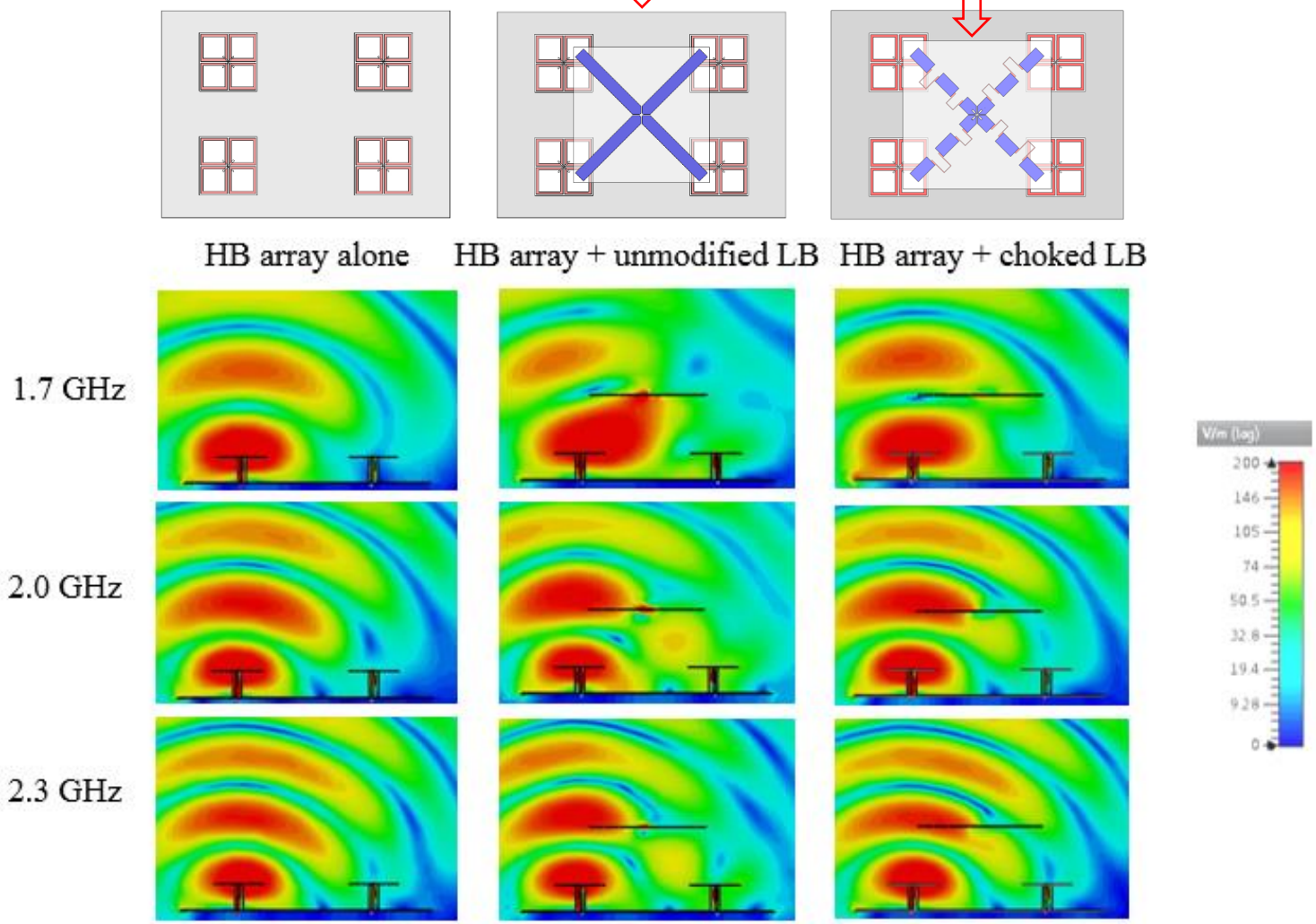
2 chokes in each arm ⟶ enough current suppression at HB

2 chokes at different frequencies ⟶ wideband choking performance

METHODOLOGY

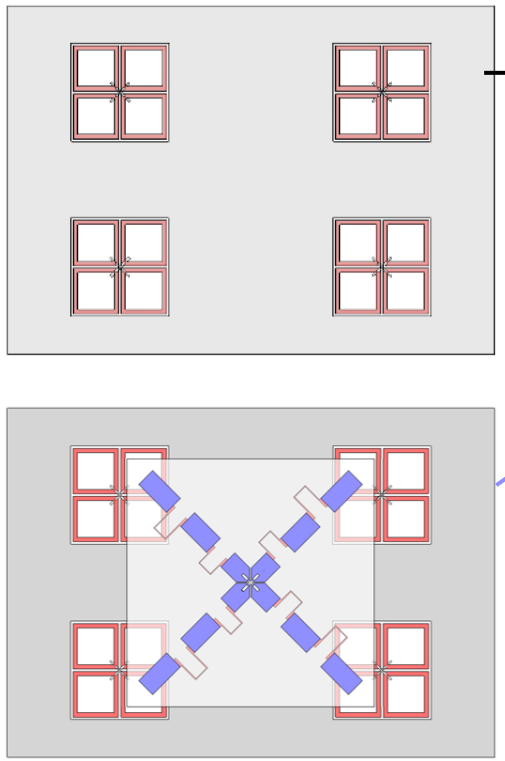
The unmodified LB radiators block HB electric field to a large extent.

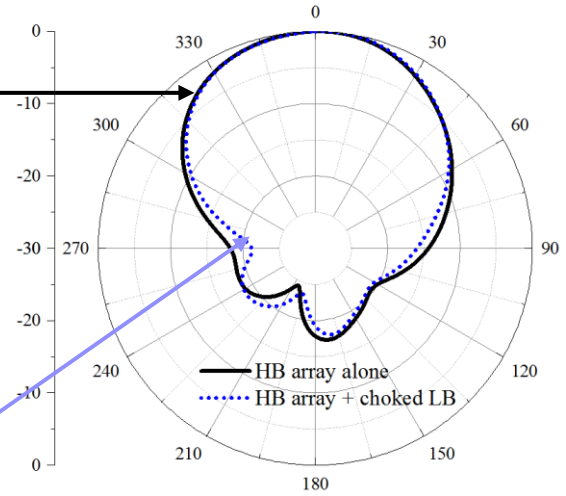
The choked LB radiators have much less effect on the HB electric field.



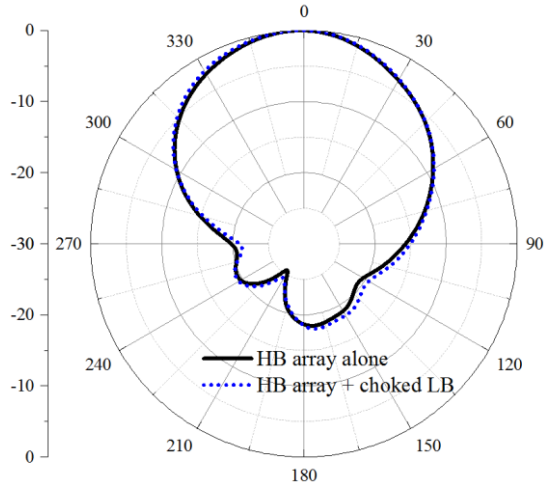
❑ *The electric field distribution at high band*

METHODOLOGY

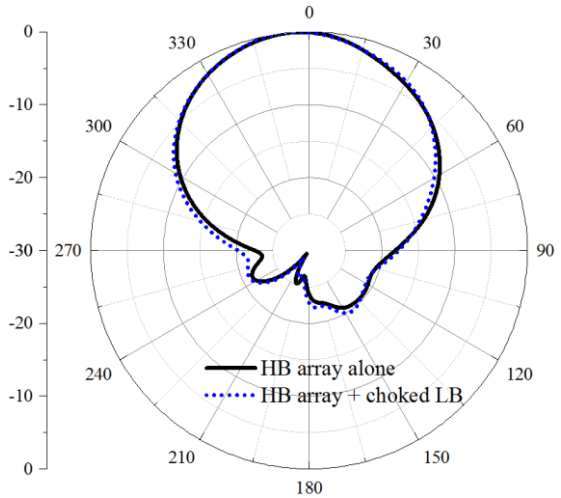




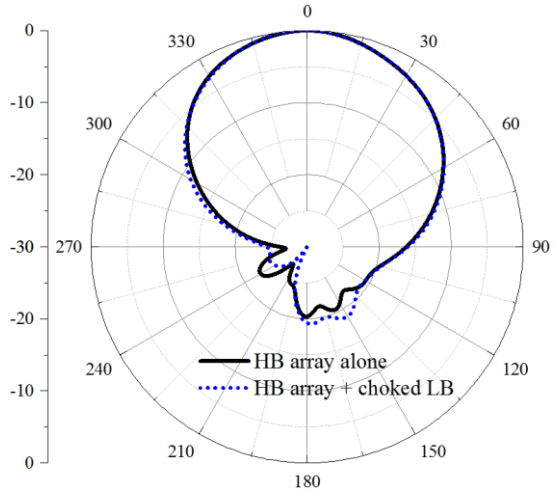
1.7 GHz



1.9 GHz



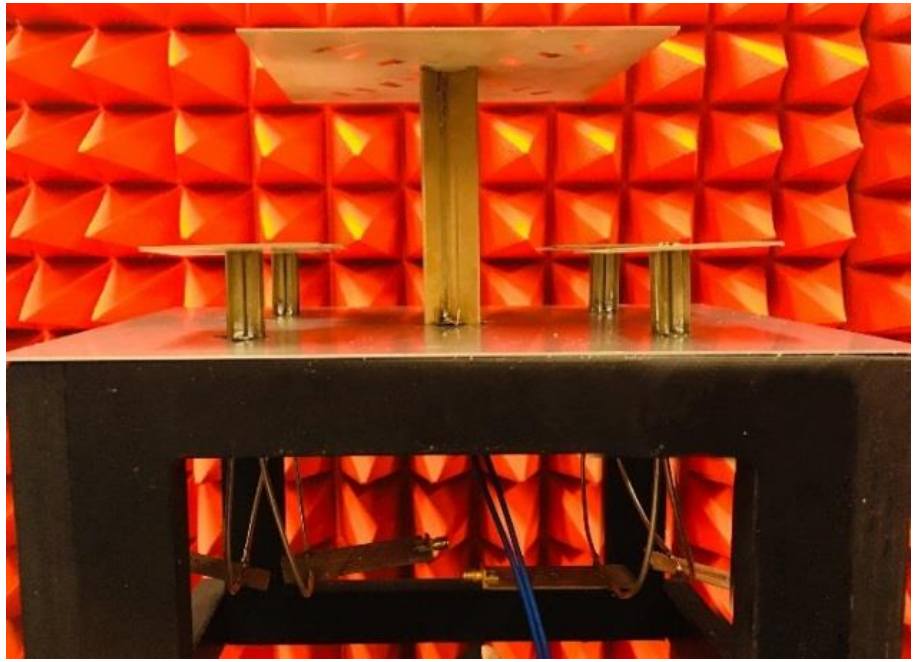
2.1 GHz



2.3 GHz

The presence of choked LB radiators does not affect the radiation performance of HB antennas.

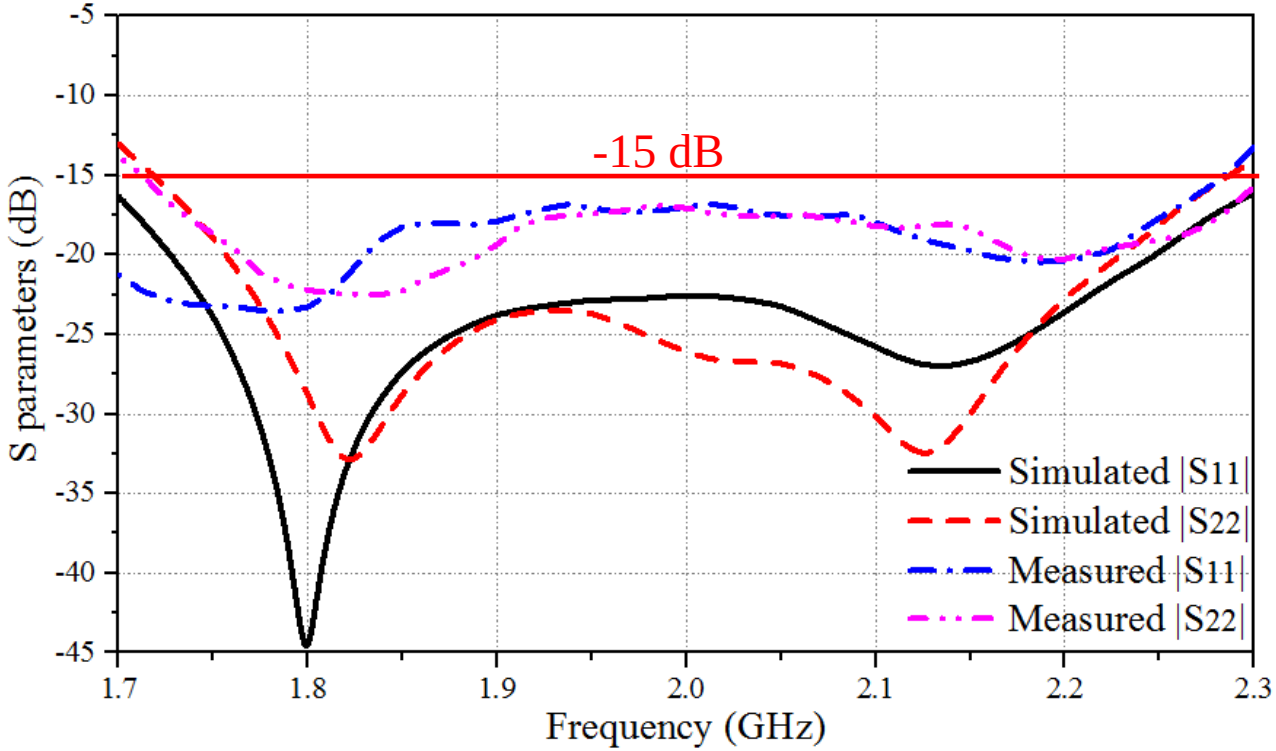
EXPERIMENTAL RESULTS



❑ *Prototype of antenna array section*

EXPERIMENTAL RESULTS

HB performance



❑ *Reflection coefficients of HB array*

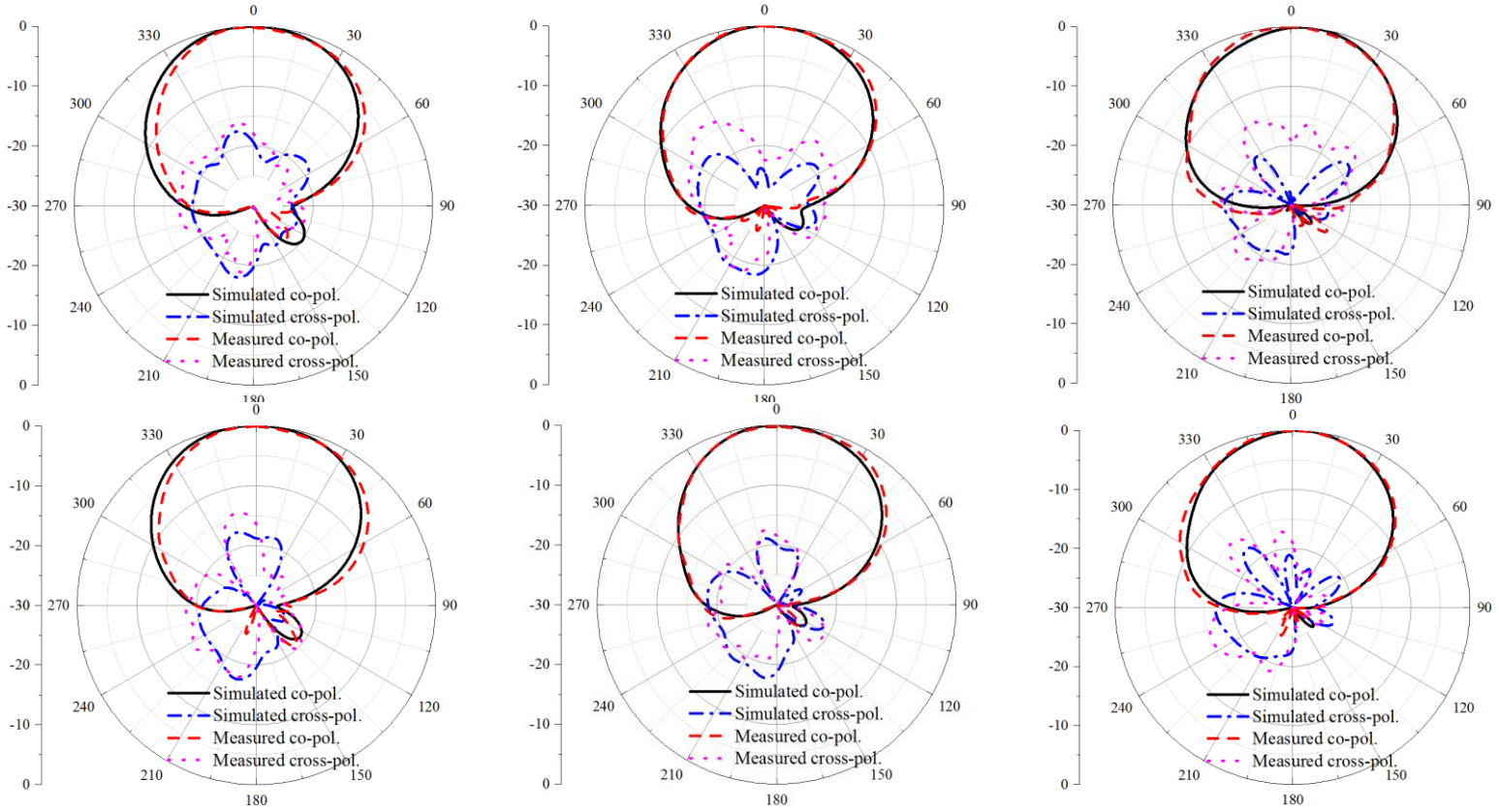
✓ Operating frequency range: 1.71 GHz to 2.28 GHz (28.6%)

EXPERIMENTAL RESULTS

HB performance

Port 1
(+45˚ polarization)

Port 2
(-45˚ polarization)

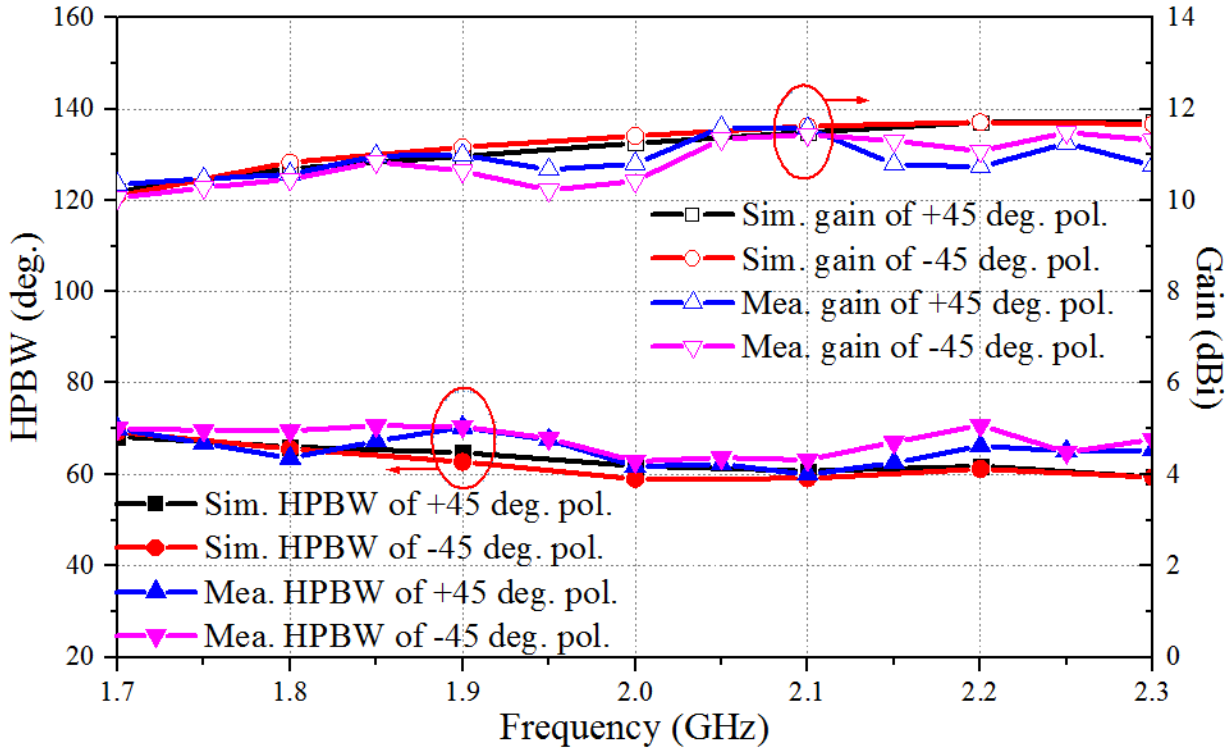


1.7 GHz *1.9 GHz* *2.2 GHz*

✓ Stable and symmetrical radiation pattern across the band

EXPERIMENTAL RESULTS

HB performance

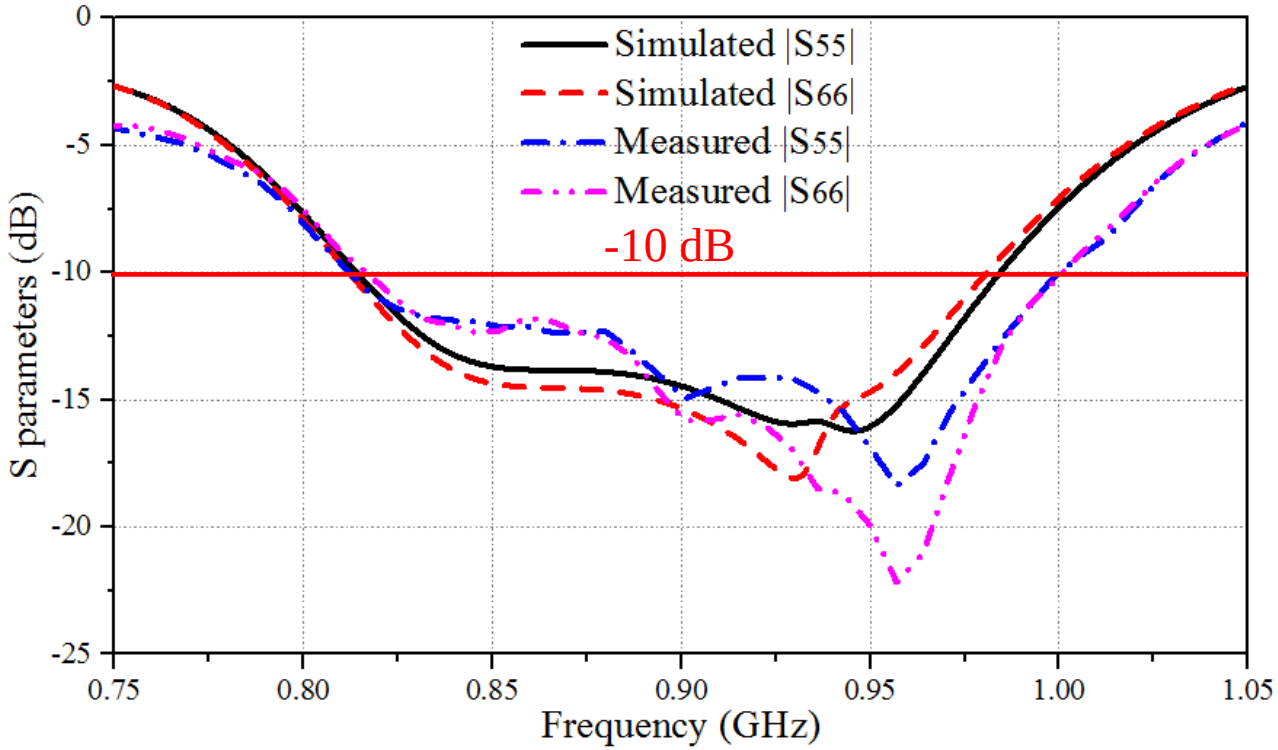


❑ *HPBW and Realized Gain*

✓ HPBW: 65˚±5˚
✓ Realized gain: 10 – 12 dBi

EXPERIMENTAL RESULTS

LB performance



❑ *Reflection coefficients of LB element*

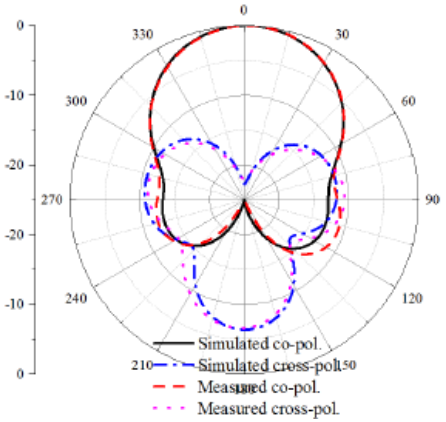
✓ Operating frequency range: 0.82 GHz to 1.0 GHz (19.7%)

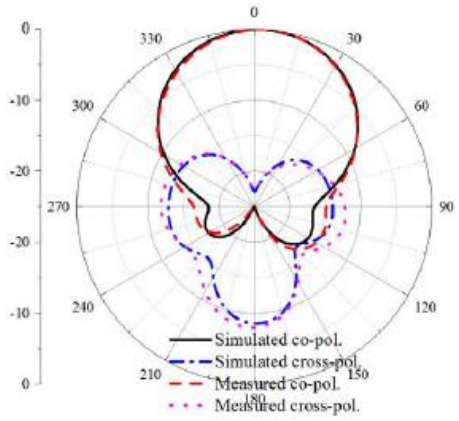
IEEE SINGAPORE RFID CHAPTER

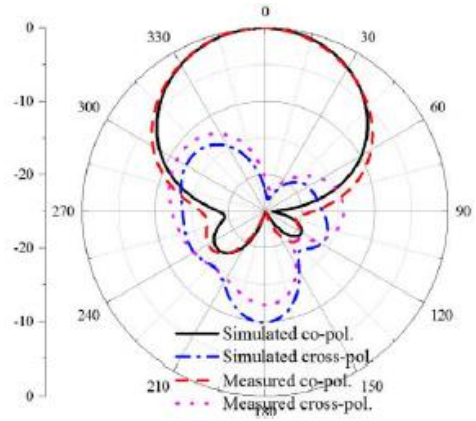
EXPERIMENTAL RESULTS

LB performance

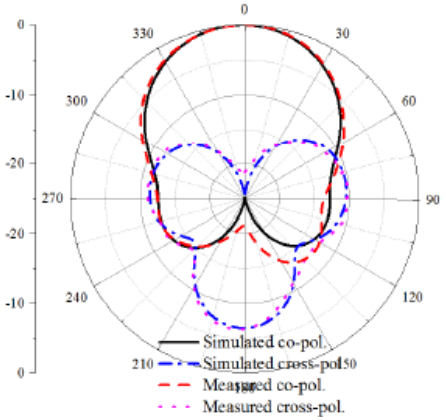
Port 5
(+45˚ polarization)

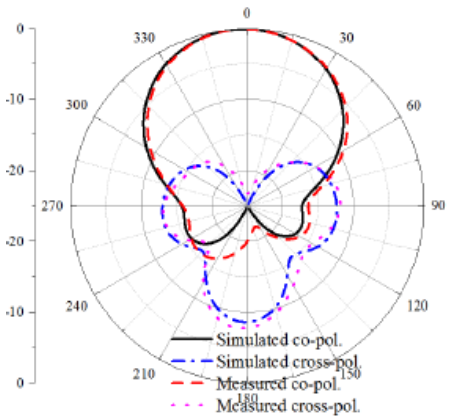


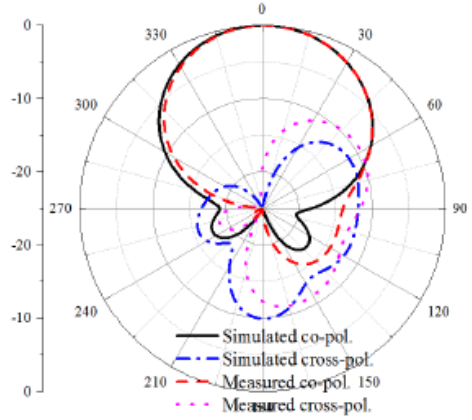




Port 6
(-45˚ polarization)





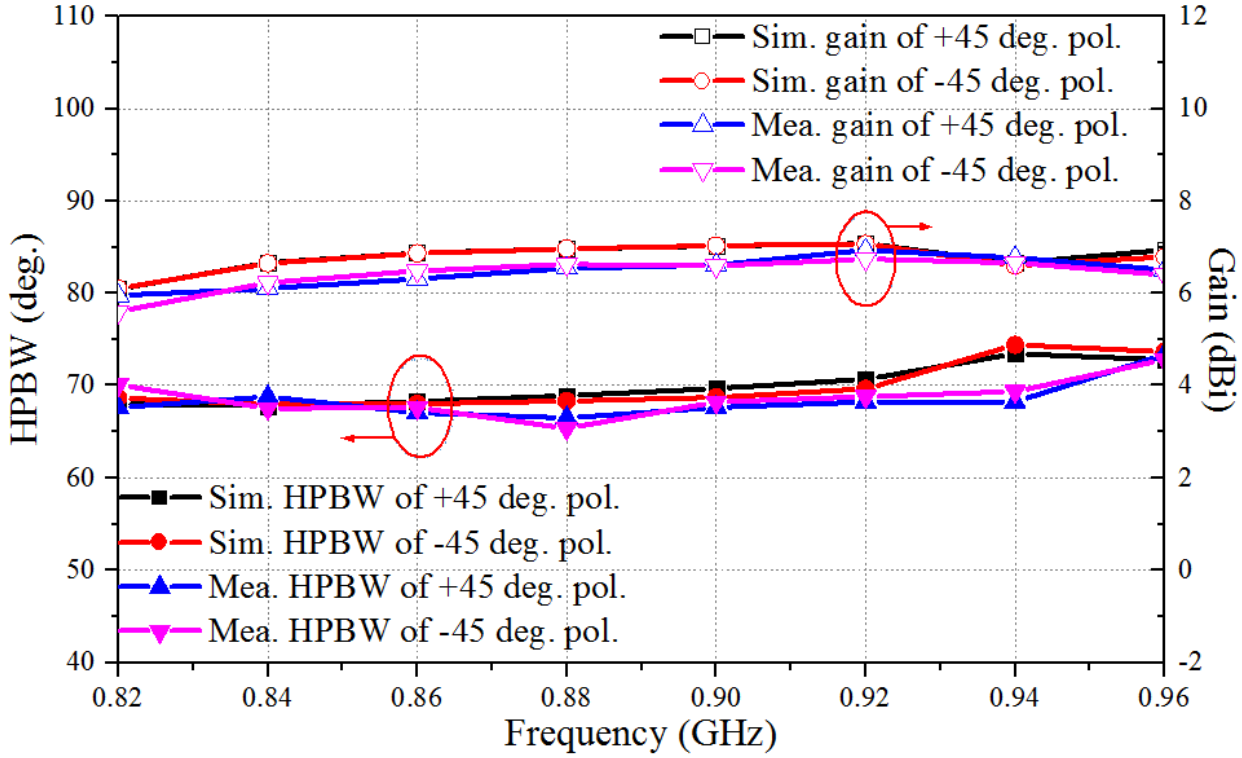


0.82 GHz *0.88 GHz* *0.96 GHz*

✓ Stable and symmetrical radiation pattern across the band

EXPERIMENTAL RESULTS

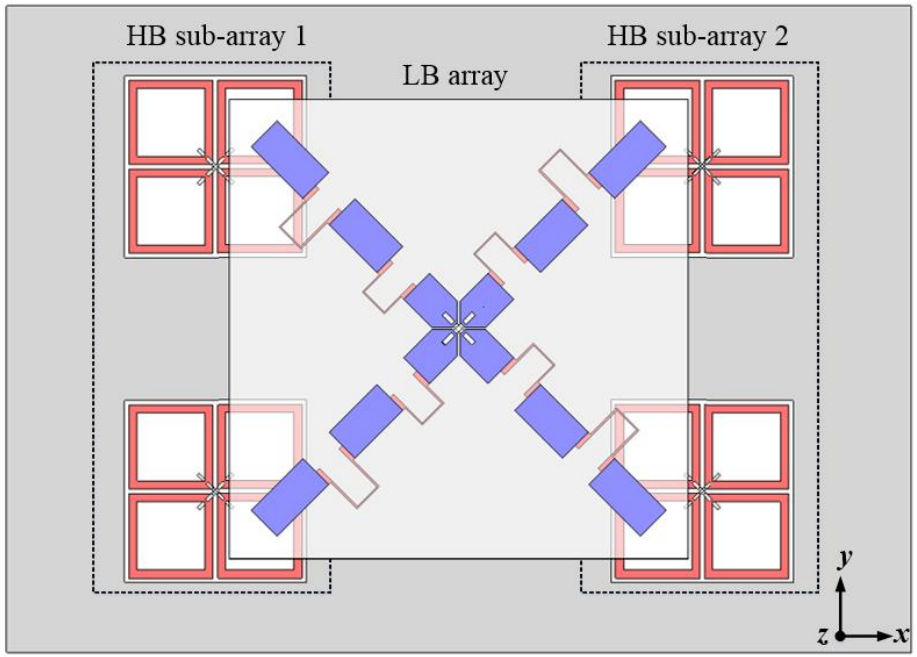
LB performance



❑ *HPBW and Realized Gain*

- ✓ Measured HPBW: 69.5˚ ± 4.0˚
- ✓ Realized gain: 6.0 – 7.0 dBi

CONCLUSION



- ✓ Addressed the cross-band scattering issue in multi-band antenna arrays
- ✓ Presented method of suppressing scattering – choking LB radiators
- ✓ Designed a dual-band dual-polarized interleaved base station antenna array section
  - LB: 0.82 – 1.0 GHz; HB: 1.71 – 2.28 GHz
  - Good matching capability
  - Stable radiation patterns in both bands
  - Compact and simple configuration

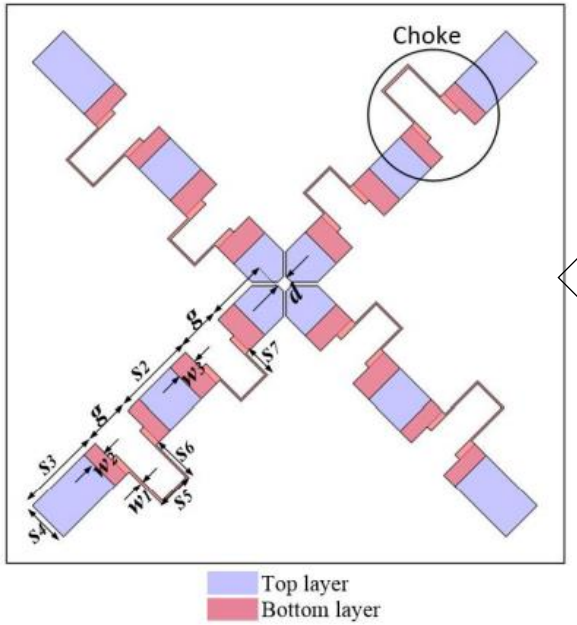
FUTURE WORK

Limitation: the choked LB element has relatively narrow bandwidth (19.7%) for base station applications.

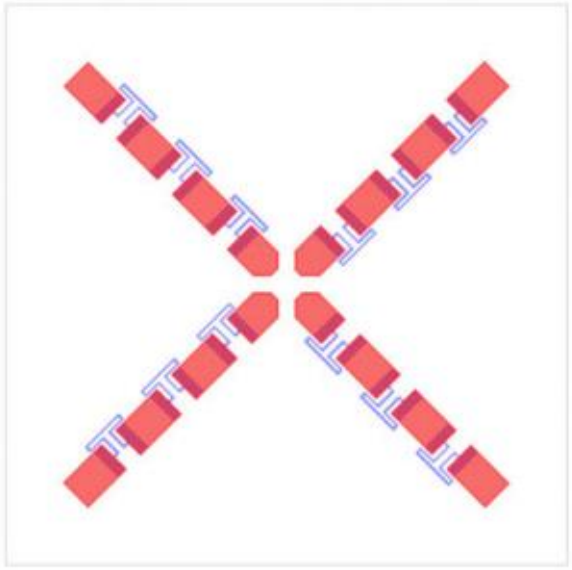
Methods to broaden the bandwidth of the choked antenna while maintaining good scattering suppression capabilities include:

A. Use different configurations of the LB radiator

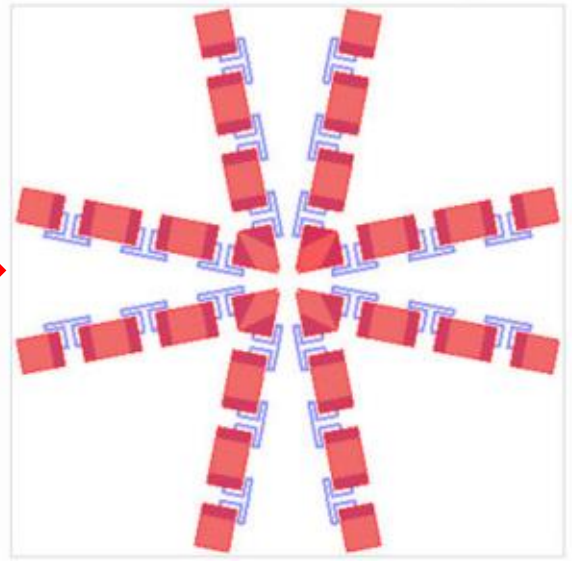
This work

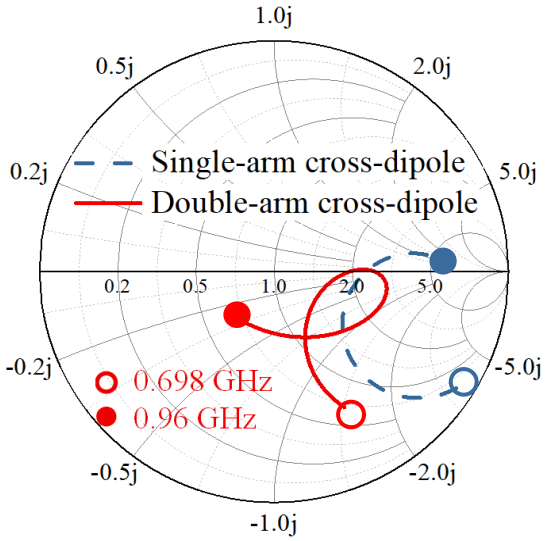


Single-arm cross-dipole



Double-arm cross-dipole





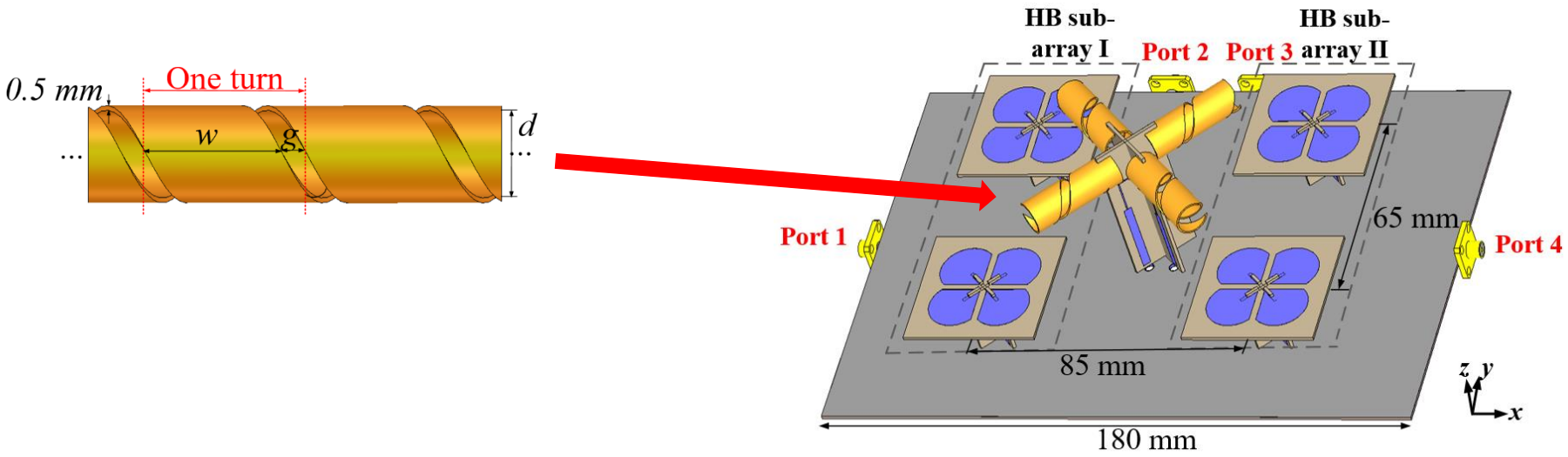
✓ Bandwidth: 31.6% (0.698 GHz – 0.96 GHz)

[1] H. -H. Sun, B. Jones, Y. J. Guo, and Y. H. Lee, "Suppression of cross-band scattering in interleaved dual-band cellular base-station antenna arrays," *IEEE Access.*, vol. 8, pp. 222486-222495, Dec. 2020.

FUTURE WORK

Methods to broaden the bandwidth of the choked antenna while maintaining good scattering suppression capabilities include:

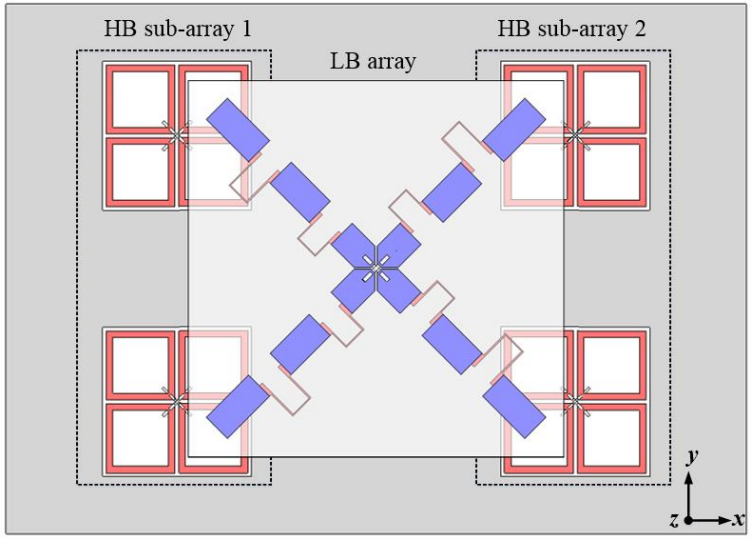
B. Develop new choking structures

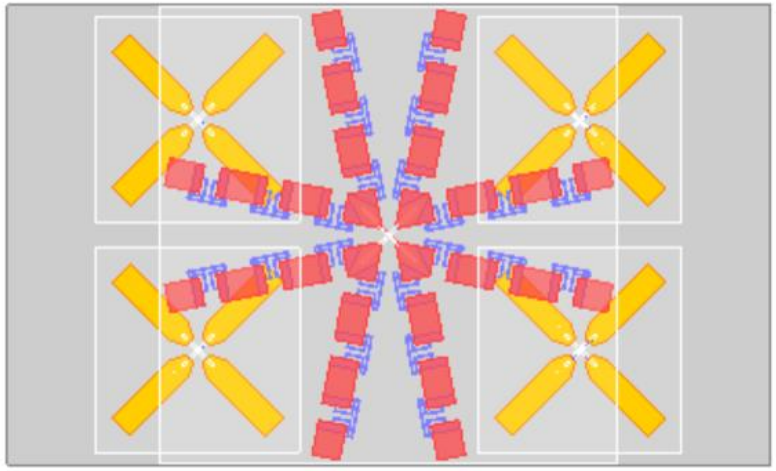


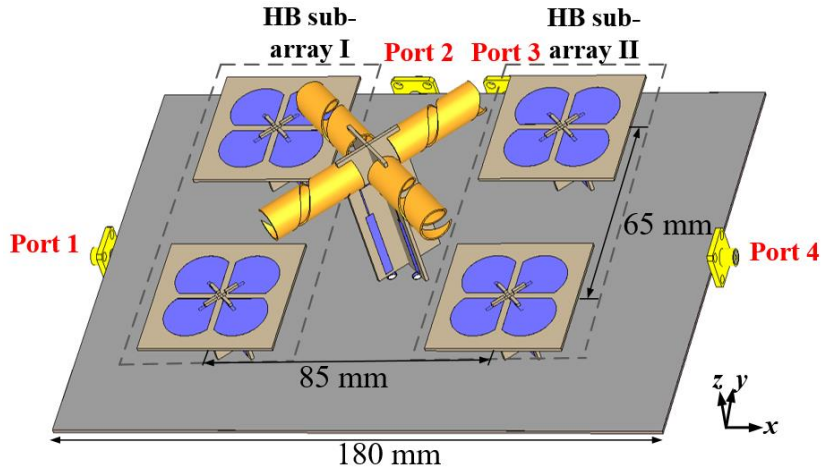
✓ Bandwidth: 28.3% ($|S_{11}| < -15$ dB)

[2] H. -H. Sun, H. Zhu, C. Ding, B. Jones, and Y. J. Guo, "Scattering suppression in a 4G and 5G base station antenna array using spiral chokes," *IEEE Antennas Wirel. Propag. Lett.*, vol. 19, no. 10, pp. 1818-1822, Oct. 2020.

FUTURE WORK







The choking techniques allow the antennas at different frequency bands to be co-located without compromising their performance, which greatly facilitates the development of multiband antenna systems.

IEEE SINGAPORE RFID CHAPTER

Thank you!

Q&A

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