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Spatial fading channel emulation for over-the-air testing of millimeter-wave radios: concepts and experimental validations

Key words: Spatial channel model; Over-the-air (OTA) testing; Wireless cable method; Multi-probe anechoic chamber (MPAC) method; FR2 validation

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Motivation

- Millimeter-wave (mmWave) new radio (NR) testing will move exclusively to over-the-air (OTA) radiated modes using device antennas as the direct interface with the test system.
- It is of great importance to optimize and validate the device performance in real-world conditions, i.e., under faded and subject to interference channel conditions with multiple cells, users, and radio access technologies.
- It would be desirable to develop cost-effective OTA testing methodologies in laboratory conditions, which makes it possible to achieve virtual field testing purposes of mmWave devices in realistic conditions.

Main idea

- In this work, the main focus is on spatial fading channel emulation for the OTA testing of mmWave radios and its validation in a practical FR2 anechoic chamber.
- We experimentally validate the wireless cable method and the multi-probe anechoic chamber (MPAC) method in a practical setup for mmWave NR testing.
- Two simple strategies to achieve wireless cable connection for mmWave radios, i.e., using antenna polarization discrimination and pattern discrimination, are proposed.

Wireless cable method

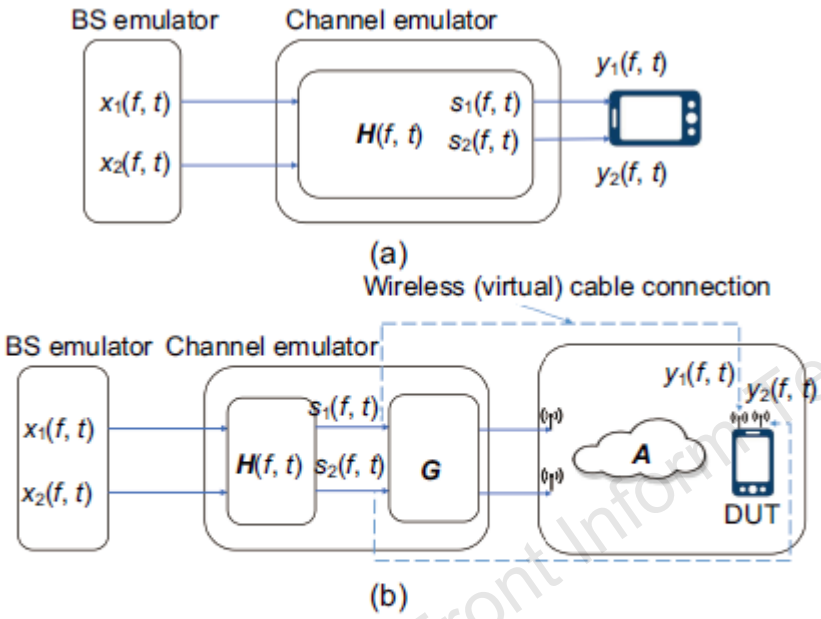


Fig. 1 Illustration of the conducted cable setup (a) and the wireless cable setup for mobile handsets supporting 2 × 2 MIMO systems (b)

BS: base station; MIMO: multiple-input multiple-output

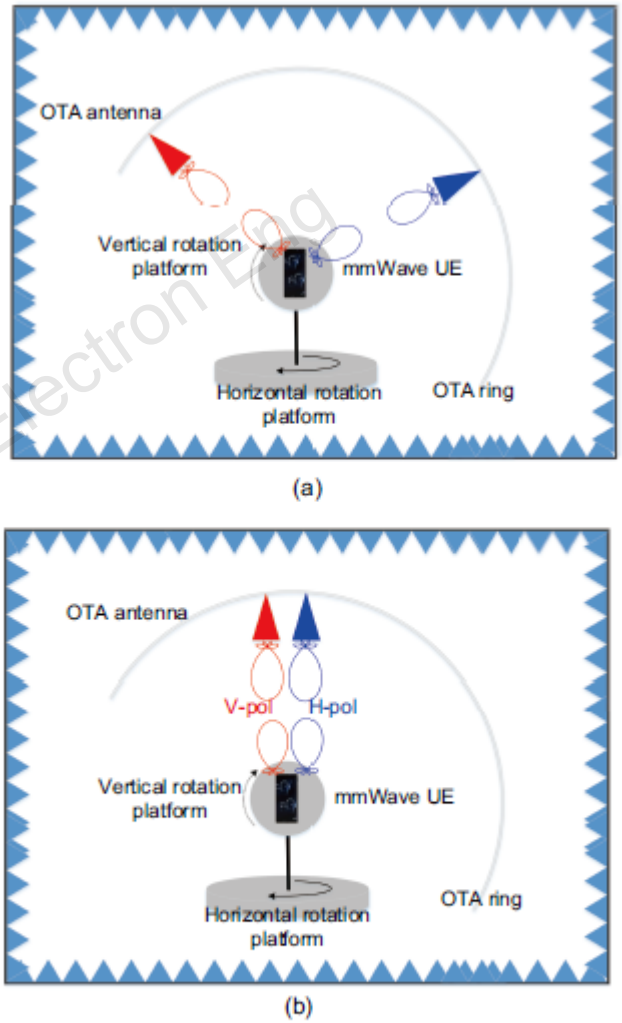


Fig. 3 Illustration for achieving wireless cable connection via antenna pattern discrimination (a) and antenna polarization discrimination (b)

mmWave: millimeter-wave; OTA: over-the-air; UE: user equipment

Wireless cable method

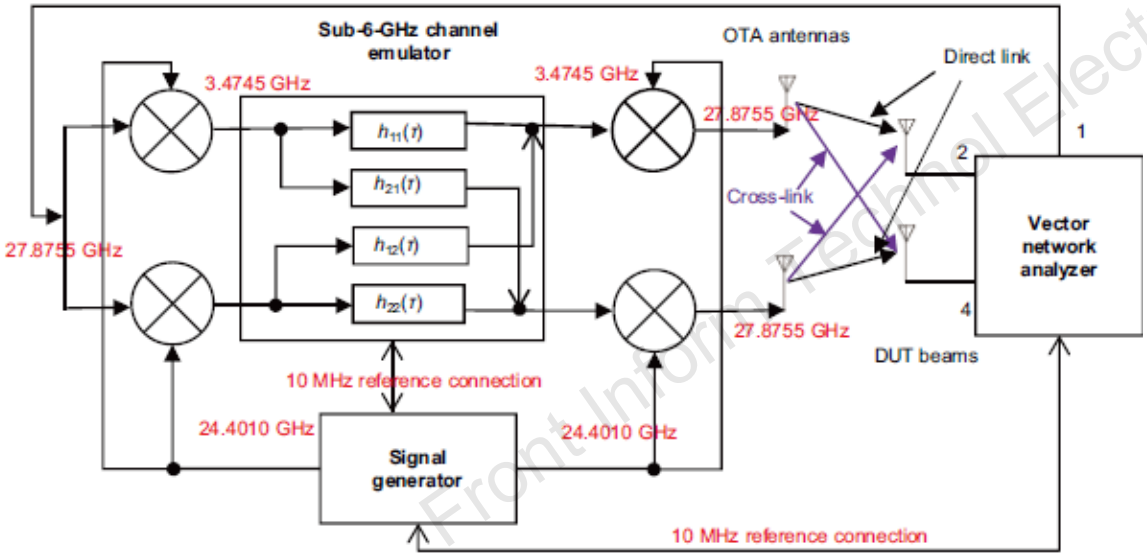


Fig. 4 System diagram for the wireless cable method validation setup
DUT: device under test; OTA: over-the-air. References to color refer to the online version of this figure

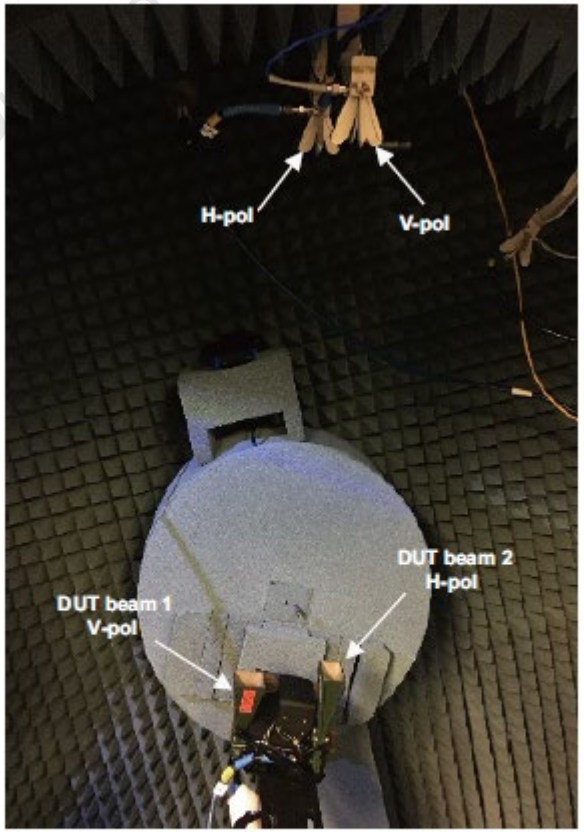


Fig. 5 Measurement setup for the wireless cable method using the polarization discrimination scheme
DUT: device under test; OTA: over-the-air; V-pol: vertical polarization; H-pol: horizontal polarization

Wireless cable method

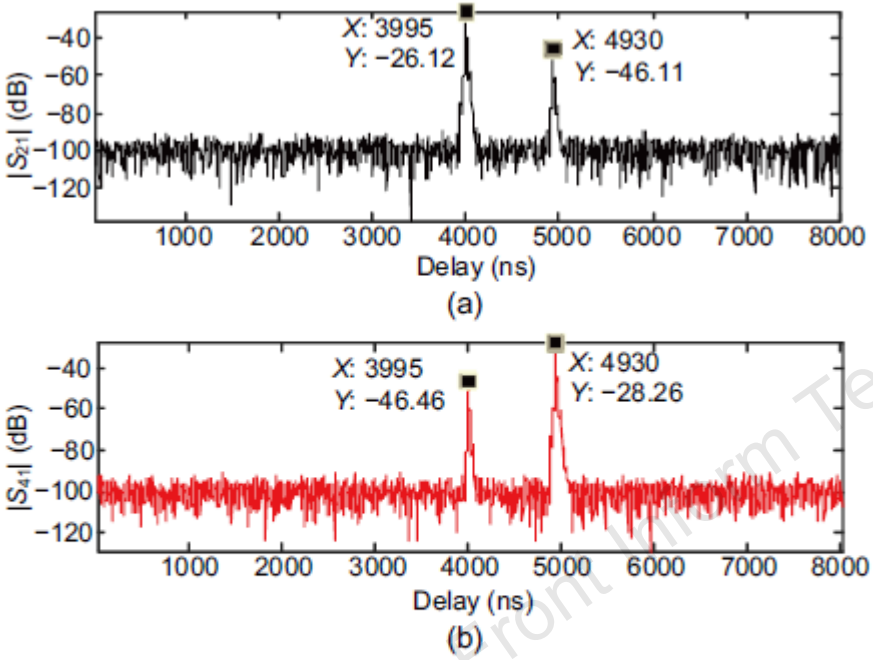


Fig. 7 Measured CIRs for the first (S_{21}) and second (S_{41}) DUT antennas using the polarization discrimination scheme

CIR: channel impulse response; DUT: device under test

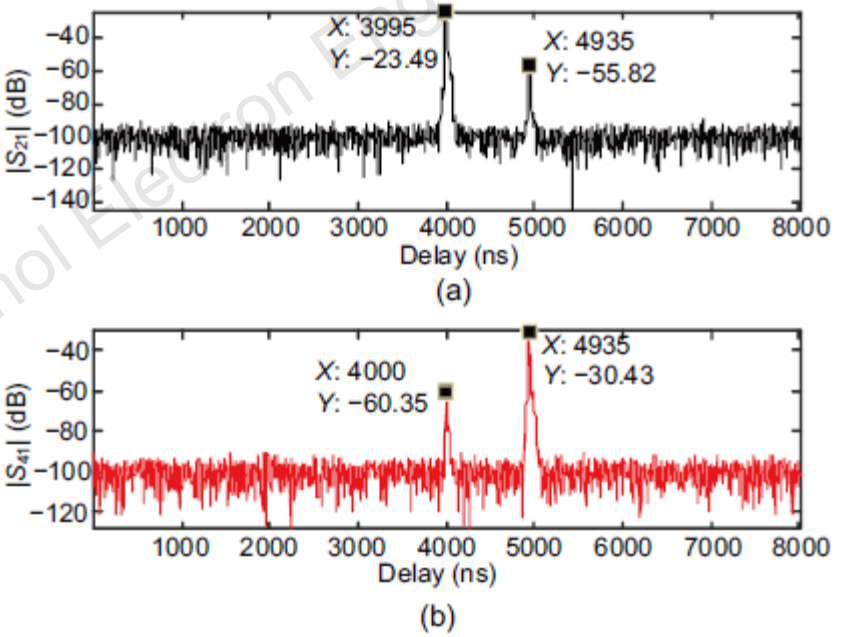


Fig. 8 Measured CIRs for the first (S_{21}) and second (S_{41}) DUT antennas using the beam pattern discrimination scheme

CIR: channel impulse response; DUT: device under test

MPAC method

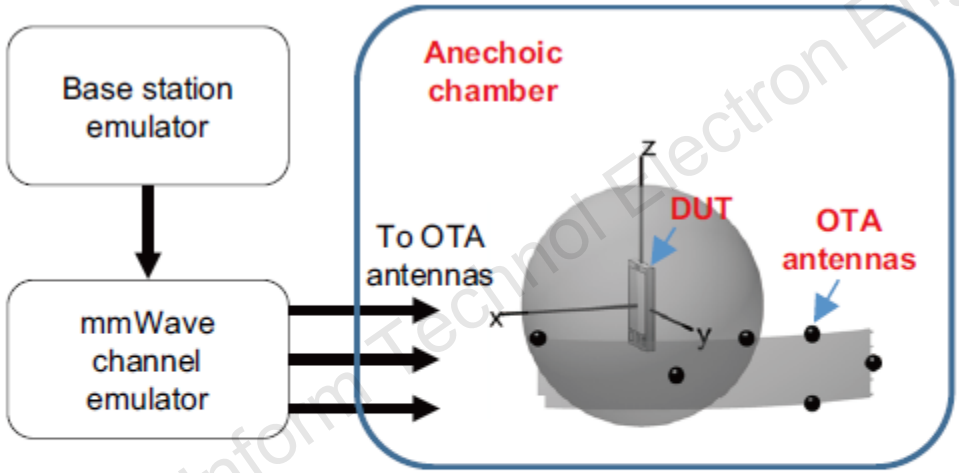


Fig. 9 MPAC system layout for OTA testing of an FR2 MIMO device

DUT: device under test; FR: frequency range; MIMO: multiple-input multiple-output; mmWave: millimetre-wave; MPAC: multi-probe anechoic chamber; OTA: over-the-air

MPAC method

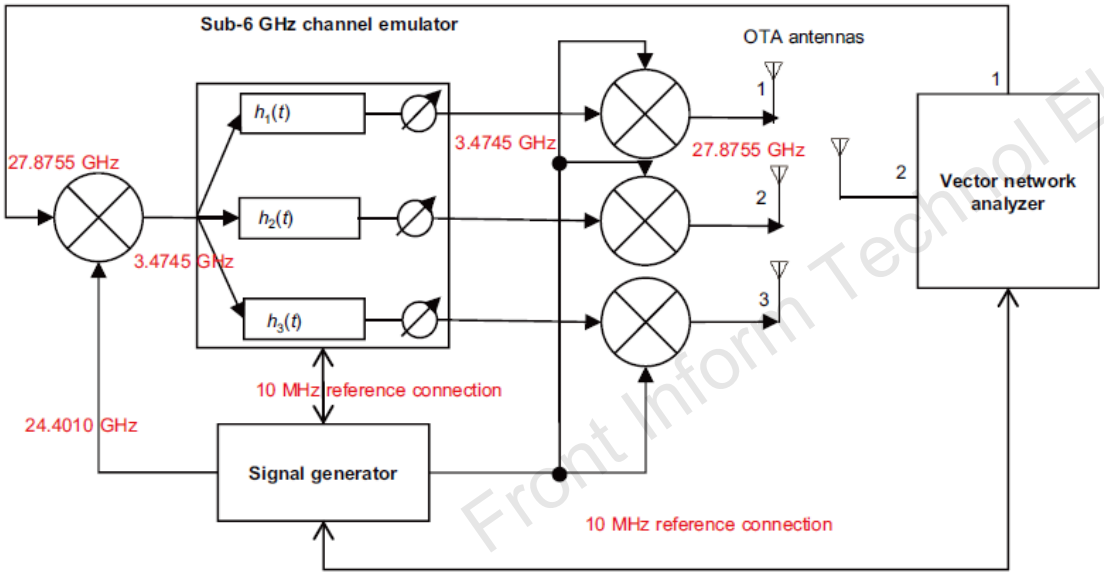


Fig. 10 System diagram for the SS-MPAC setup

OTA: over-the-air; SS-MPAC: simple sectored multi-probe anechoic chamber

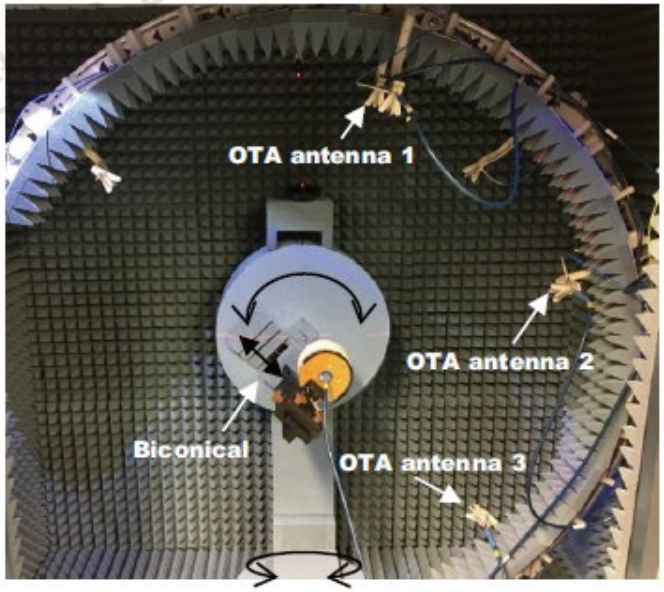


Fig. 11 System diagram for the MPAC setup

MPAC: multi-probe anechoic chamber; OTA: over-the-air

MPAC method

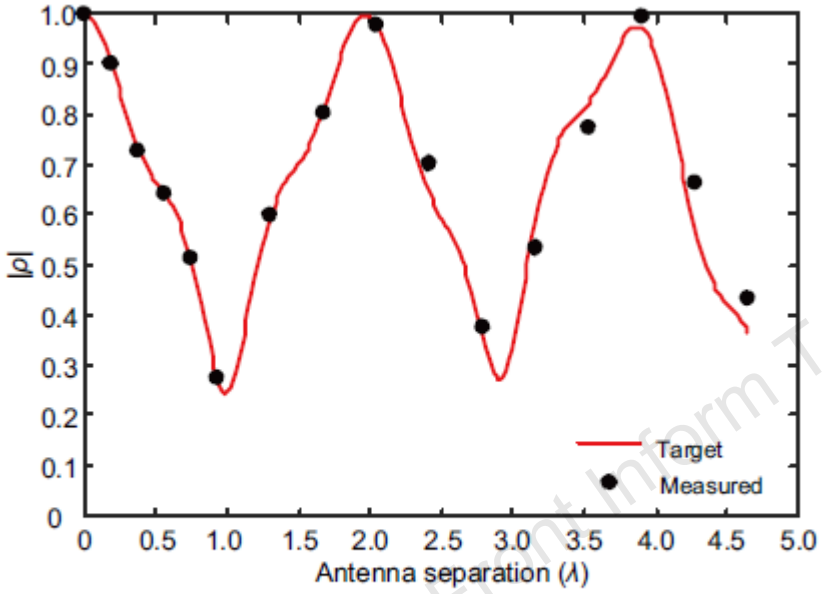


Fig. 12 Measured and target spatial correlation in the MPAC setup

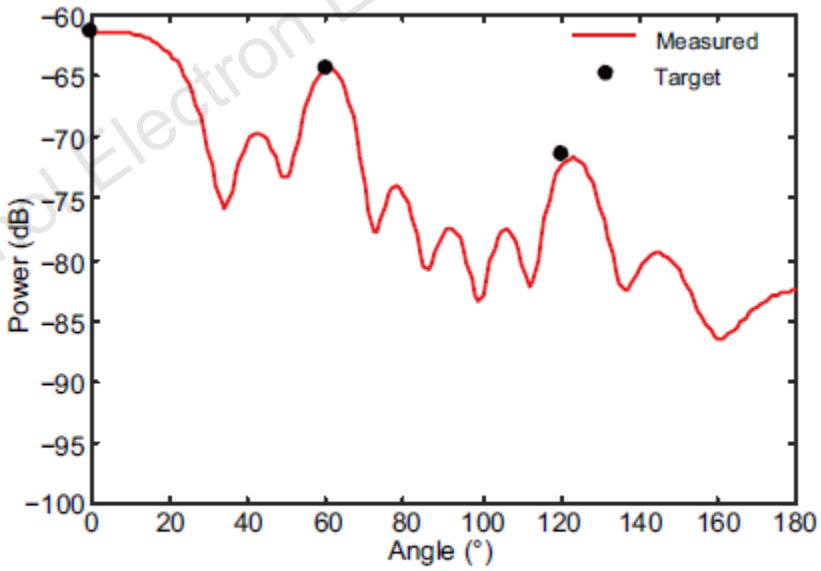
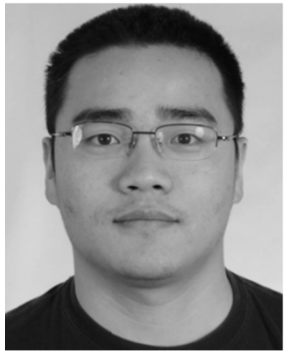


Fig. 13 Measured and target power angular spectrum in the MPAC setup

MPAC: multi-probe anechoic chamber

Conclusions

- Two OTA methods, namely, the wireless cable method and the MPAC method, have been investigated for mmWave radios with preliminary experimental results.
- Three strategies to achieve wireless cable connection have been discussed, i.e., transfer function matrix calibration, polarization discrimination, and antenna pattern discrimination. It is shown in the preliminary measurement results at around 28 GHz that an isolation more than 20 dB and 30 dB can be achieved for the wireless cable method using polarization discrimination and antenna pattern discrimination, respectively.
- The spatial correlation and PAS have also been investigated for a simple MPAC setup in the FR2 chamber. Excellent agreement between the measurement results and the target values is achieved in terms of spatial correlation and PAS, which validates the effectiveness of the MPAC method in the mmWave bands.



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