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Monopulse transmitarray antenna fed by aperture-coupled microstrip structure

Key words: Monopulse antenna; Microstrip; Transmitarray; X-band

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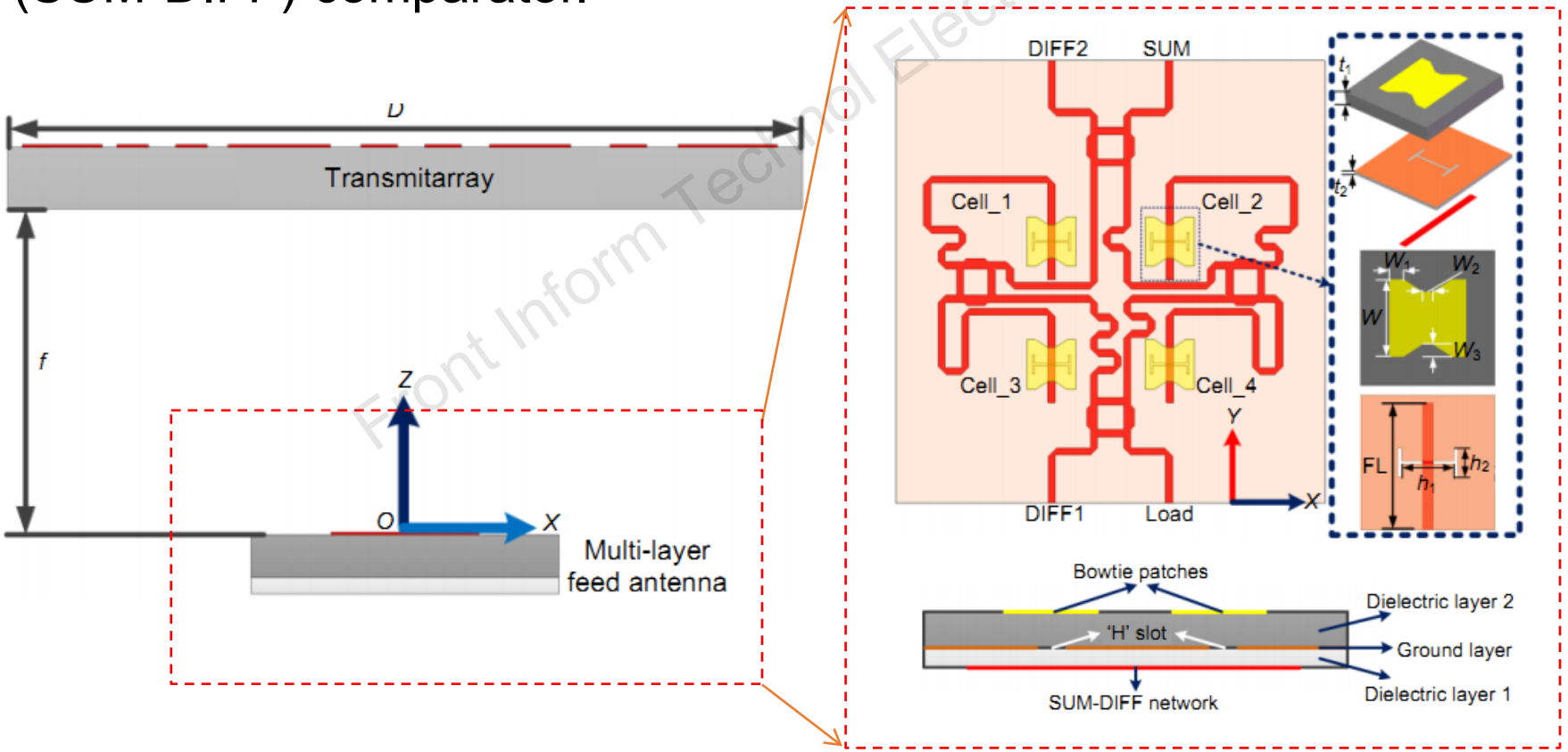
Introduction

1. Monopulse technique, also known as the simultaneous beam comparison method, is used mainly to measure the direction of arrival (DOA). The monopulse technique has been widely applied in SATCOM on the move (SOTM) missile guidance.
2. Recently, reflectarrays have been proposed for use in monopulse antennas, and have shown good performance. As an alternative to reflectarrays, transmitarrays not only have the advantages of reflectarrays, but also have no shielding effect from the feeds.
3. In this study, we propose an X-band monopulse transmitarray antenna fed by an integrated structure. A prototype of the X-band monopulse transmitarray antenna has been designed, fabricated, and measured.

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Feed antenna design

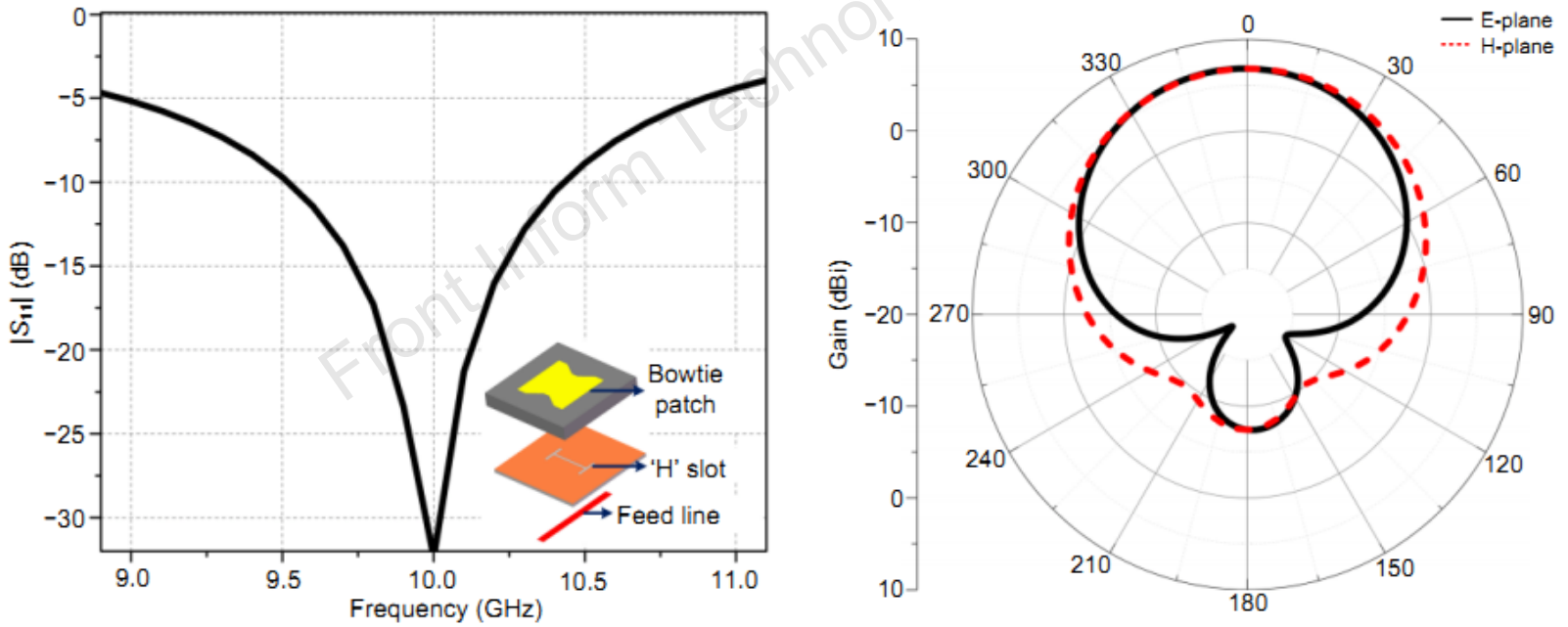
1. The X-band monopulse transmitarray antenna is composed of a transmitarray and a feed source which combines aperture-coupled microstrip antennas (ACMAs) and a sum-difference (SUM-DIFF) comparator.



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Feed antenna design

2. The topology of the multi-layer feed antenna based on the aperture-coupled microstrip antenna (W_1=1.5 mm, W_2=1 mm, W_3=1.3 mm, W=8 mm, h_1=5.5 mm, h_2=3 mm, FL=13.2 mm, t_1= 2 mm, t_2=0.5 mm).

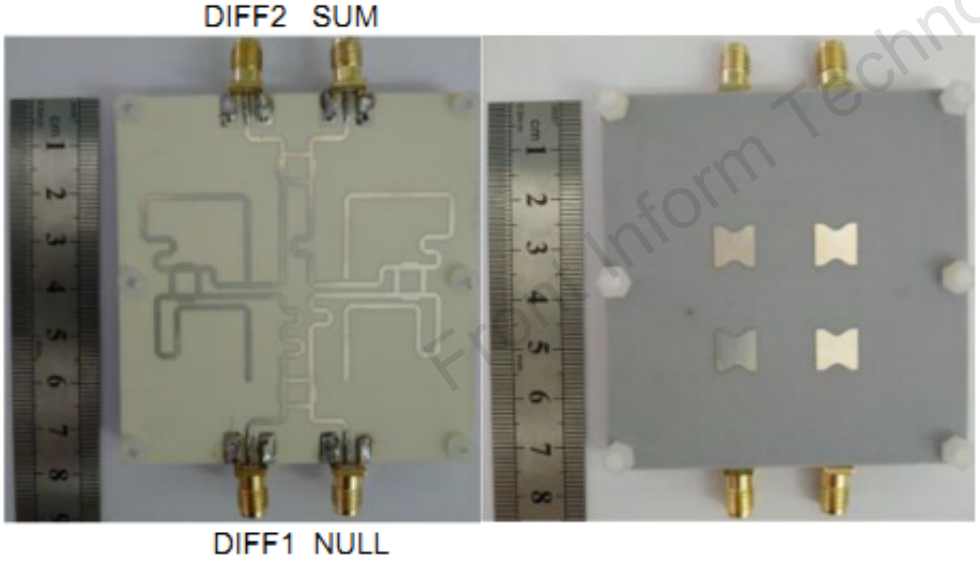


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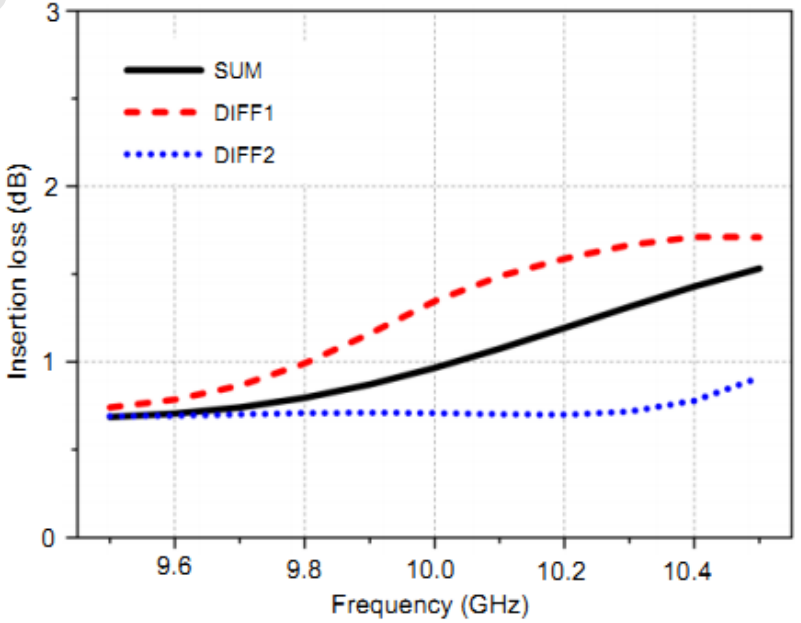
$|S_{11}|$ and radiation patterns of the aperture-coupled microstrip antenna unit cell

Feed antenna design

3. The fabricated prototype of the integrated feed source contains two layers: the SUM-DIFF network layer and the ACMA layer. Insertion losses from the SUM, DIFF1, and DIFF2 ports to the four ports of the antenna elements can be calculated.



Fabricated prototype

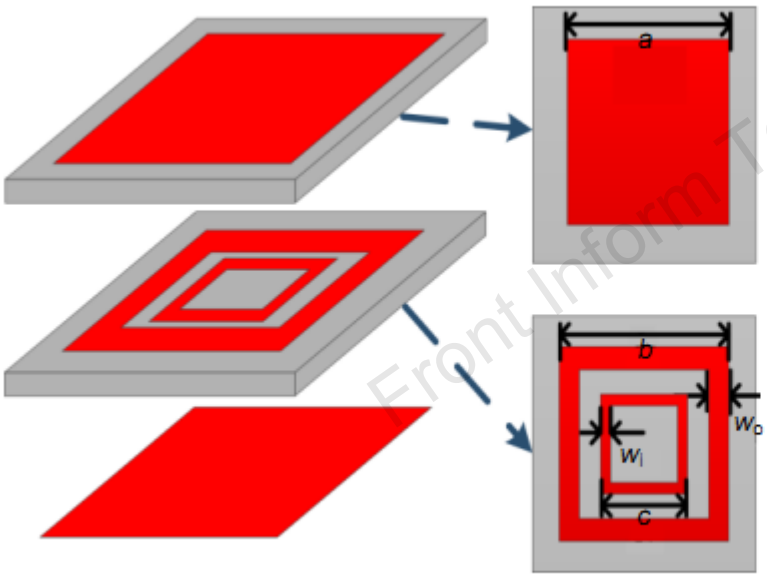


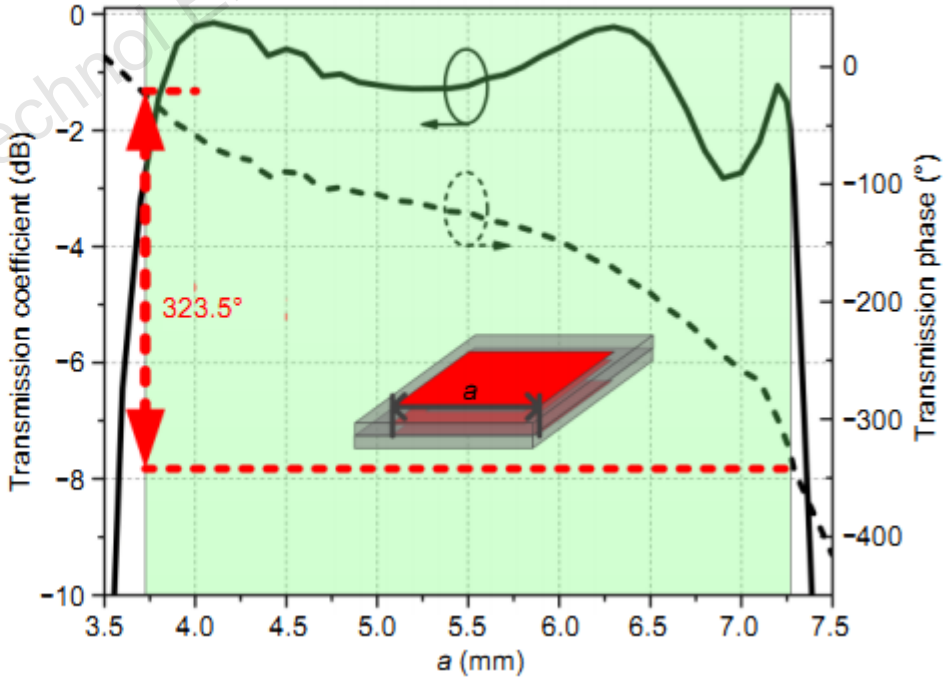
Insertion losses

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Transmitarray design

1. To obtain phase regulation for the feed antenna using the transmitarray, a transmitted element with two layers of tightly bound substrates is proposed.





Layout of the transmitted unit

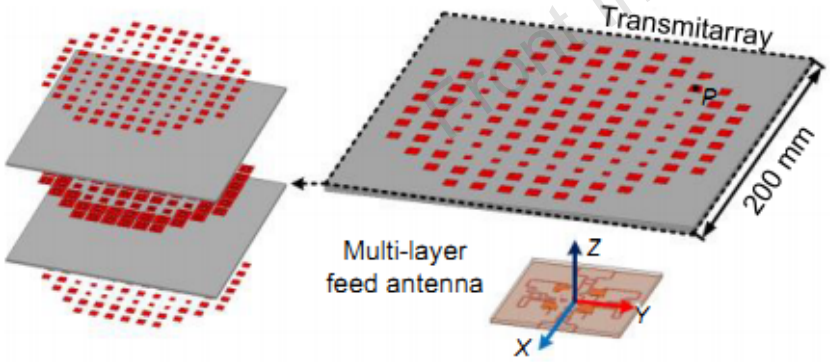
Transmission coefficient and transmission phase

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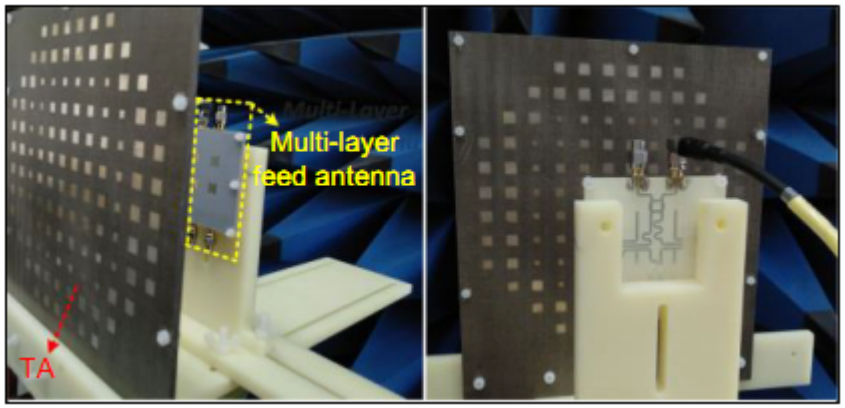
Transmitarray design

2. The phase centers of the feed source and transmitarray lens are usually in a direct line with each other. To generate sum-difference patterns, the phase shift distribution at position *P* can be calculated as $\varphi_P = k_0|OP| + 2n\pi$. In the measurement setup, the transmitarray and the multi-layer feed antenna with the sum-difference network are mounted onto a plastic holder.

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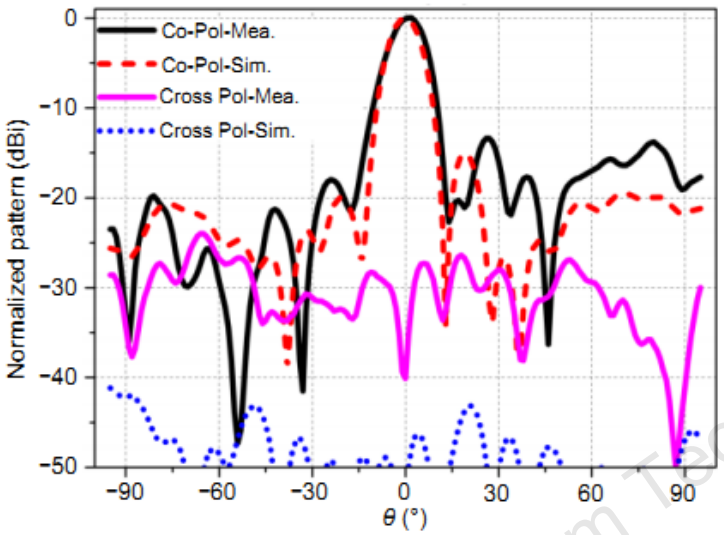


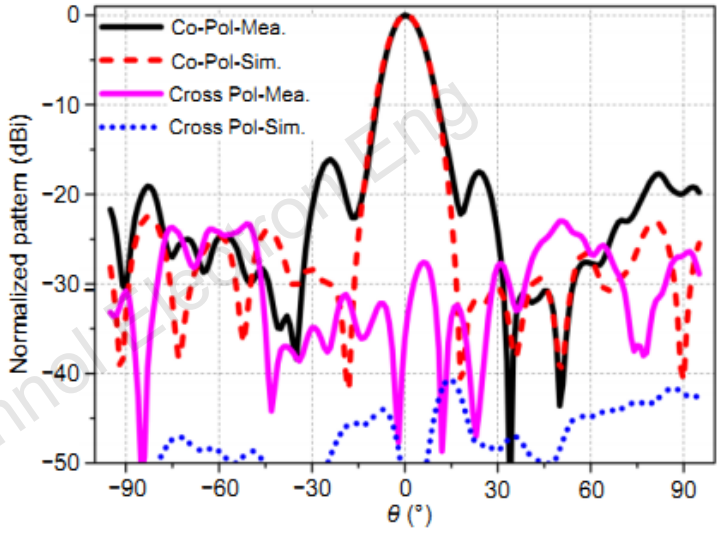
Topology of the transmitarray

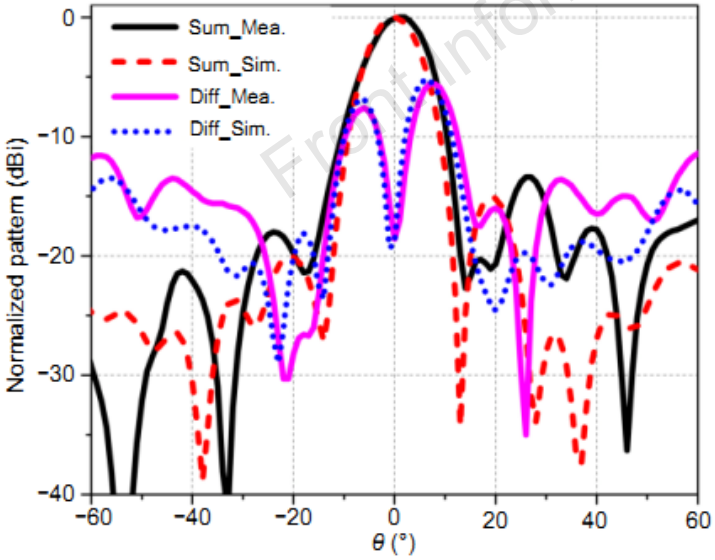


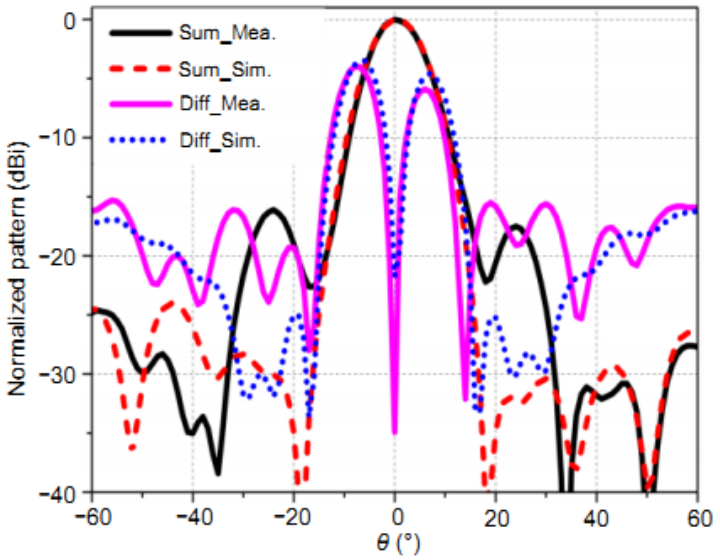
Fabricated prototype of the transmitarray

Radiation patterns









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Conclusions

An X-band monopulse antenna based on a transmitarray is proposed in this paper. The combination of ACMAs and a sum-difference comparator is introduced as feed of the two-layered transmitarray, generating high-gain sum-difference patterns. Results from simulation and measurement showed good agreement. Sum beams with a 3-dB beam width of 11° and a sidelobe level of less than −13.4 dB were realized. Difference beams with gain ratios to sum beam of 5.6 dB in the E-plane and 4 dB in the H-plane were generated. The proposed transmitarray-based monopulse antenna has light weight, low cost, low profile, and easy fabrication features.

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余世星，贵州大学大数据与信息工程学院副教授，硕士生导师，2017年6月博士毕业于西安电子科技大学。研究领域包括阵列天线、人工电磁媒质、涡旋电磁波等。在国家自然科学基金和贵州省科学技术基金等课题支撑下，开展天线与微波技术相关领域研究工作。以第一或通讯作者身份在IEEE TIE、IEEE TMTT、APL等国际期刊发表学术论文10余篇，其中3篇入选ESI高被引论文。获2018年度中国电子教育学会优秀博士论文奖、陕西省第14届自然科学优秀学术论文二等奖。

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