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Naeem, U., Fusco, V., Keaveney, M., O'Shea, M., & Breslin, J. (2019). Extremely wideband imaging antenna with unifrom radiation patterns. In *2019 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, APSURSI 2019 - Proceedings* (pp. 853-854). [8888754] (International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting: Proceedings). Institute of Electrical and Electronics Engineers Inc.. <https://doi.org/10.1109/APUSNCURSINRSM.2019.8888754>

Published in:

2019 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, APSURSI 2019 - Proceedings

Document Version:

Peer reviewed version

Queen's University Belfast - Research Portal:

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Extremely Wideband Imaging Antenna with Unifrom Radiation Patterns

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Abstract—The presented work details the design of extremely wideband antenna and balun. The antenna front-end is designed to operate from 10 GHz to 40 GHz with linear polarization. An extremely wideband balun is also designed and integrated to the radiating element. The structure is optimized to achieve uniform radiation patterns for the complete operating frequency band. The simulated and measured results show the feasibility of the structure for wideband imaging applications.

Keywords—wideband; antenna; balun

I. INTRODUCTION

Antenna front-end is the most critical part in wideband imaging systems. Most of the robust and efficient wideband antennas pose two major challenges: (1) they are mostly fed differentially, and (2) they take the form of bulky 3D structure, which makes their integration with the front-end electronics more challenging. The most commonly used antenna for such type of applications is Vivaldi antenna [1], which for its 3D structure may not be suitable for some applications. The cross-polarization ratio in the diagonal plane is also poor for wide angles. Periodic surfaces [2] are also suitable for extremely wideband applications, particularly in radio astronomy, due to their inherent frequency independent property. Integration of these type of structures with front-end electronics is also very challenging.

This paper presents design of a low profile and extremely wideband antenna integrated with wideband balun. The operating frequency for the integrated system is from 10 GHz to 40 GHz. In section II design of the wideband sinuous antenna is presented, section III describes the design of wideband balun. The performance of the antenna along with the balun is presented in section IV.

II. WIDEBAND SINUOUS ANTENNA

The detailed view of the proposed wideband antenna structure is shown in Fig. 1. The feed structure is detailed in the inset. The antenna sits on spacer above stepped ground plane.

Fig. 1. Proposed structure of the four arm sinuous antenna

A two arm sinuous antenna is designed employing the above feeding structure. The antenna is optimized for 208 Ω differential impedance.

III. DESIGN OF WIDEBAND BALUN

A. The wideband blun

An ultra-wideband balun is designed for 10-40 GHz frequency band with Taconic TLY-5 substrate, for which the permittivity is 2.2. and height is 0.254 mm. The design of the balun is adopted from [3]. The structure and simulated response are shown in Fig. 2. Fig. 2c shows good amplitude and phase imbalance responses.

Fig. 2. (a) Balun (b) S Parameters of the balun (c) Amplitude and phase imbalances of the baluns

B. Performance of the Balun in Back-to-Back configuration

The initial balun structure (Fig. 2) is tested with standard SMA connectors in back-to-back configuration. Although the baluns are designed to operate upto 40 GHz the use of SMA connectors will limit the operation upto 18 GHz. The reflection and transmission behaviour of the structure is shown in Fig. 3.

Fig. 3. (a) Fabricated balun in back-to-back configuration (b) transmission and (c) reflection coefficients of the balun

IV. THE INTEGRATED FRONT-END

The wideband sinuous antenna is now integrated with the wideband balun as shown in Fig. 4. The simulated and measured response of the whole structure is shown in Fig. 4d.

Fig. 4. (a)-(c) The proposed integrated antenna, and (d) the return loss of the antenna

Fig. 5. Simulated co-pol radiation patterns for $\phi=0, 45$ and 90 degrees planes

Fig. 6. Measured normalized co-pol radiation patterns for $\phi=0$ degrees plane

The simulated co-polar patterns are shown in Fig. 5 for $\phi=0, 45$ and 90 degrees planes. The integrated antenna was measured in far field anechoic chamber. The measured patterns of the integrated antenna are shown in Fig. 6. The radiation efficiency of the antenna is better than 90 % over the whole frequency of operation. The results above 30 GHz are more noisy as the structure is more lossy at higher frequencies and because of limitations of the measurement setup.

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