On-wafer determination of impedance of planar 100 GHz double slot antenna

Published in:
Electronics Letters

DOI:
10.1049/el:19990892

Published: 01/01/1999

Document Version
Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

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In this Letter, we present an on-wafer measurement technique for determining the impedance of a 100GHz planar double slot antenna structure with a dielectric lens at the point where a bolometric detector is inserted into the receiver. This methodology was developed to enable an independent scale model determination of the driving point impedance of a 50GHz planar antenna/dielectric lens receiver for which the optimisation had been performed theoretically [1].

Device geometry and fabrication: The planar antenna/dielectric lens receiver shown schematically in Fig. 1 comprises a double slot antenna coupled to a centrally positioned bolometer via lengths of coplanar waveguide (CPW) transmission line. The DC signal from the bolometer is sensed via the RF choke structures, designed to ensure maximum coupling onto the CPW line feeding the bolometer. The double slot topology allows the length of the slot elements and their separation to be independently varied to adjust the H- and E-plane radiation patterns, respectively. In this way, a near rotationally symmetric radiation pattern can be realised. The slot separation also determines the length of the CPW lines feeding the bolometer from the slots and so affects the matching between the antenna and the detector.

A photograph of the 100GHz on-wafer probable scale model structure is shown in Fig. 2. This structure is equivalent to an 'unfolded' version of the scale model shown in Fig. 1. By measuring the two-port S-parameters of the scale model structure and then de-embedding the CPW lines feeding from the on-wafer probes to the antenna slots, the measurement reference planes can be shifted to a distance a from the slots (equivalent to the position of the bolometer in the full antenna structure). The de-embedded S-parameters can then be transformed to Z-parameters, enabling the impedance at the bolometer position to be determined from

\[ Z_{\text{bolometer}} = Z_{11} + Z_{22} - Z_{12} - Z_{21} \]

The structures fabricated for this study including on-wafer probable network analyser calibration standards were produced using a combination of an electron beam, and optical lithography on a 500μm thick high resistivity (30kΩcm) silicon wafer coated with 200nm thermally grown SiO₂. The groundplane and CPW metallisation comprised 30nm NiCr and 400nm Au. Airbridges were used in the CPW feeds to suppress slotline modes.

Measurement details and results: During on-wafer measurement, performed with an Anritsu 360B 67-110GHz network analyser and cascade W-band on-wafer probes, the sample was placed on an extended hemispherical high-resistivity silicon lens with a diameter...
of 20mm. The extension length of the lens was 3.35mm. The combined sample and silicon lens assembly was held in a perspex housing 50mm above the metal chuck of the on-wafer probe system which was covered with a sheet of Eccosorb to minimise unwanted reflections back onto the antenna.

![Image](image_url)

Fig. 2 Photograph of test structure for determining antenna impedance

Wideband single layer microstrip antenna for array applications

M. Clenet and L. Shafai

A wideband single layer microstrip antenna, fed by two different networks, is presented. A bandwidth of ~15% for SWR < 2 is obtained. As its dimensions are the same as those of a conventional 2 × 2 sub-array, this radiating element can be used in array configuration.

Introduction: Microstrip antennas have been used for two decades in many applications in millimetre and microwave systems because of their thin profile, light weight, low cost and capability of being integrated in active devices. However, they suffer from a narrow bandwidth behaviour, due to their resonant nature. Different techniques have been developed to increase their bandwidth, all based on the addition of another resonator. Examples include coupled coplanar patches [1], stacked patches [2], resonant slot inserted in the main patch [3], or a combination of these techniques [4]. As most applications require high gain, we propose a wideband microstrip antenna element, which can be used in array configuration. To avoid increasing the complexity of fabrication, the proximity coupling technique is used to achieve a wide bandwidth. Two feeding networks are studied. One uses quarter wavelength transformers, while the second is designed to avoid width discontinuities, to reduce their undesirable radiation. Results from simulation and measurement, for the impedance bandwidth, are presented.

Antenna geometry: The geometries of the sub-arrays are shown in Fig. 1. They are realised in the C-band on a dielectric substrate of permittivity 2.5 and thickness 3.2mm. The lengths of the excited resonators and the parasitic elements are slightly different to obtain the wide bandwidth behaviour. The air gap between them is optimised for maximum impedance bandwidth. The distance between the horizontal resonators corresponds to a 0.8λ0 inter-element spacing. Two feeding network have been considered. In the first configuration (Fig. 1a), a quarter wavelength transformer (QWT) is added to match the single patch to 100Ω. It is bent at 45° in order to reduce the width of the corporated feeding network, which must be confined between the patches. In the second configuration (Fig. 1b), the feeding network is realised with a 100Ω line. The position of the feedline on the non-radiating edge of the patch is chosen such that the impedance of the antenna element at the input of the 'T' junction is 200Ω. In both cases, the

![Image](image_url)

Fig. 3 Comparison of measured and modelled antenna impedance

(i) Re(Zan)
(ii) Re(Zmeas)
(iii) Im(Zan)
(iv) Im(Zmeas)

To enable a comparison of the experimental and modelled data, the lens antenna geometry on which extensive EM simulations have been performed [1] was modified by adding two CPWs at both slots using standard transmission line techniques. In this way, the modelled impedance of the 100GHz scaled version of the antenna structure was obtained.

Fig. 3 shows a comparison of the real and imaginary parts of the experimentally and theoretically determined driving point impedance of the 100GHz antenna structures evaluated using the methods outlined above. It can be seen that the agreement is good across the complete measurement frequency range. There are small deviations in the absolute impedance and resonant frequency values, which may be due to the degree of de-embedding required in the analysis and the resulting uncertainties arising from reference plane definitions in the on-wafer measurements. Additionally, between the antenna slots, the test structure groundplane configuration is not identical to the simulated structure which may account for a change in the resonant frequency.

Conclusion: In summary, the agreement between the experimental and simulated impedance values is good, suggesting that this measurement strategy can be used in the future for validating planar antenna simulation studies.

Acknowledgments: This work was funded by ESA through Contract number 1165395/ NL/PB, Integrated Antenna Development.

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Electronics Letters Online No: 19990892
DOI: 10.1049/el:19990892

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