FEATURES

By Lars Jacob Foged

# A NEW APPROACH FOR THE ACCURATE MEASUREMENT OF 5G CELLULAR NETWORKS

## UNDERSTANDING AND WORKING WITH NEW 5G TECHNOLOGIES WILL REQUIRE OUT-OF-THE-BOX THINKING

**Active Antenna System (AAS)** technology is receiving increased attention as a component for upcoming 5G cellular networks. These networks will have flexible radiation patterns that are capable of adapting to changing conditions. In order to fully characterize AAS' in the 3D space, a new approach to active antenna measurement will be required. This article takes a look at new ways to achieve quick and accurate AAS characterization.

### ANTENNA CHARACTERISTICS

Multiple-Input-Multiple-Output (MIMO) antenna arrays or "Massive MIMO" will play a prominent role in the 5G development, both in user, and network segments. The definition of "massive" can vary from AAS arrays with relatively few elements, to more conceptual designs involving hundreds of antennas. The common denominators for both are distributed amplification, beam steering, and full integration of the densely packed antenna elements.

In order to characterize the AAS, the collective performance must be determined in a calibrated over-the-air (OTA) setup, in which the spatial-directional power and sensitivity profile are measured. Consequently, the useful performance parameters in AAS testing are very similar to the existing tests for much smaller mobile devices.

### AAS PERFORMANCE PARAMETERS

The performance parameters of interest for AAS are the directional dependent power and sensitivity performances under far-field (FF) conditions [1], they are:

- Effective Isotropic Radiated Power – EIRP(θ,ϕ)
- Total Radiated Power – TRP
- Effective Isotropic Sensitivity – EIS(θ,φ)
- Total Isotropic Sensitivity (TIS) or Total Radiated Sensitivity (TRS)
- Antenna Directional Gain – G(θ,φ,)

The EIRP and EIS are directional performance parameters that can be measured, for a given direction of the antenna, via a calibrated OTA measurement. The directional EIRP, is the radiated power weighted by the directional gain of the antenna. The TRP can be determined from a full sphere integration of EIRP and associating isotropic gain to the antenna. Likewise, directional EIS is TIS/TRS weighted by the directional gain of the antenna. TIS/TRS can be determined by integrating the EIS, over the full sphere and associating isotropic gain to the antenna.

### FAR-FIELD MEASUREMENT CONDITION

A generally accepted criteria, which defines the FF distance of an antenna, is 2D2/λ, where D is the diameter of the antenna and λ is the free-space wavelength [2]. For electrically small antennas, such as antennas for mobile communication devices, the measurement, in the FF condition, is generally satisfied over convenient short measurement distances.

However, for moderate size, or larger AAS antenna systems, the FF measurement condition places unrealistic requirements on the measurement distance. Figure 1 illustrates the elevation pattern of an 8-element array antenna at 2 GHz, for different near-field (NF) distances, and the referenced FF distance. As can be observed, the elevation pattern is not fully formed at any realistic measurement distance.

The FF pattern of a given antenna can be measured directly using a Compact Antenna Test Range (CATR) [1, 2] or determined from NF to FF transformation, using standard NF techniques [3]. NF measurements are often preferred for 3D performance scenarios, since they require physically smaller measurement setups, and are generally considered faster and more accurate.

However, due to the capability of power conservation, AAS performance parameters can be determined at any distance from the device, using a calibrated OTA setup.

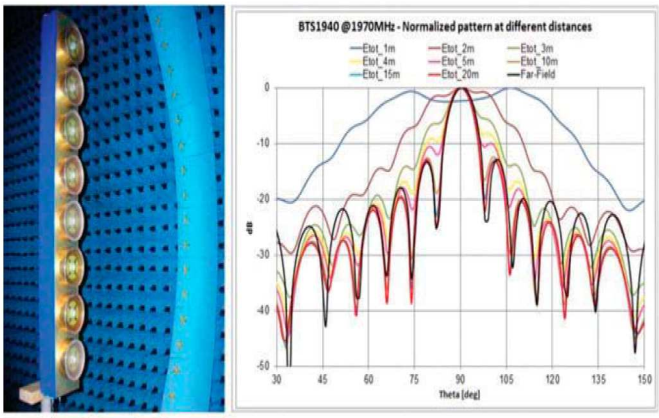


FIGURE 1. MEASURED ELEVATION PATTERN @ 2 GHZ OF AN 8-ELEMENT ARRAY ANTENNA FOR DIFFERENT NF DISTANCES AND FF.

The difference in NF to FF gain of the antenna can be determined and compensated for by standard NF to FF transformation techniques [3].

## PHASE RECOVERY IN ACTIVE MEASUREMENT SCENARIO

Since the AAS antenna is an active device with no fixed phase reference, the measurement in FF condition can be done using an FF setup, such as CATR, or a NF range. Applying phase recovery techniques allow NF to FF field transformation.

A common phase recovery method is the holographic technique, which uses different combinations of an unknown, measured signal against a stable reference signal. This is the preferred method, based on the simultaneous reception of the reference, and measured signals. A Phase Recovery Unit (PRU) has been designed to perform all the necessary amplification, filtering and signal combination for the accurate determination of the phase of the modulated signal.

## VALIDATION OF THE PRU

The actual AAS antenna is emulated using a mobile phone with an LTE protocol, connected to an 8-element passive array as the external antenna (see Figure 1). Figure 2 illustrates the comparison of the measured amplitude and phase of the co-polar NF, using phase recovery. This is then compared to passive measurements on the same antenna. As can be seen, the amplitude and phase correlation between the measurements is very good.

The measurement with phase recovery, using LTE modulation, was performed with the PRU set to a 10 MHz bandwidth around the 1940 MHz center frequency of the BTS

FEATURES

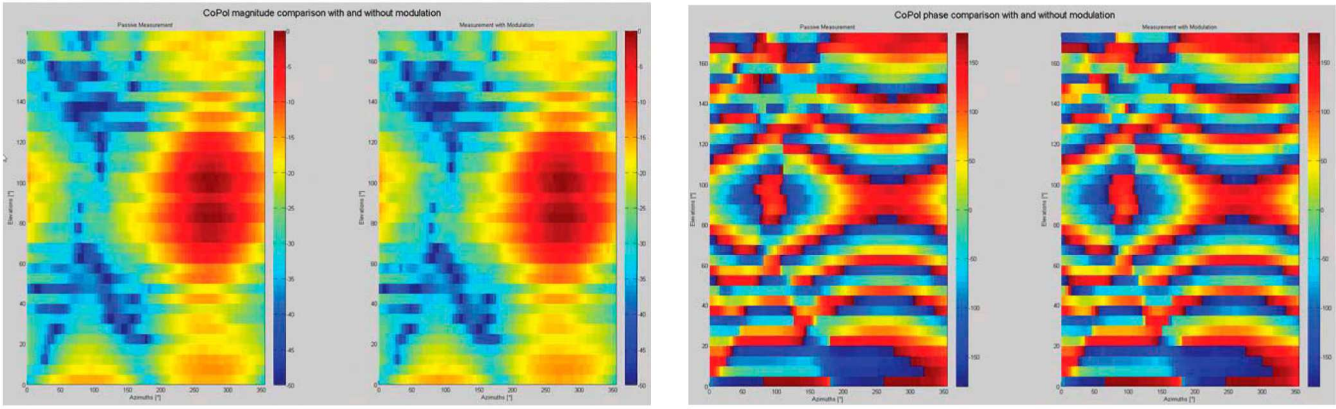


FIGURE 2. CO-POLAR, NF OF 8-ELEMENT ARRAY ANTENNA. REFERENCE MEASUREMENT (LEFT) AND ACTIVE MEASUREMENT (RIGHT) LTE PROTOCOL, USING PRU. MAGNITUDE (TOP), PHASE (BOTTOM).

antenna. The error introduced by the phase recovery technique was determined to be equivalent to a -45 dB noise level.

## VALIDATION ANTENNA FOR EIS (θ,φ), EIRP(θ,ϕ) MEASUREMENT

In order to validate the NF approach, a validation device with known EIS(θ,φ) and EIRP(θ,ϕ) is required. Since the 8-element antenna and LTE device in this example are separable, the reference EIS(θ,φ) and EIRP(θ,ϕ) performance of the combined device can be determined from the antenna gain and the sensitivity/radiated power of the LTE device from a conducted measurement.

## EIS MEASUREMENT OF AN 8-ELEMENT ARRAY ANTENNA WITH LTE PROTOCOL, USING NF TECHNIQUES

The EIS of the 8-element array antenna at 1940 MHz using the LTE protocol has been measured in NF and compared to the reference scenario to validate the approach. The EIS elevation and azimuth pattern of the reference and NF measurement, using the PRU unit in a 10 MHz bandwidth around the 1940 MHz center frequency, are compared in Figure 3.

As expected, the pattern shapes are very similar in both azimuth and elevation. The ~1 dB offset in measured sensitivity by the two methods, is justified by the uncertainties relative to the NF measurements and the determination of the reference scenario. Range calibration and the sensitivity search accuracy for EIS measurements are considered the main uncertainty contributor for the NF measurements. Range calibration and sensitivity search accuracy for conducted sensitivity are considered the main uncertainty contributors for the reference scenario.

## MEASUREMENT OF EIRP OF 8-ELEMENT ARRAY ANTENNA WITH LTE PROTOCOL USING NF TECHNIQUES

The EIRP of the 8-element array antenna at 1940 MHz was measured using the LTE protocol and compared to a reference scenario to validate the approach. The EIRP, elevation and azimuth pattern of the reference and NF measurement, using the PRU unit in a 10 MHz bandwidth around the 1940 MHz center frequency, are compared in Figure 4. As expected, the pattern shapes are very similar in both azimuth and elevation. The ~0.5dB offset

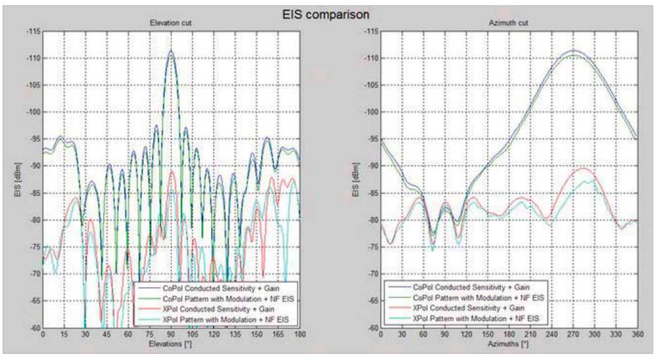


FIGURE 3.

in EIRP of the two measurements is justified by the uncertainties relative to the NF measurements and the determination of the reference scenario.

## CONCLUSION

The NF measurement technique has been demonstrated effectively in the measurement of performance parameters such as EIRP and EIS for AAS. It has been confirmed, experimentally, that the implemented PRU technique can, reliably,



Previous Page | Contents | Zoom in | Zoom out | Front Cover | Search Issue | Next Page
Qmags THE WORLD'S NEWSSTAND

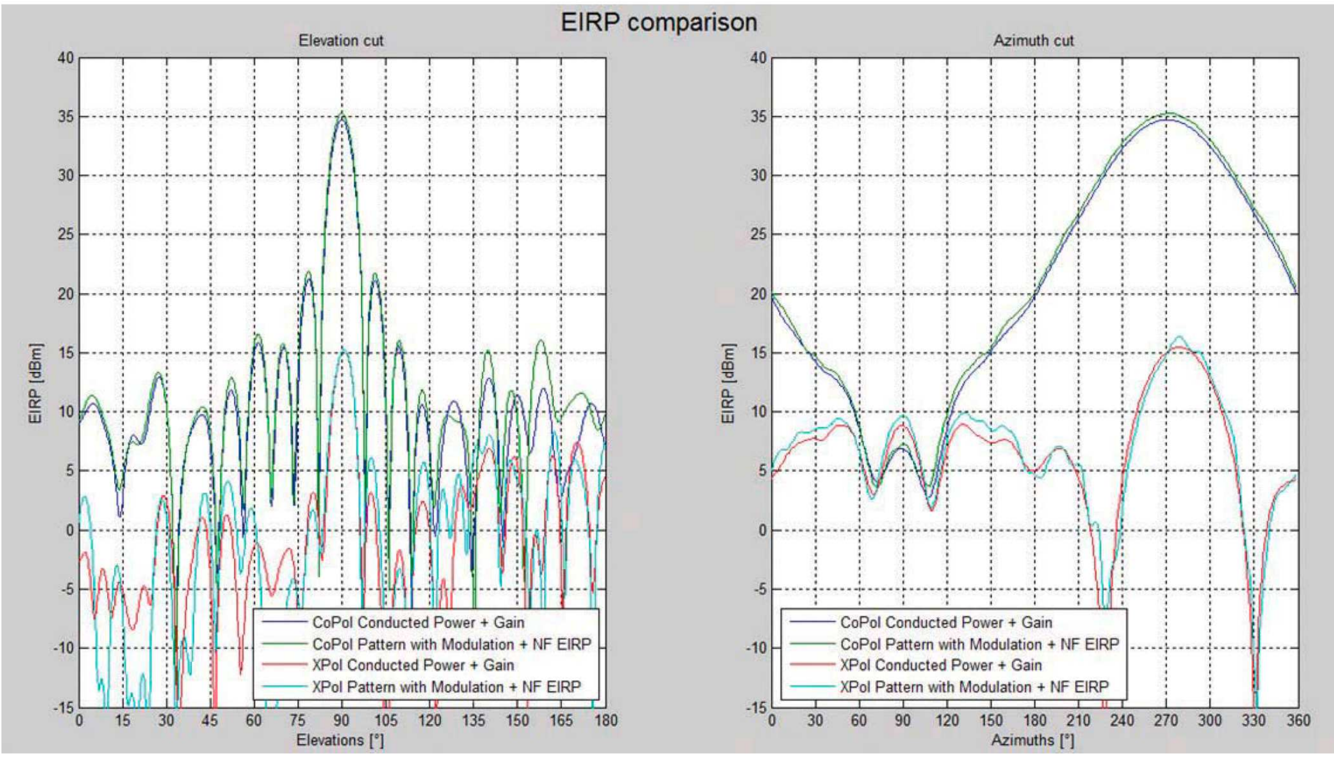


FIGURE 4. COMPARISON OF MEASURED ELEVATION AND AZIMUTH EIRP(Θ,Φ) OF 8-ELEMENT ARRAY ANTENNA USING LTE PROTOCOL.

measure the phase in NF for modulated signal with large bandwidth, such as LTE, and allow for accurate NF/FF transformation. The intrinsic advantages of NF measurement techniques makes this, in the author's opinion, the best way for the accurate measurement and testing of 5G devices.

## REFERENCES

[1] Ericsson contribution, "On radiated testing of AAS BS," 3GPP R4-132211, May 2013.

[2] ANSI/IEEE Std. 149-1979; Standard Test Procedures for Antennas.

[3] IEEE Recommended Practice for Near-Field Antenna Measurements, IEEE Std, 1720-2012.

[4] L. J. Foged, A. Scannavini, N. Gross, F. Cano-Facila "Accurate Measurement of Transmit and Receive Performance of AAS Antennas in a Multi-Probe Spherical NF System," IEEE International Symposium on Antennas and Propagation, Vancouver, British Columbia, Canada, July 19-25, 2015.

Lars Jacob Foged is Scientific Director, Microwave Vision and Associate Director, Microwave Vision Italy. Email him at lars.foged@microwavevision.