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Filtering antennas: from innovative concepts to industrial applications

Key words: Filtering antenna; Dual-band; Antenna array

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Motivation

1. A filtering antenna is a device with both filtering and radiating capabilities. It can replace the cascading connection of the filter and antenna, avoid causing additional insertion loss, and achieve a more compact size.

2. Filtering antennas can be used to solve the problem of cross-band mutual coupling between different subarrays at different bands, which does not increase the total size of the multi-band array.

Main idea

1. Several filtering antennas, including single- and dual-polarized filtering patch antennas, a single-polarized omni-directional filtering dipole antenna, and a dual-polarized filtering dipole antenna, are reviewed. The antennas have the advantages of compact size, simple structure, and little extra loss of gain.

2. Three dual-band antenna array prototypes are introduced. In the dual-band arrays, mutual coupling between the elements operating at different bands is effectively suppressed using filtering antenna elements.

Compact filtering antennas without extra circuits

1. High-gain single-polarized filtering patch antenna

Method: Three shorting pins and one U-shaped slot on the driven patch are used to achieve high out-of-band suppression and sharp roll-off rate near the lower band-edge. The stacked patch is used to enhance frequency selectivity and the gain at the upper band-edge.

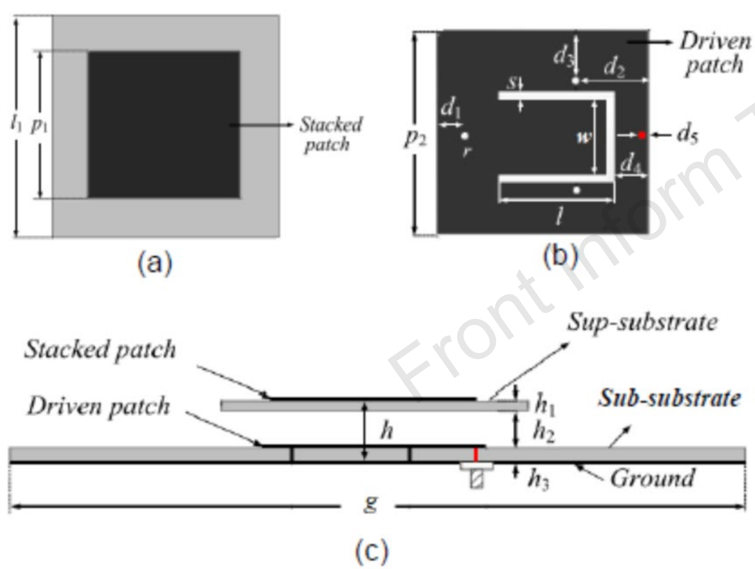

Fig. 1 Geometry of the filtering patch antenna: (a) stacked patch; (b) driven patch; (c) side view
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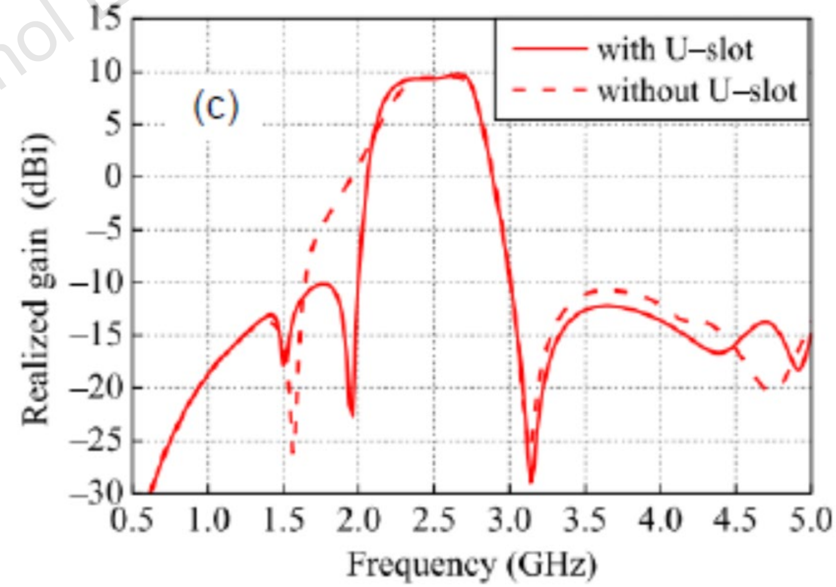

Fig. 2c Realized gain of the stacked antenna with and without a U-slot
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Compact filtering antennas without extra circuits (Cont'd)

2. Dual-polarized filtering patch antenna with high selectivity and low cross polarization

Method: This feeding network with H-shaped lines can realize a radiation null and sharp roll-off rate at the lower band edge, low cross polarization, and high polarization isolation. The upper stacked patch is used to improve in-band gain and suppression levels at the upper stopband.

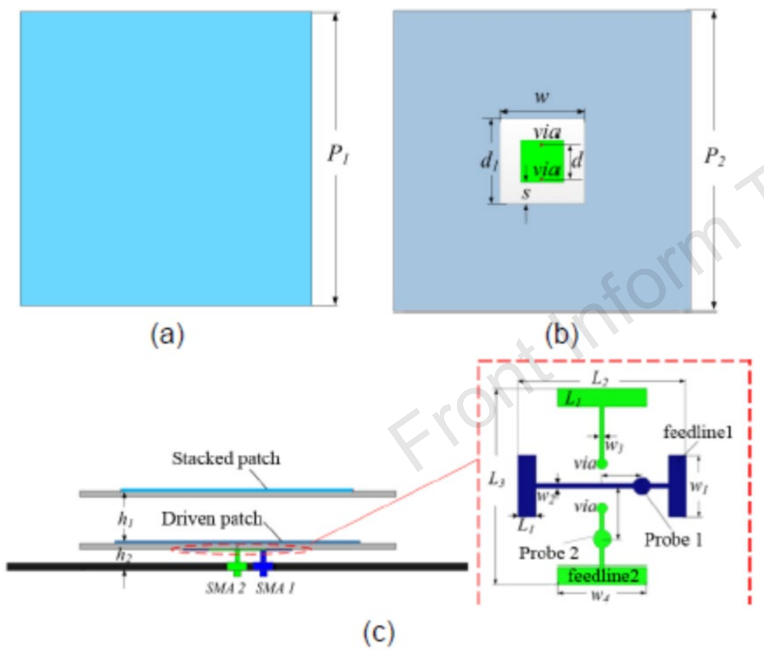

Fig. 3 Geometry of the dual-polarized filtering antenna: (a) stacked patch; (b) driven patch; (c) side view
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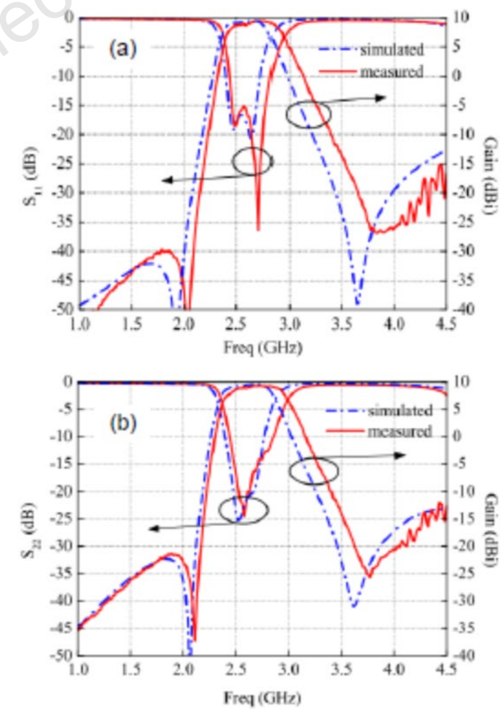

Fig. 4 Reflection coefficients and gain curves: (a) port 1; (b) port 2
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Compact filtering antennas without extra circuits (Cont'd)

3. Low-profile planar filtering dipole antennas with omni-directional radiation pattern

Method: A radiation null at the lower band is generated by the U-shaped microstrip line coupled to the slotline on the ground. The radiation null at the upper band is generated by two I-shaped slots on the ground.

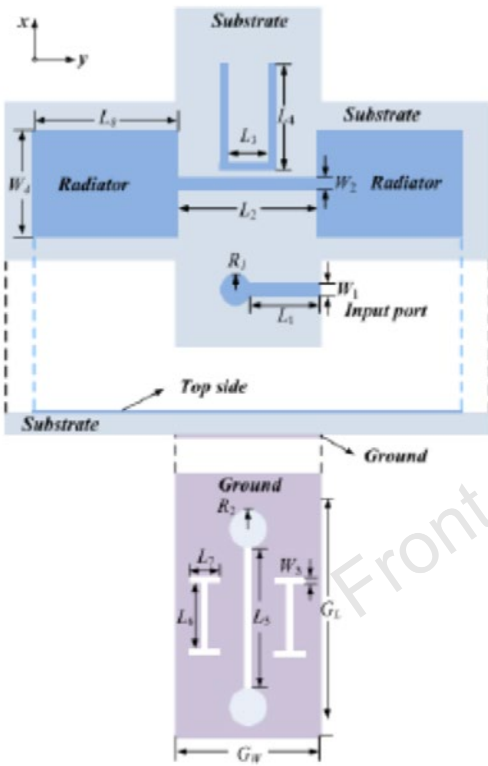

Fig. 6 Configuration of an omni-directional filtering dipole antenna
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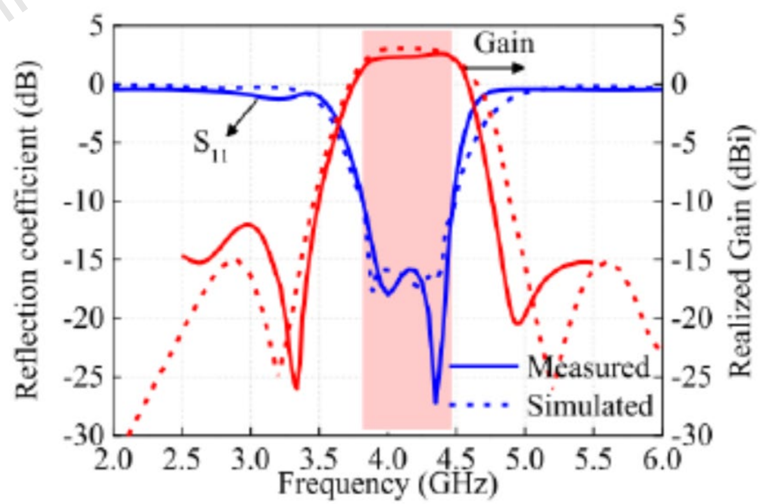

Fig. 7 Measured reflection coefficient and realized gain of the proposed omni-directional filtering dipole antenna
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Compact filtering antennas without extra circuits (Cont'd)

4. Compact dual-polarized filtering dipole antenna with broad bandwidths and high selectivity

Method: Square parasitic and cross-shaped loops are used to generate one radiation null at the lower band and another at the higher band. Simple stubs are extended from the dipole arms to further improve the higher band-edge, roll-off rate, and antenna bandwidth.

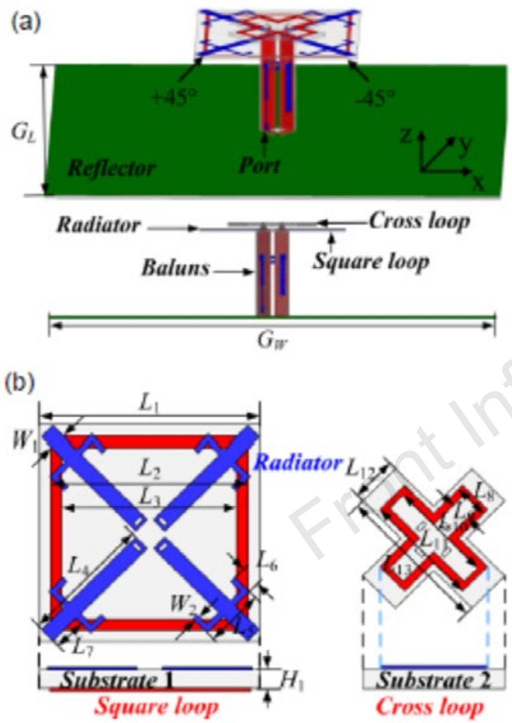

Fig. 8 Configuration of the proposed compact dual-polarized filtering dipole antenna (a) and the radiator and two parasitic loops (b)
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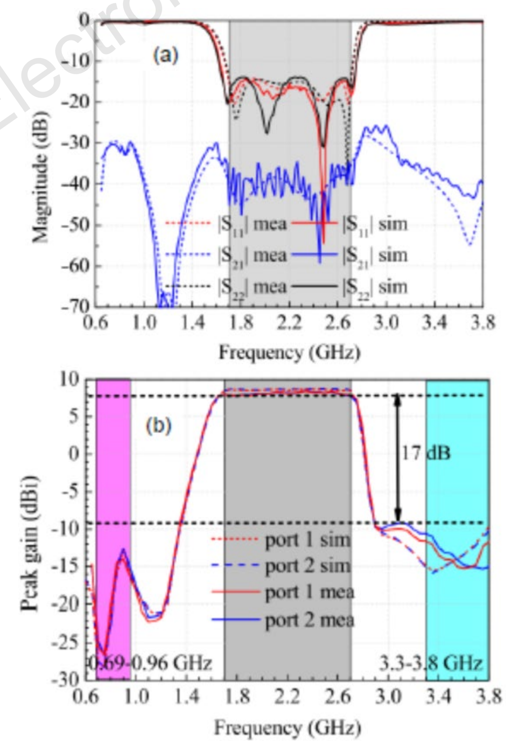

Fig. 9 Measured and simulated S-parameters of the proposed antenna (a) and measured peak gains of the proposed antenna (b)
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Dual-band antenna array based on filtering antenna elements

1. Dual-band base station array using filtering antenna elements for mutual coupling suppression

Method: Mutual coupling is reduced due to the use of filtering antenna elements.

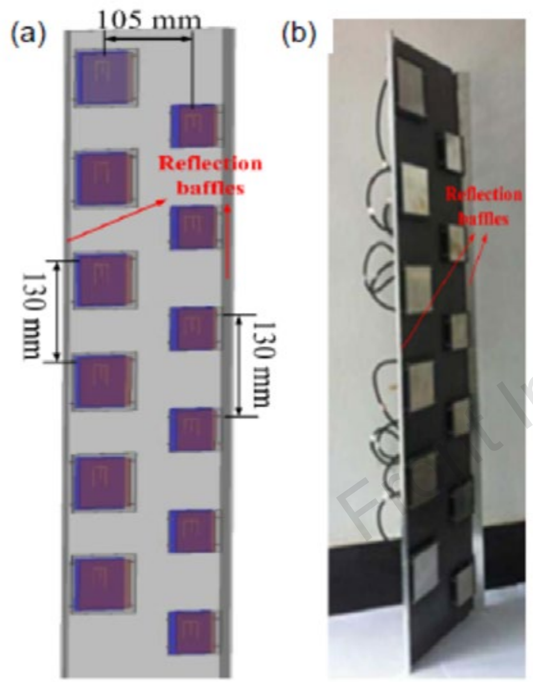

Fig. 14 Proposed dual-band filtering antenna array: (a) top view of the array model; (b) test prototype
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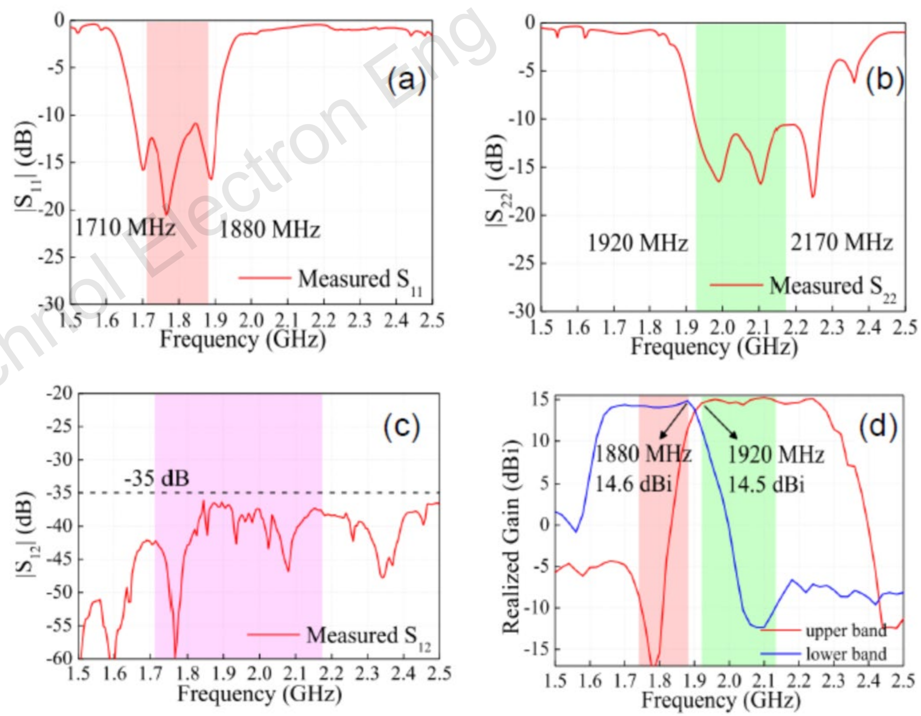

Fig. 16 Measurement results: (a) reflection coefficient of the lower band array; (b) reflection coefficient of the upper band array; (c) isolation parameter $|S_{12}|$; (d) boresight gain of the dual-band filtering antenna array
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Dual-band antenna array based on filtering antenna elements (Cont’d)

2. Compact dual-band dual-polarized interleaved two-beam array with stable radiation pattern based on filtering elements

Method: Using the filtering elements, the LB and HB subarrays are interleaved. The two-beam array consists of two 4×4 subarrays, where the larger size is for LB and the smaller size for HB.

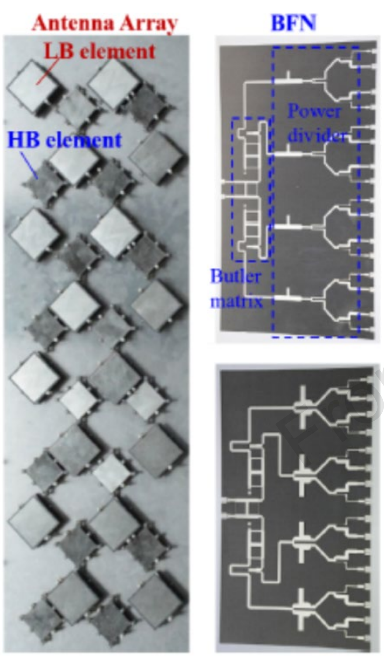

Fig. 17 Prototypes of the antenna array and BFN
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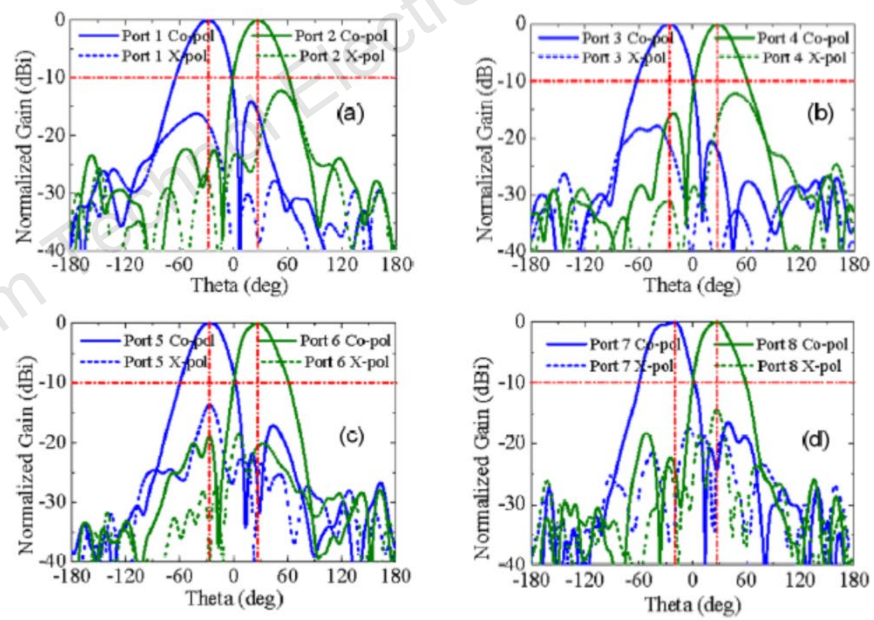

Fig. 19 Measured normalized radiation patterns at center frequencies: (a) port 1/2 excitation at 2.0 GHz; (b) port 3/4 excitation at 2.0 GHz; (c) port 5/6 excitation at 2.6 GHz; (d) port 7/8 excitation at 2.6 GHz
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Dual-band antenna array based on filtering antenna elements (Cont'd)

3. Dual-band dual-polarized base-station antenna array with a small frequency ratio using embedded filtering elements

Method: The LB antenna element is embedded into the HB antenna to achieve a more compact size. To realize high cross-band isolation between the two embedded elements, the LB patch antenna and HB dipole antenna have bandstop responses at the higher and lower band edges, respectively.

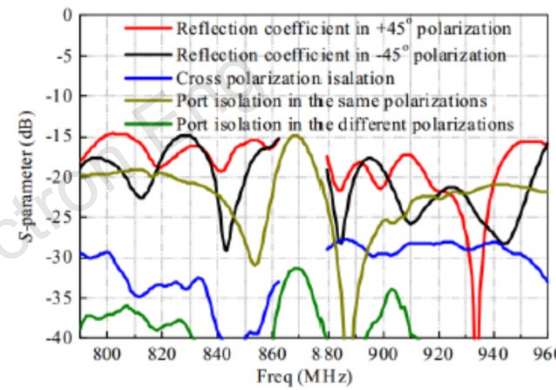

Fig. 24 Measured reflection coefficients and isolations of the proposed filtering antenna array

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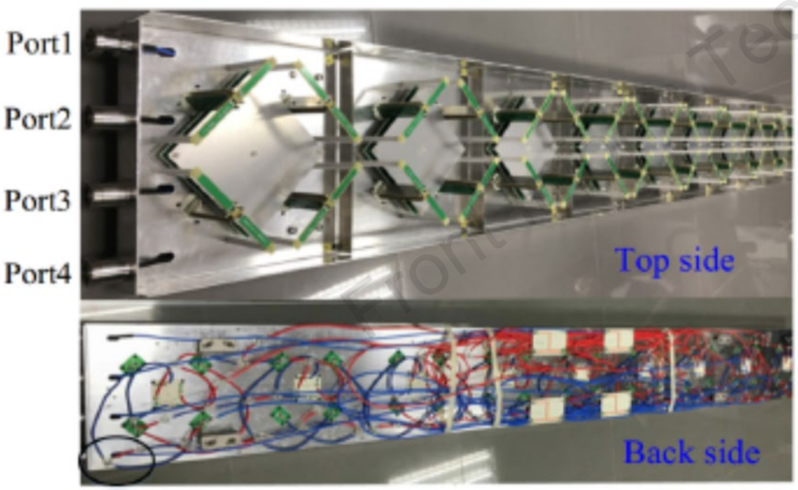

Fig. 23 Photos of the proposed dual-band dual-polarized filtering antenna array with its feeding networks

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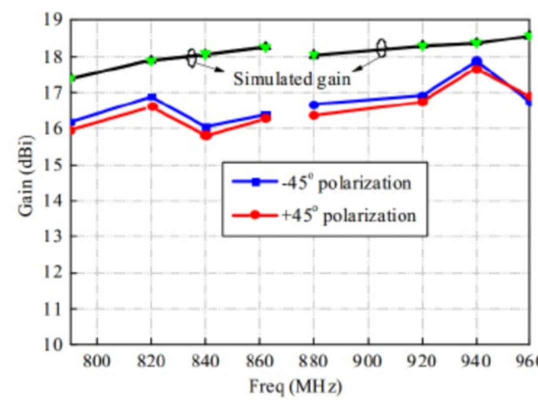

Fig. 25 Gains of the proposed dual-band dual-polarized antenna array

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Conclusions

1. All the filtering antennas proposed by the authors feature an innovative concept of eliminating extra filtering circuit, resulting in compact size, simple structure, good in-band radiation performance, and high out-of-band suppression.

2. Three types of dual-band antenna array based on the filtering elements have been reviewed. Specifically, the dual-polarized antenna array is more compact than the related industry products, and is a good choice for dual-band base-station applications.