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Optimized Design and Implementation of a Blended Rolled Edge Reflector CATR

Marc Dirix[(1)], and Stuart F. Gregson[(2,3)]
(1) Antenna Systems Solutions, Santander, Spain
(2) Next Phase Measurements LLC, CA, USA
(3) Queen Mary University London, London, UK

Summary

In order to expand the measurement capabilities in terms of frequency and antenna system size, an existing direct far-field 5G base station measurement range is being retrofitted with an optimized, blended rolled edge, compact antenna test range. This paper presents an overview of the design and implementation of this unusual 5G NR enabled measurement system, where the design process used combines a state of the art genetic optimization processor with a high speed parallel simulation performance evaluation employing a highly accurate current element based electromagnetic model.

1. Introduction

It is expected that the antenna size for 5G new radio (NR) base stations at FR2 bands will be far smaller than those antennas used for FR1 bands. However, for the integrated antenna system in the application of 5G NR massive MIMO, the total antenna system size can still be considerable. Even though research has shown that for certain applications measurements results are acceptable at slightly shorter distances [1], the far-field distance scales rapidly with the total antenna size, and thus existing direct far-field (DFF) ranges often encounter significant limitations in terms of scaling of the antenna system size, or the limitations to the upper bound frequency. Due to this fact, in order to facilitate far-field measurements the 3GPP standards have approved the compact antenna test range (CATR) as one of the standard approaches to measure 5G figure of merits [2].

In order to expand existing measurement capabilities, a blended rolled edge (BRE) CATR setup has been designed to integrate with and therefore compliment the frequency span of a DFF [3,4,5] facility. To minimize the total space and cost allocation, the existing measurement chamber and AUT positioner are retained, with the CATR being incorporated in such a way as to minimize the impact on the existing DFF measurement capability.

2. Design and Optimization

In order to retrofit a CATR into an existing DFF range with as little impact on the existing setup as possible, a floor fed configuration was chosen. As a result, a previously existing moveable absorber screen could be used to provide an absorber wall behind the CATR reflector and as the absorber screen to shield the reflector while the DFF range is being operated. The allocation of the key CATR components as well as the existing AUT positioner is shown in Figure 1. Here, the reflector pedestal and feed shroud are shown without their respective absorber treatment for the sake of clarity. The required quiet zone (QZ) size was determined to be a cylinder with 1.1 meter diameter and 1.1 meter length. The maximum reflector body size was governed by the available space. The initial lower bound primary operating frequency was set to 10 GHz, with a clear desire to push the lower frequency boundary as far as practicable. While the allocation and maximum size of the reflector and feed positioner are determined by the available space and chamber layout, the reflector surface and edge treatment have been optimized for the specific case. A finely tuned genetic optimizer [6] which harnessed an extremely fast simulation of the QZ performance was used to perform the optimization. The simulation relies on the current element method which has been shown to provide highly accurate results for the BRE case [4,7], with the optimization process itself being treated in great detail in the open literature [6,7,8]. After completing the optimization process, it was found that the predictions suggested that the reflector would work well down to *circa* 3.5 GHz with the performance improving as the electrical size of the reflector increases with full performance being achieved by 4 GHz [4]. The results of the simulation at 3.5, 3.95 and 10 GHz are shown in Figure 2. Given the amplitude tapering and flat phase response at 10 GHz, it was found that the results above 10 GHz stabilize with only ever-smaller ripple until surface roughness considerations limit performance in the sub-millimeterwave region. These results are not presented herein as a consequence of available space. The Cx-Polar level is mainly governed by the physical allocation of the reflector and feed positioner based on available space and scattering requirements, which in this case was chosen to be floor fed; and thus outside the scope of the optimization, and is typically of lesser importance for the intended application.

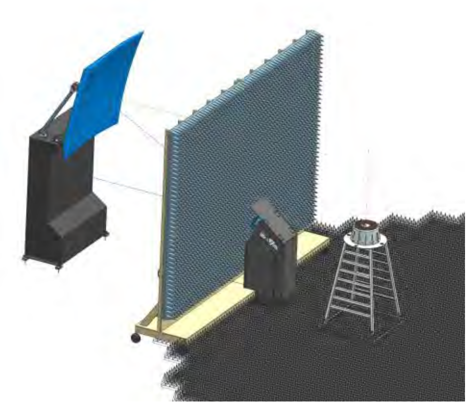

Figure 1: Allocation CATR components

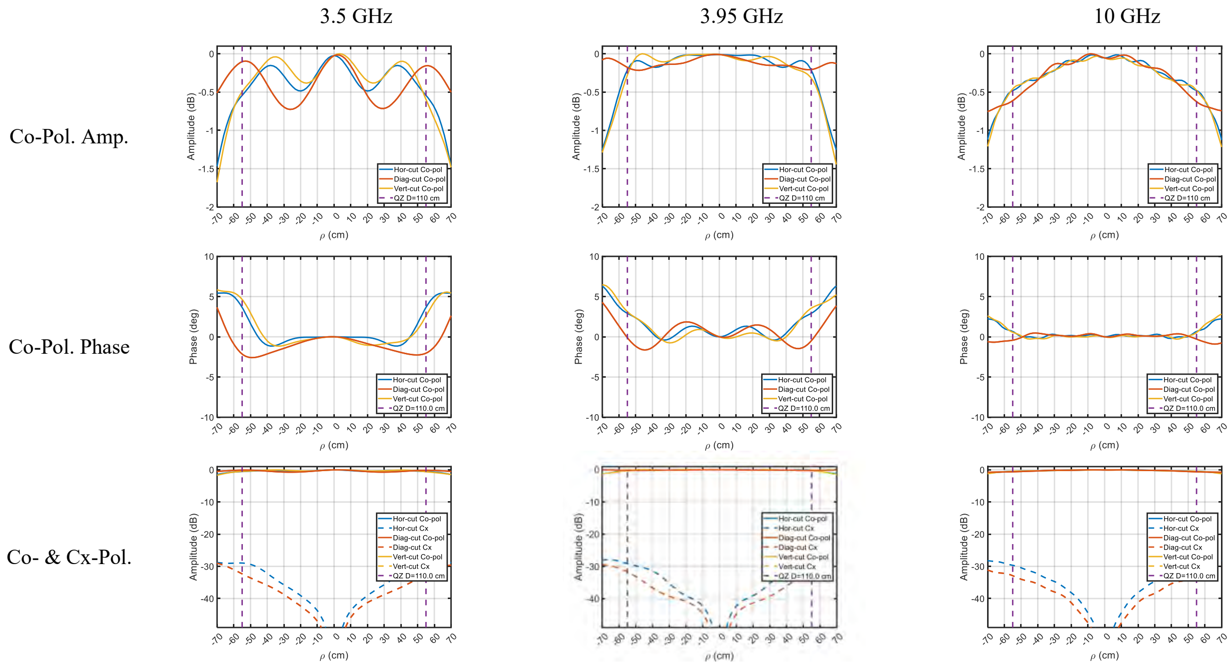

Figure 2: Simulation results of the optimized BRE CATR

3. Production

After the reflector design was finished, the reflector was manufactured and its surface profile characterized. The CATR is being installed at its final location. Figure 3 shows the reflector after manufacturing and surface evaluation. The measured mechanical surface accuracy was found to be sufficient for this reflector to operate up to *circa* 300 GHz.

reflector shown following FAT and just prior to shipping.

4. Conclusion

In this paper the genetic optimization together with the fast simulation technique was applied for the design of a BRE CATR with the purpose of retrofitting an existing DFF range to expand its frequency range and antenna system measurement capabilities.

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