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A high-isolation coupled-fed building block for metal-rimmed 5G smartphones

Key words: Fifth generation (5G) communication; Multiple-input multiple-output (MIMO); High isolation; Building block

Corresponding author: Aidi REN
E-mail: renaidi@ahu.edu.cn
ORCID: https://orcid.org/0000-0002-0600-4550

Motivation

1. For a multi-antenna multiple-input multiple-output (MIMO) array, it is very difficult to achieve high isolation due to the limited space in a smartphone. Besides, the conventional decoupling method used additional external decoupling structures will increase complexity and size of the MIMO system.

2. The increased strength, durability, metallic luster, and stylish exterior have made the metal bezel attractive to customers. However, the existence of the metal bezel blocks the radiation of electromagnetic fields. Therefore, it is still a challenging task to design a high-isolation MIMO array within a compact size for metal-rimmed smartphone application.

Main idea

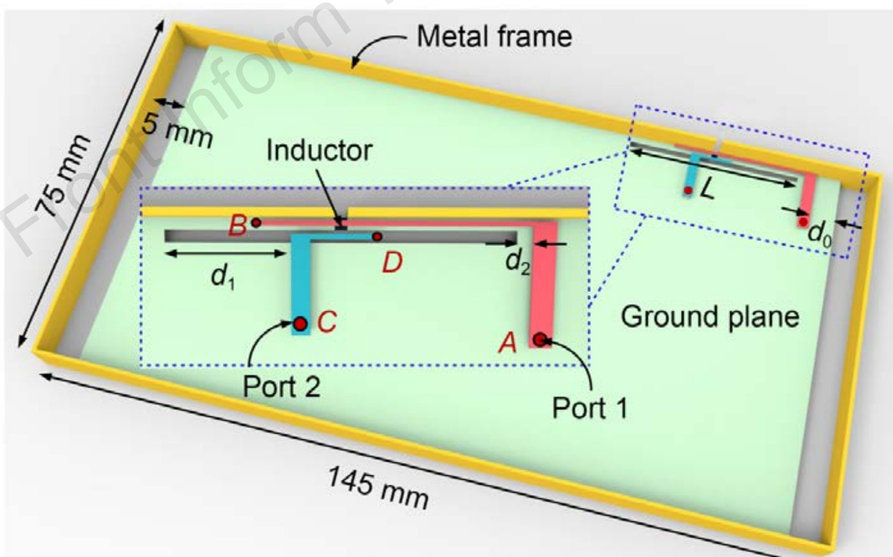
1. A compact dual-antenna building block with high isolation is presented for metal-rimmed fifth-generation (5G) smartphones.

2. A coupled-fed loop antenna and a coupled-fed slot antenna based on a simple T-slot etched on the ground plane are meticulously designed to form a compact building block.

3. Afterward, an 8×8 MIMO system is achieved by integrating four such dual-antenna building blocks.

Dual-antenna module

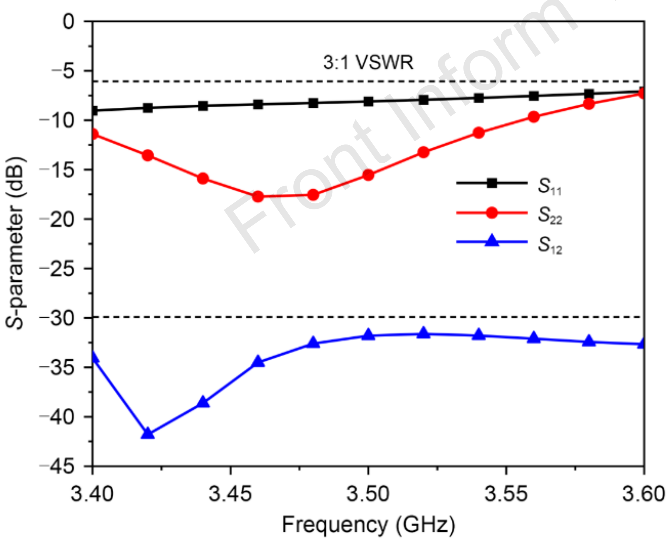
1. The T-shaped open slot on the ground plane is coupled fed by two L-shaped feed branches, which excites the loop mode (antenna 1) and slot mode (antenna 2).
2. A chip inductor (6.2 nH) is placed at the opening gap of the slot to improve the impedance matching of antenna 1.



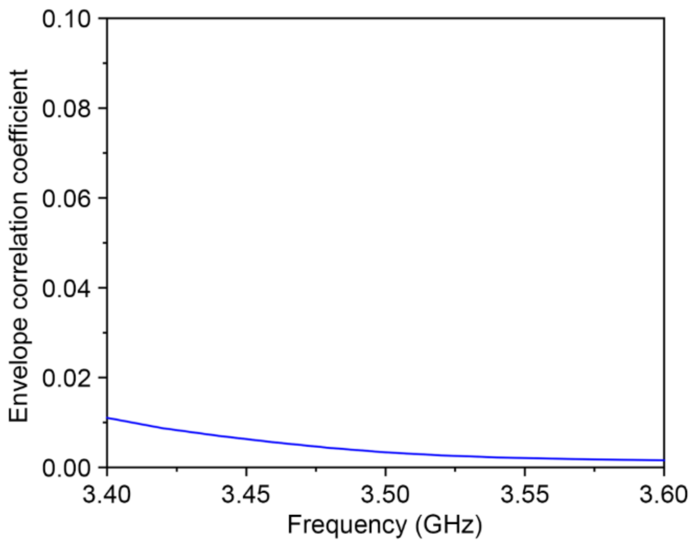
Structure of dual-antenna building block

Performance of the block

1. The reflection coefficients of the two antennas in the 3.40–3.60 GHz frequency band are <−6 dB.
2. The isolation between the two antennas is >30 dB.
3. The envelope correlation coefficient (ECC) of the two antennas is <0.02 in the entire working frequency band, indicating good diversity performance.



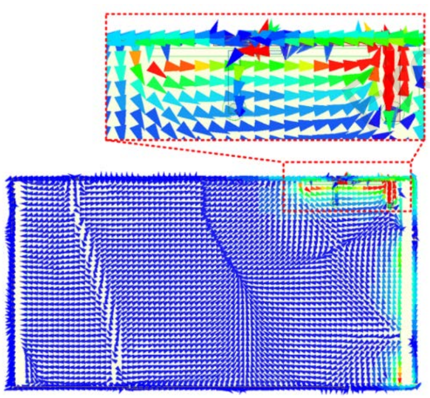
S-parameters of the block

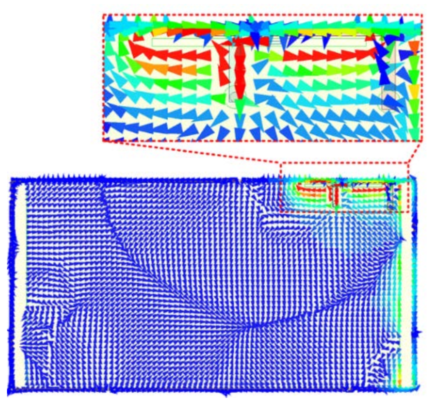


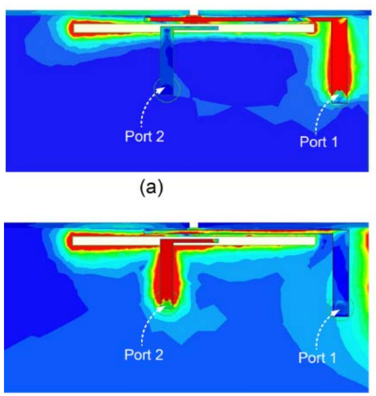
ECC of the block

Mechanism

1. Ground currents induced by antennas 1 and 2 are orthogonal, and the coupling from the ground plane is effectively mitigated.
2. The current distributions around the dual-antenna module caused by antennas 1 and 2 are also orthogonal.
3. When the two antennas work separately, the current flowing into the other antenna feed port is very weak.


Antenna 1 at 3.50 GHz

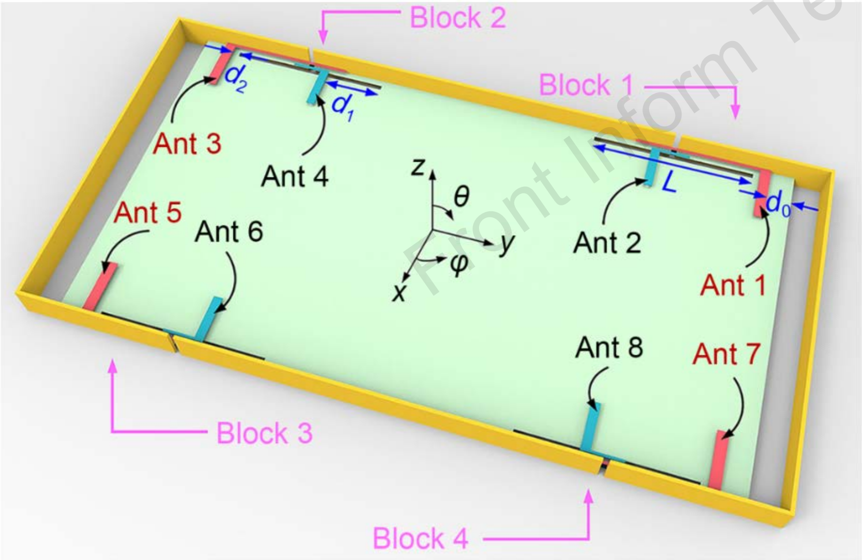

Antenna 2 at 3.50 GHz



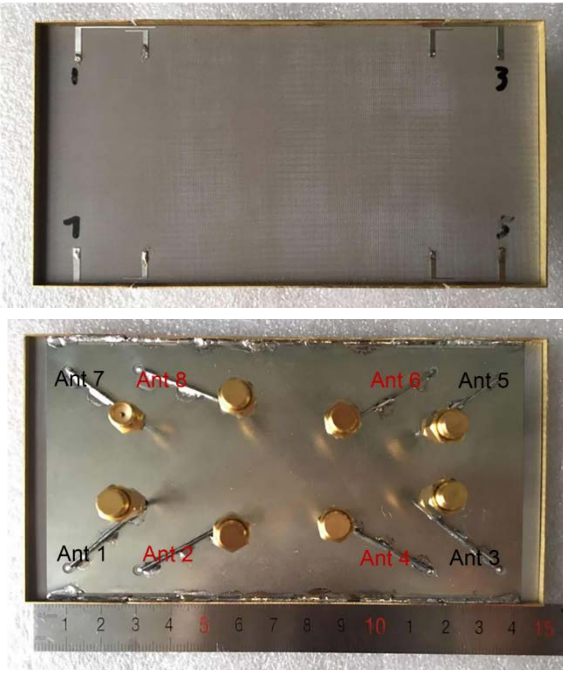
Current amplitude at 3.50 GHz

8×8 MIMO system

1. The 8×8 MIMO system has a symmetrical structure that is composed of four completely identical dual-antenna modules.
2. The 8×8 MIMO array is processed and measured to evaluate the performance of the designed eight-element MIMO system.



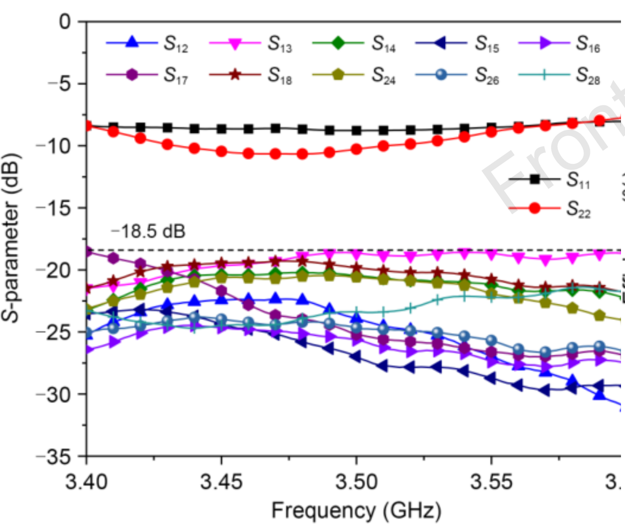
Conceptual diagram of the 8×8 MIMO system



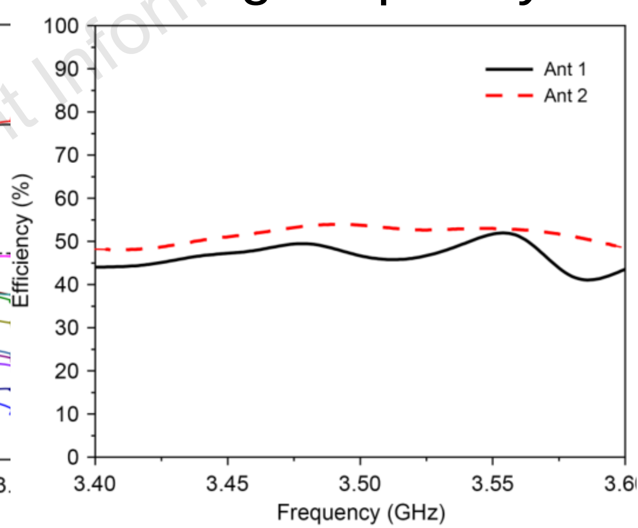
Physical diagram of the 8×8 MIMO system

Major results

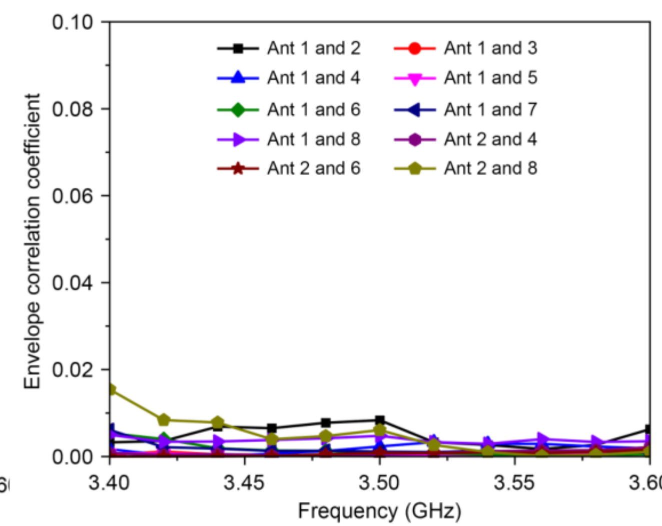
1. The measured reflection coefficients for both antennas 1 and 2 are <−6 dB in the 3.40–3.60 GHz band, and the measured isolation of the whole MIMO system is >18.5 dB.
2. The measured efficiency of the antenna varies from 43% to 54% over the entire frequency band, which meets the actual application requirements.
3. The measured ECCs of the eight-element MIMO system are <0.02 in the entire working frequency band 3.40–3.60 GHz.



S-parameters



Radiation efficiencies



ECCs

Remaining challenges

1. Enhance the operating bands to cover more 5G bands

Multiple 5G bands are deployed to meet the requirement of 5G communication network; upcoming 5G multiband communication accelerates the investigation of wideband MIMO system.

LTE band 42	3.4–3.6 GHz
N77	3.3–4.2 GHz
N78	3.3–3.8 GHz
N79	4.4–5.0 GHz
5G WLAN	5.150–5.925 GHz

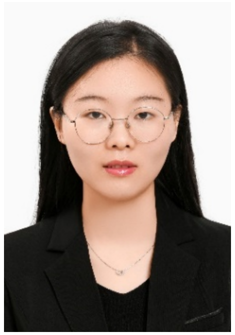
Sub-6 band spectrum deployment

Conclusions

1. In conclusion, this paper presents a dual-antenna building block with high isolation for metal-rimmed 5G smartphones. Although the coupled-fed loop antenna and the coupled-fed slot antenna share the same aperture, a desirable isolation of >30 dB is exhibited.

2. In the 8×8 MIMO system, four such dual-antenna building blocks are integrated. The measured isolation of the MIMO system is >18.5 dB without any decoupling elements. Both the antenna efficiencies (>43%) and ECCs (<0.02) can meet the working standards, which indicates that the designed MIMO array has great potential in 5G metal-rimmed mobile phones.

3. Although considerable progress has been made, there remain important challenges in the future research.



Aidi REN was born in Chaohu, Anhui Province, China in 1991. She received the BS and PhD degrees in School of Electronic Engineering from Xidian University, Xi’an, China in 2014 and 2020, respectively. Her current research interests include small antennas for handset device and MIMO antennas for wireless communications, especially for massive MIMO antenna for future 5G smartphones.

Chengwei YU was born in 1998 in Lu’an City, Anhui Province, China. She received the BS degree in Computer Science and Technology from Huangshan College, Huangshan, China in 2021. She is currently working toward the MS degree in communication and information systems with the School of Electronic Information Engineering, Anhui University, Hefei, China.