Accurate Measurement of Transmit and Receive Performance of AAS Antennas in a Multi-Probe Spherical NF System

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***Abstract*—The Active Antenna System (AAS) is receiving an increased attention for the upcoming 5G cellular networks. The actual measurement AAS antennas require new thinking in active antenna measurement. This paper describes a new measurement approach based on NF antenna measurements techniques to determine directional dependent performance parameters such as EIRP and EIS and their derived performance parameters such as TRP and TIS.**

I. INTRODUCTION

In order to characterize an Active Antenna System (AAS), the amplifier, the receiver and the antenna characteristics must be known. Due to the inseparability of these components in AAS, the performance must be determined in an Over-the Air (OTA) setup in which the spatial-directional power and sensitivity profile is measured. Consequently, the useful performance parameters in AAS testing are very similar to current testing of much smaller devices [1].

II. AAS ANTENNA PERFORMANCE PARAMETERS

The transmit performance parameters of interest for AAS antennas are: Effective Isotropic Radiated Power, EIRP(θ,φ) and Total Radiated Power, TRP. The EIRP(θ,φ) is a directional performance parameter that can be measured for a given direction of the antenna device in a calibrated Over-the-Air (OTA) measurement setup. The TRP can be determined from the fact the directional EIRP(Θ,ϕ) is the power weighted by the directional gain G(Θ,ϕ) of the antenna. From a full sphere integration of the EIRP(Θ,ϕ) we can determine the TRP by associating isotropic gain to the antenna.

The receiver parameters of interest are: Effective Isotropic Sensitivity or EIS(θ,φ) and Total Isotropic Sensitivity (TIS) or Total Radiated Sensitivity (TRS). The EIS(Θ,ϕ) is a directional performance parameter and can be measured for a given direction of the antenna device in a calibrated OTA setup. TIS/TRS can be determined since directional EIS(Θ,ϕ) is TIS/TRS weighted by the directional gain G(Θ,ϕ) of the antenna. By integrating the EIS(Θ,ϕ) over the full sphere we can determine TIS/TRS by associating isotropic gain to the antenna.

III. FF MEASUREMENT CONDITION

A generally accepted criterion to define the far-field distance of an antenna is $2D^2/\lambda$, where D is the diameter of the antenna and λ is the free-space wavelength [3]. For electrically small antennas, such as mobile communication devices, this criterion is generally satisfied for most measurement distances. However, for moderate size AAS antennas this is no longer the case. Fig. 1 show the elevation pattern @ 2GHz of an 8-element array antenna, BTS1940 from MVG, for different NF distances and the reference FF distance. The elevation pattern is not fully formed for any realistic measurement distance and the measurement must therefore be performed in FF condition.

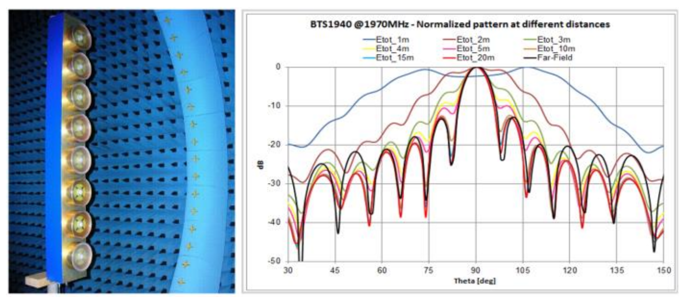

Fig. 1. Measured elevation pattern @2GHz of an 8-element array antenna for different NF distances and FF.

IV. PHASE RECOVERY IN ACTIVE MEASUREMENT SCENARIO

The AAS antenna measurement in FF condition can be accomplished in a FF range or NF range using phase recovery techniques to allow Near-Field to Far-Field transformation. A common method is the holographic phase recovery techniques using a combination of the measured unknown signal with a stable reference signal and different combinations of fixed phase shifts. The preferred approach here is an evolution of this approach 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.

V. Validation of the Phase Recovery Unit

The actual AAS antenna is emulated using a mobile phone with LTE protocol connected to the 8-element passive array in Fig. 1, as external antenna. Fig. 2 show the comparison of the measured amplitude and phase of the co-polar near field using phase recovery compared to passive measurement on the same antenna. The amplitude and phase correlation between the measurements are very good.

The measurement with phase recovery in LTE modulation was performed with the PRU unit in a 10MHz bandwidth around the 1940MHz centre frequency of the BTS antenna. The error introduced by the phase recovery technique was determined to be equivalent to a -45dB noise level

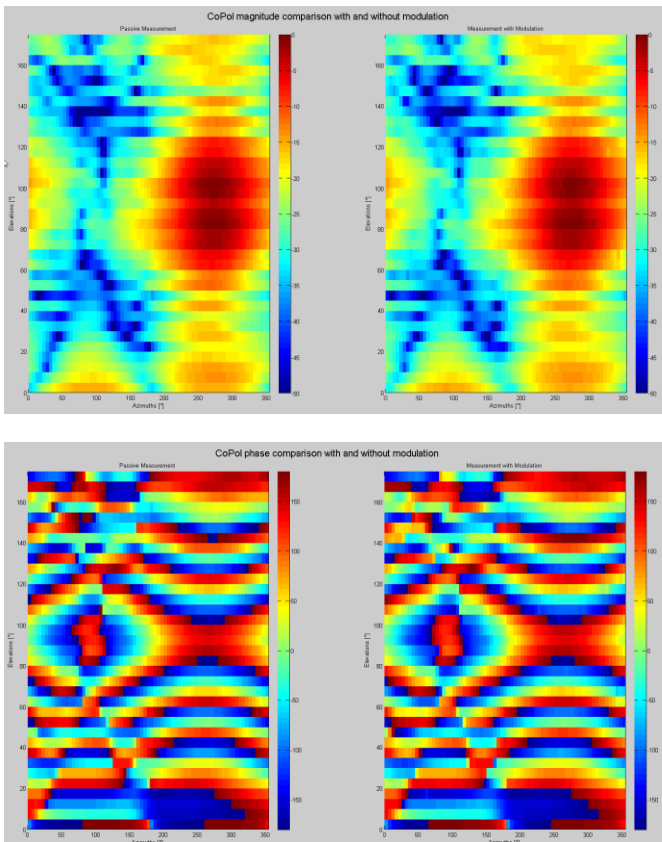

Fig. 2. Co-polar, Near Field of 8-element array antenna. Reference measurement (left) and active measurement (right) LTE protocol, using PRU. Magnitude (top), Phase (bottom)

VI. Near field EIS(Θ,Φ) measurement of 8-element array antenna using LTE protocol

The EIS(Θ,ϕ) of the 8-element array antena @ 1940MHz has been measured using the LTE protocol. I order to validate the NF approach, the EIS(Θ,ϕ) has been measured using two differente methodologies. Taking advantage of separate measurements of the 8-element antenna in terms of gain in passive mode and the conducted sensitivity of the active LTE device, the reference scenario of the combined devices has been defined. This reference has been compared to direct EIS(Θ,ϕ) measurement of the 8-element antenns and device using LTE modulation in NF using phase recovery (PRU).

The EIS(Θ,ϕ) elevation and azimuth pattern of the reference and NF measurement using the PRU unit in a 10MHz bandwidth around the 1940MHz centre frequency are compared in Fig. 3. As expected, the pattern shapes are very similar in both azimuth and elevation. The main difference is ~1dB difference in the boresight sensitivity. This difference is justified by the combined estimated uncertainties on the NF measurements and the reference scenario. Range calibration and the sensitivity search accuracy for EIS measurement are considered the main uncertainty contributor for the near field measurements. Range calibration and sensitivity search accuracy for conducted sensitivity are considered the main uncertainty contributors for the reference scenario.

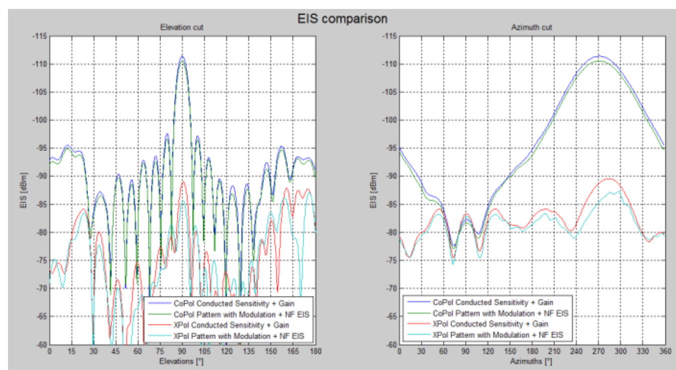

Fig. 3. Comparison of measured elevation and azimuth EIS(Θ,ϕ) of 8-element array antenna using LTE protocol.

VII. Conclusion

Near field measurement technique has been demonstrated effective in the measurement of EIRP(Θ,ϕ) and EIS(Θ,ϕ) for large active antennas such as AAS. It has been shown experimentally, that the implemented phase recovery unit technique can reliably measure the phase in near field for modulated signal with large BW such as LTE.

References

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

[2] IEEE Reccomended Practice for Near-Field Antenna Measurements, *IEEE Std, 1720-2012*

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