Numerical Investigation of Cross Polar Reduction CATR Feed in Dual Linar Polarisation

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***Abstract*— The polarization purity of an antenna system is an important performance parameter, particularly in dual-polarized systems, where depolarization can prevent operating objectives from being achieved. Accurace polarisation testing, requires a significantly higher polarisation purity of the test system than the test object. The Compact Antenna Test Range (CATR) is widely used for antenna system testing purposes [1]. It provide convenient testing, directly in far-field conditions of antenna systems placed in the Quiet Zone (QZ). Polarization performance is often the main motivation for the CATR implementation based on a more expensive and complex, dual compensated reflector optics rather than a single reflector optics. Improving the QZ cross-polarization performance of the single reflector CATR has been a challenge for the industry for many years. Recently, a feed, based on conjugate matching of the undesired cross-polar QZ fields has been validated sperimentally [2-3]. In this paper, we show by numerical simulation, that the cross-polar discrimination of the QZ can be improved by as much as 10dB with respect to standard feeds on a 1.6:1 bandwidth for dual liner polarization in standard side and edge-feed single reflector CATR.**

Keywords*— *Compact Range, Quiet Zone, Cross Polarization Compensation

I. Introduction

Compact Antenna Test Ranges (CATR) provide convenient far-field conditions testing. However, the offset parabolic reflector of single reflector CATR causes a variation of the polarization tilt angle as a function of position in the Quiet Zone (QZ). This Geometrical Optics (GO) effect gives rise to cross-polarization in the QZ with a null region along the plane of symmetry of the reflector optics. Therefore, accurate polarization measurement, in single reflector CATR, can only be achieved, when the Antenna under Test (AUT) is positioned at the centre of the QZ and its size is at least 10 times smaller than the CATR reflector [4]. Unfortunately, this requirement makes accurate cross-polar measurements rather difficult for physically large antennas, such as arrays or reflector antennas, or antennas naturally offset in the QZ if mounted on a structure, as is the case with satellite antennas.

When testing electrically large antennas and/or fitted to large platforms, the QZ cross-polar performance is often the reason that a more expensive, complex, compensated dual reflector CATR is chosen rather than a single reflector CATR. This complexity and cost deterrent is why much research has been done on minimizing the QZ cross-polarization of the single reflector CATR. Solutions such as reflector geometry adjustments, other hardware improvements and post-processing techniques have been proposed over the years but the drawback of these techniques have been a hindrance for their widespread use. An overview of such techniques are reported in [2-3].

Recently, the application of conjugated matched feeds providing cross-polar reduction has been presented [5-10]. The concept provide cancellation of the GO cross-polar component induced by an offset reflector system. Solutions based on multi-mode horns have been presented for space applications [5-8]. Although very elegant techniques, the drawback is that the cross-polar compensation is possible only for one polarization and the reported bandwidths are limited. A different concept of conjugated matched feeding, overcoming the dual polarization and partially the bandwidth limitations, has been introduced in [9-10] based on a patch array feed system. However, this implementation is aimed at applications with different beam-width in the principle planes.

In [2-3], we proposed a novel conjugate matched feed specifically suited for CATR applications as shown in Fig. 1. It consists of a 3-element array of wideband dual linearly polarized horns with integrated feeding network: a central corrugated horn, which produces high co-polarization purity illumination of the reflector, such as a standard CATR feed, and two cross-polarized side-elements, creating the conjugate field matching taking advantage of the array characteristics.

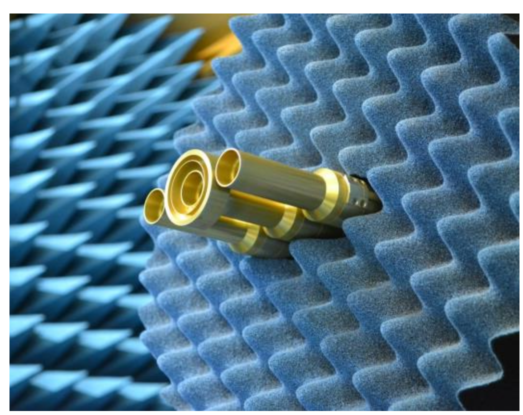

Fig. 1. Conjugate matched feed providing cross-pola1.6:1 bandwidth in dual linear polarisation.

II. PERFORMANCE INVESTIGATION

The conjugate matched feed can be simulated using full wave simulation tools [11]. The corresponding CATR QZ performance can then be determined using Physical Optics techniques on the reflector. Following this procedure, the simulated and measured performances has been shown to be in good correlation, confirming the accuracy of the numerical approach [2-3].

Simulations on different side and corner-fed CATR optics have been performed using the conjugate matched feed shown in Fig. 1. The feed covers 10-16GHz and is based on a compact waveguide orthomode junction [12]. It can easily be adapted for each CATR optics configuration. A simulated example of CATR, QZ cross polarization distribution of the conjugate matched feed compared to a traditional feed is shown in Fig. 2.

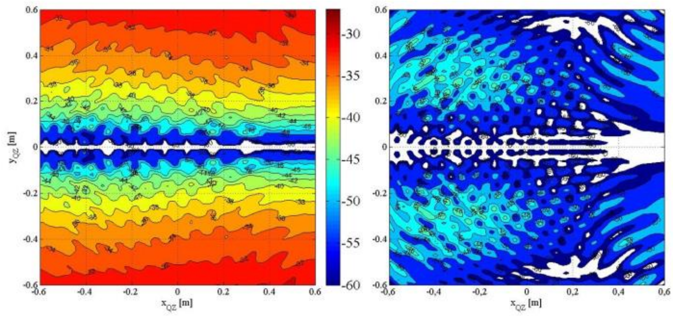

Fig. 2. Contour plots of simulated QZ cross-polarization at 13.0 GHz normalized to co-polar peak (horizontal polarisation). CATR geometry, side-fed, F/D≈3, 1.7m x 1.7m reflector dimension and serrated edges. Standard CATR feed (Left), proposed conjugate matched feed (Right).

The QZ compensation performance over frequency can be evaluated as maximum and mean value of the cross-polar amplitude field in the QZ window normalized to the co-polar peak. The significant improvement in the full 1.6:1 band of the proposed feed is achieved at the same level for both the polarizations and it is evident, when compared to the performance of the traditional CATR feed, as shown in Fig 3.

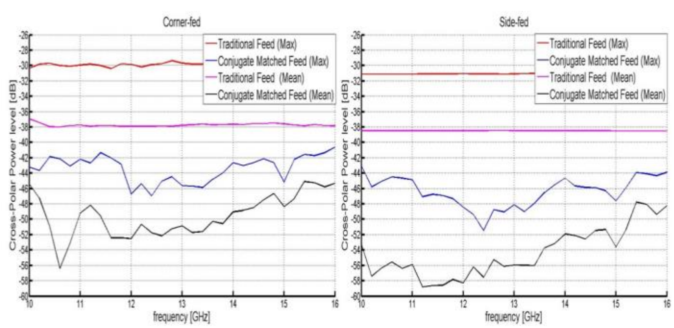

Fig. 3. Maximum and mean QZ cross-polarization normalized to co-polar peak as function of frequency (horizontal polarisation). Proposed feed vs traditional feed. CATR geometry, F/D≈3, 1.7m x 1.7m reflector dimension and serrated edges: Corner-fed (Left), Side-fed (Right).

III. COMMENTS, CONCLUSIONS AND NEXT STEPS

The side-fed CATR geometry seems to have slightly better performance than the corresponding corner-fed geometry when comparing the means and max QZ cross polarisation level. This is due to lower primary cross-polar component from the conjugate matched feed when adapted for side-fed optics.

The development of the conjugate-matched feed concept is a significant breakthrough for CATR systems as it extends their measurement capabilities way beyond the traditional polarisation limitations at the limited cost of a new feed.

In this paper, we have show by numerical simulation, that the cross-polar discrimination of the QZ can be improved by as much as 10dB with respect to standard feeds on a 1.6:1 bandwidth for dual liner polarization in standard side and edge-feed single reflector CATR. A prototype of the proposed conjugate matched feed has been manufactured. Next step include measured validation in side and edge feed CATR.

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