Key issues of MIMO over-the-air testing in the multi-probe anechoic chamber setup examined

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It is particularly important to conduct over-the-air (OTA) testing of multiple-input, multiple-output (MIMO) devices. MIMO-OTA techniques overcome the limitations of the traditionally conducted tests and are widely used for performance evaluation of the whole MIMO device. There are three main categories of MIMO-OTA testing methods, namely the reverberation chamber-based method, the radiated two-stage method, and the multi-probe anechoic chamber (MPAC) based method. The MPAC-based method can accurately reproduce arbitrary wireless propagation channels and is the only feasible solution for testing adaptive beamforming. Thus, it becomes the most promising OTA testing methodology for 5G devices.

A paper published in *Science China Information Sciences* mainly summarizes the 2D MIMO-OTA testing algorithms for UE and 3D MIMO-OTA testing algorithms for base stations (BS) in the MPAC test setup, and compares the related algorithms. Additionally, the authors discuss some key requirements for designing OTA testing systems and some novel testing methods for 5G wireless devices.

The main idea of the channel emulation is to ensure that the signal transmitted from the probe antennas is correctly controlled so that the emulated channel experienced by the DUT approximates to the target channel. There are two common signal emulation methods, namely the pre-fading signal synthesis (PFS) method, and the plane wave synthesis (PWS) method.

The main idea of the PFS method is to assign appropriate power weights to the probes to reproduce the spatial characteristics of the target channel at the receiving end. The main idea of the PWS method is to assign appropriate complex-valued weights to the probes to reproduce the electromagnetic field of the target channel at the receiving end.

In addition to the channel emulation algorithms, the design requirements of the MPAC testing system, including the number of OTA probes, the size of the test area, and the physical size of the test setup, are also very important aspects to be considered. In addition to the PFS and PWS methods, another method called EIV is also discussed, which assigns complex-valued weights to the probes to reproduce the target received voltage for 2D UE OTA testing.

The advantage of the PFS technique is that only power calibration is required, but cannot obtain enough emulation accuracy when the angular spread of the clusters is small. The PWS technique can accurately synthesize arbitrary plane waves, but requires both amplitude calibration and phase calibration. When the radius of the OTA probe ring is large enough, the EIV technique can achieve the same emulation accuracy as the PWS technique. But the EIV technique is not suitable for the case when the radius of the OTA probe ring is small. The 2D UE MIMO OTA channel emulation accuracy can be characterized by the spatial correlation error, the field synthesis error, the channel capacity error, and the throughput error. The latter can reflect the real end-to-end performance of the device under test.

In addition, the authors also summarize the design requirements of the 2D UE testing system, including how many probes should be used, how to decide the size of the testing area, and how to choose the physical size of the test setup.

An original 3D sectored MPAC test setup has been introduced for 3D BS OTA testing. The two channel emulation algorithms, i.e., PFS and PWS, are compared for this application as well. The cost function of the PFS technique can be either the spatial correlation error or the PAS error. The PFS technique with the PAS error as the optimization objective has higher emulation accuracy than the PFS technique with the spatial correlation as the optimization objective. In addition, since the PWS technique requires enough probes to emulate accurate 3D channels, the phase calibration of the BS OTA testing is very difficult. By comparison, the PFS technique turns out to be more suitable for 3D BS

MIMO OTA testing.

The authors also summarize the design requirements of the 3D BS test system, including flexible probe selection algorithms (multi-shot algorithm, ABC algorithm, PSO algorithm) and how to choose the physical size of the test setup. Some new 5G wireless testing methods, including 5G massive virtual testing and new methods based on reflective properties of concave surfaces, are also discussed.

More information: Huiling Pei et al, Key issues and algorithms of multiple-input-multiple-output over-the-air testing in the multi-probe anechoic chamber setup, *Science China Information Sciences* (2022). DOI: 10.1007/s11432-021-3285-y

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