Detection and Suppression of Scattered Fields from Coplanar Micro-Probe and Positioner in Millimeter Wave On-Chip Antenna Measurements

L.J. Foged1, L. Scialacqua1, P. Iversen2, E. Szpindor2
1Microwave Vision Italy, Pomezia, Italy
2ORBIT/FR, Inc., Horsham, PA, USA

Abstract – **The inverse source technique is an accurate post processing and diagnostics method for antenna measurements [1-3]. Indeed, this technique has proven useful to suppress and filter disturbances in measurement scenarios such as presence of the feeding cable and mounting support [4-6]. Performing accurate measurements of on-chip antennas at millimeter wave frequencies is difficult in particular due to the nature of the electrical interface and the physical size of the antennas. The measurements are performed with electrically large probing and positioning equipment, causing interference with the measurement [7]. In this paper, we use the filtering properties of the inverse source technique to quantify and suppress the undesired scattering of the fields in the probing and support structure. To the knowledge of the authors, the filtering of such electrically large scattering objects has never been reported at millimeter wave frequencies. The effectiveness of the approach is demonstrated by measurements on a 60GHz patch antenna with integrated EBG structures.**

***Index Terms* — Measurement, Millimeter wave measurements, Filtering, On- chip.**

1. Introduction

Recent growth of WiGig standard alliance to achieve gigabit data rates has increased the development activity of on-chip antennas at millimeter wave frequencies. In particular on-chip antennas based on silicon technologies at 60GHz [8]. Measurement systems for testing such antennas require a coplanar micro-probe to ensure the connection to the Antenna Under Test (AUT). The micro-probe is attached to a probe positioner that is maneuvered into position to land it on-the chip to ensure connection during test, as is shown in Fig 1.

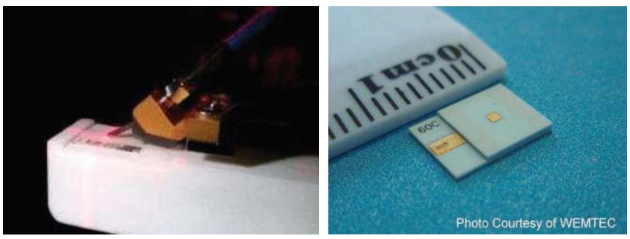

Fig 1. Chuck holder and landed air coplanar probe (ACP) (left); 60GHz LTCC patch antenna with integrated EBG structures as AUT (right).

In the conception of on-chip antennas, part of the design effort is to reduce currents on the chip substrate. This serves to minimize interaction with both the measurement setup during verification measurements and with the surrounding components in the final packaging [7]. Despite design optimization, some residual currents and reflections still cause interference with the AUT in the test scenario. In this paper, we examine how such effects can be diagnosed and suppressed by post-processing the measured data with the inverse source technique.

2. Equivalent currents diagnostics and filtering

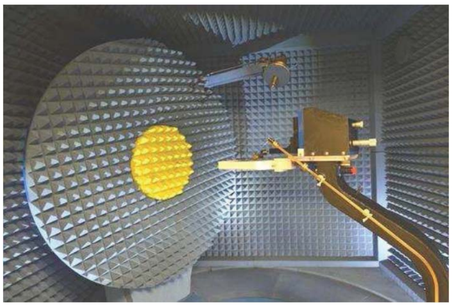

Fig 2. Orbit/FR μLab on-chip measurement setup.

The 60GHz on-chip LTCC patch antenna has been measured in the Orbit/FR μLab measurement system in Fig 2 using conventional spherical Near Field techniques [9]. Equivalent sources on a conformal geometry has been determined by INSIGHT processing of the measured data [6]. The conformal geometry represents the AUT, micro-probe and probe positioner as shown in Fig 3.

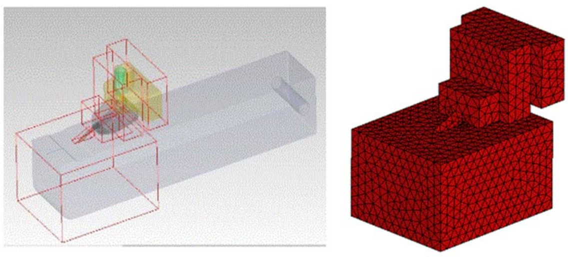

Fig 3. AUT and the measurement set-up, overlaid with the reconstruction geometry (left); meshed geometry of reconstruction (right).

Copyright ©2016 by IEICE

The measurement scenario consists of the probe, part of both the dielectric chuck and the probe support. The reconstruction surface represents these objects to detect all details needed for accurate diagnostics. For the calculation, the geometry is discretized as a triangular mesh of step 0.25λ. The computed electric and magnetic currents on the defined equivalent surface are shown in Fig. 4.

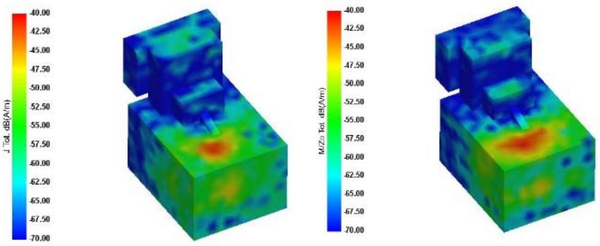

Fig 4. Amplitude of J (left) and M (right) equivalent currents reconstructed at 60GHz with 30dB dynamic scale.

As expected, the currents associated with the AUT as the intended radiator, is the "hot" portion of the equivalent sources. However, equivalent currents at 15dB below peak levels on the probe positioner is an indication of the weak interaction with the AUT. This interaction can be removed from the measured antenna pattern by spatial filtering of the currents in which the far field pattern is calculated only from the currents associated to the antennas as shown in Fig. 5 [2].

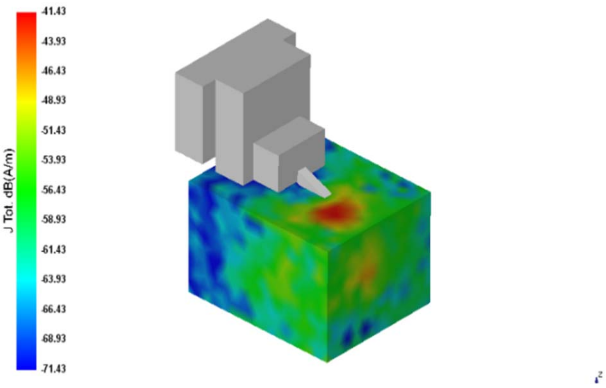

Fig 5. Spatial filtering of the antenna support structure. Amplitude of J electric currents on 30dB dynamic scale.

The measured and simulated far field pattern of the LTCC on-chip patch antenna are reported in Fig. 6. By comparing, the measured pattern with and without filtering it is clear that ripple with a high spatial frequency has been eliminated by the equivalent source filtering. As expected, this ripple is likely attributed to weak interaction with the measurement setup. However, a lower spatial frequency ripple is still present in the measured pattern when comparing to the expected pattern from numerical simulation [7]. The source of this is very close to the antennas so likely to be some residual currents on the chip substrate that could be eliminated by further design optimization.

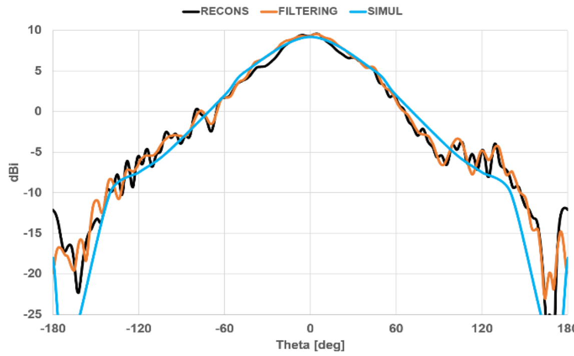

Fig 6. Directivity pattern, H-plane comparison at 60GHz. Numerical simulation (SIMUL), Measurement (RECONS), Meas. with equivalent current filtering (FILTERING).

3. Conclusion

The interaction between the AUT and the measurement setup in an on- chip antenna measurement of an LTCC patch in an Orbit/FR µLab has been investigated by the inverse source technique. Thanks to the spatial filtering capabilities of this measurement post-processing technique, the coupling between the antenna and measurement set-up has been quantified and attenuated.

Acknowledgment

The authors would like to thank William E. McKinzie III for designing the 60GHz patch antenna in LTCC with integrated EBG structure used as AUT in this study.

References

[1] J. L. Araque Quijano, G. Vecchi, "Improved accuracy source reconstruction on arbitrary 3-D surfaces. Antennas and Wireless Propagation Letters, IEEE, 8:1046-1049, 2009.

[2] J. L. A. Quijano, G. Vecchi, L. Li, M. Sabbadini, L. Scialacqua, B. Bencivenga, F. Mioc, L. J. Foged, "3D spatial filtering applications in spherical near field antenna measurements", AMTA 2010 Symposium, October, Atlanta, Georgia, USA.

[3] L. Scialacqua, F. Saccardi, L. J. Foged, J. L. Araque Quijano, G. Vecchi, M. Sabbadini, "Practical Application of the Equivalent Source Method as an Antenna Diagnostics Tool", AMTA Symposium, October 2011, Englewood, Colorado, USA.

[4] J. L. Araque Quijano, L. Scialacqua, J. Zackrisson, L. J. Foged, M. Sabbadini, G. Vecchi "Suppression of undesired radiated fields based on equivalent currents reconstruction from measured data", IEEE Antenna and wireless propagation letters, 2011, p314-317.

[5] L. J. Foged, L. Scialacqua, F. Saccardi, J. L. Araque Quijano, G. Vecchi, Paul Duxbury" Advanced Cross Polar Source Diagnostics based on the Equivalent Currents Reconstruction from Measured Data", LAPC 2015 , November 2015, Loughborough, UK.

[6] http://www.mvgworld.com/products/field_product_family/antenna-measurement-2/insight

[7] Edmund C. Lee, Edward Szpindor, William E. McKinzie III, "Mitigating Effects of Interference in On-Chip Antenna Measurements", AMTA Symposium, October 2015, Atlanta, Georgia, USA.

[8] A. Bisognin, D. Titz, F. Ferrero, G. Jacquemod, R. Pilard, F. Gianesello, D. Gloria, C.Laporte, H. Ezzeddine, D.Lugara, C. Luxey, "Probe-fed measurement system for F-band antennas", Antennas and Propagation (EuCAP), 8th European Conference, pp. 722-726, 2014.

[9] IEEE Recommended Practice for Near-Field Antenna Measurements," in *IEEE Std 1720-2012*.