Verification of Feed Spillover Reduction using FF-MARS in a CATR Using Computational Electromagnetic Simulation

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***Abstract*—The Mathematical Absorber Reflection Suppression (MARS) technique is used ordinarily to identify and then suppress effects of spurious scattering within an antenna range measurement. This paper, for the first time, demonstrates by means of computational electromagnetic simulation that MARS can also be used to attenuate feed spillover in an offset parabolic reflector compact antenna test range. Preliminary results are presented and discussed.**

***Keywords*—compact antenna test range, mathematical absorber reflection suppression, feed spillover, computational electromagnetics.**

I. Introduction

For over a decade now, a post-processing and measurement technique named Mathematical Absorber Reflection Suppression (MARS) has been used to great effect to identify and then extract range multi-path effects in spherical [1, 2], cylindrical [3] & planar [4] near-field antenna test systems, far-field [5] and compact antenna test ranges (CATR) [6, 7]. A detailed theoretical treatment of the technique can be found presented in [8]. A large portion of the early work concentrated on verification by empirical means. However, some supporting evidence was also obtained using computational electromagnetic (CEM) simulations that considered far-field [9] and subsequently near-field cases [10, 11]. The recent development of a highly accurate CATR CEM simulation tool [12] that permits the simulation of "measured" far-field pattern data [13] has for the first time permitted the careful verification of the far-field MARS (FF-MARS) technique for a given antenna under test (AUT) and CATR combination in various circumstances. It has been long suspected that FF-MARS was capable of suppressing feed spillover, as in part this had been thought to have been observed experimentally [7]. However definitive confirmation was required and as such recourse to more easily controlled numerical simulation was sought. Although the effectiveness of MARS for the purposes of scattering reduction has been demonstrated in a CATR by means of CEM simulation [14] this paper, for the first time, demonstrates that FF-MARS can used with similar effect to suppress the CATR feed spill-over. Preliminary results are shown in Section II with the discussed and conclusions being presented in Section III.

II. Preliminary Results

To illustrate the ability of MARS to suppress feed spillover in a CATR, we used the 5.4m focal length sector-shaped single offset reflector mm-wave CATR that is presented schematically in Fig. 1 as a test case. This 3.0m 8 GHz to 60 GHz CATR facility is installed at Queen Mary University of London (QMUL) and is described in [15]. Direct illumination of the CATR quiet-zone is usually minimized through the use of absorber collars on the feed and/or baffles positioned within the chamber [8]. However feed spillover effects are seen, to some extent, in many ranges with the widely employed offset reflector configuration and low gain feed making this to some extent almost unavoidable with dual reflector CATRs being perhaps the most susceptible designs.

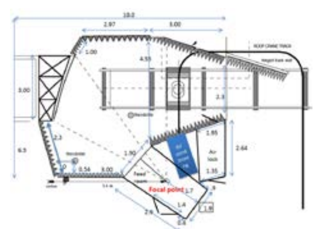

Fig. 1. Schematic representation of sector-shaped single offset reflector CATR at QMUL.

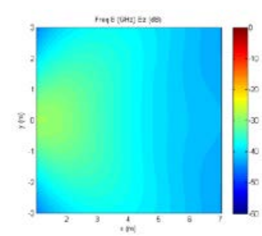

Fig. 2. Z-component of field radiated by feed in CATR QZ transverse to the range boresight.

Typically CATR QZ field probing involves using a planar near-field scanning system [8] to measure the horizontal and vertically polarized components of the electric field across a plane that is transverse to the boresight, *i.e.* z-axis, of the range. It can be seen that the x- and y-polarized components of the field radiated by the feed in the CATR QZ are generally comparatively small (*e.g.* 40 dB down) when compared to the pseudo plane-wave formed by reflection from the reflector itself. However the z-polarized component of the field radiated by the feed in CATR QZ, which in practice is not normally characterized during range commissioning or validation activities, can be significant and in this case was *circa* 15 to 20 dB *greater* than the longitudinal component of the pseudo plane wave thereby dominating this polarization. Fig. 2 shows the amplitude of the z-polarized electric field radiated by the feed in the CATR QZ where the levels have been plotted normalized relative to the peak of the pseudo plane wave, *i.e.* the E_x component in this case. Crucially, it is the entire electromagnetic six-vector of the pseudo plane wave formed by the CATR that couples into the aperture of the test antenna that produces the measured far-field antenna pattern [13, 14] function. The actual coupling can be determined using the reaction integral which is based upon a reciprocity relationship. This suggests that on boresight feed spillover related effects could be comparatively small. However, as the AUT is rotated so that its aperture aligns more closely with the z-axis of the range then the coupled power can increase meaning that feed spillover effects become more pronounced on the wide out antenna pattern function.

The existing QMUL CATR CEM model [12, 13, 14] was used to compute the fields radiated by the CATR at 8 GHz with and without direct illumination of the QZ by the feed. The coupling of these fields into the AUT was then obtained from a numerical evaluation of the reaction integral which produced a simulated CATR measurement. As in common with all MARS type measurements, the AUT was offset from the origin of the measurement coordinate system by an amount that was larger than the maximum dimension of the AUT and in this case a 0.61 m displacement in the *z*-axis was used which is at a normal to the aperture plane of the AUT which is also orthogonal to the vertical azimuth rotation axis of the CATR. Respectively, Fig. 3 and Fig. 4. present azimuth and elevation far-field AUT patterns. Here, the red trace denotes the reference ideal far-field patterns which are shown plotted against the simulated "measured" fields which are denoted by the magenta traces. As expected, these differ most significantly in the region of the wide-out side-lobes. Standard F-MARS processing was used to suppress the effects of the feed spillover with the results of the MARS processing being denoted with the blue traces. As expected feed spillover had the greatest impact in the horizontal plane as this is the plane in which the feed was offset.

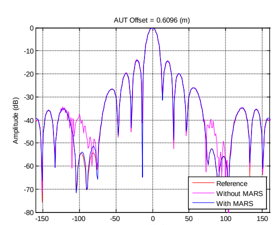

Fig. 3. Far-field azimuth cut showing feed spillover and it suppression with MARS processing.

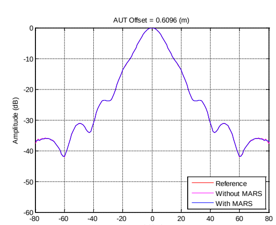

Fig. 4. Far-field elevation cut showing very little effect arising from feed spillover.

From inspection of Fig. 3, it is clear that the FF-MARS processing has significantly reduced the effect of the feed spillover (by *circa* 15 dB around ±90°) with the reference and MARS processed patterns yielding very encouraging agreement.

III. Summary and Conclusions

Results of a FF-MARS acquisition have been presented showing for the first time the quantitative impact of feed spillover on a CATR measurement. We have shown that this effect is primarily due to the z-component of the quiet zone field generated by the feed and that this component contributes to the measured field when the AUT points significantly away from boresight. We have demonstrated that FF-MARS processing can be used to suppress these effects with results that very nearly remove the effect completely.

As this paper summarizes the findings of an on-going program of research the future plans include demonstration of MARS spillover suppression on real measured patterns in our CATR and the extension of the MARS technique to electromagnetic scattering measurements.

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