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Profiled Horn Antenna with Wideband Capability Targeting Sub-THz Applications

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Abstract: This paper proposes a wideband profiled horn antenna designed using the piecewise biarc Hermite polynomial interpolation and validated experimentally at 55 GHz. The proposed design proves S_{11} and directivity better than −22 dB and 25.5 dB across the entire band and only needs 3 node points if compared with the well-known spline profiled horn antenna. Our design makes use of an increasing radius and hence does not present non-accessible regions from the aperture, allowing its fabrication with electro erosion techniques especially suitable for millimeter and submillimeter wavelengths.

Keywords: electro erosion; Hermite polynomial interpolation; profiled smooth circular waveguide horn; plasma diagnostics; spline profile

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1. Introduction

Horn antennas are widely used for applications such as radio astronomy, satellite, and terrestrial communication, plasma diagnostics, etc. A detailed description of different horn antenna configurations was provided by Olver and Clarricoats [1]. Many researchers have proposed novel horn designs, including Potter horns [2], corrugated horns [3], matched-feed horns [4], dielectric horns [5–7], metamaterial horns [8], etc., with an aim to improve the radiation performance of horn antennas, reducing their size, manufacturing complexity, optimization time, etc. Among various horn antenna options, the corrugated horn antenna is widely used due to several advantages. However, due to a complex mode-converter structure, the radial corrugated horn design becomes challenging especially at millimeter and submillimeter waves [9] and terahertz frequencies [10]. Some of the alternative solutions are axial corrugated horn [11,12], hybrid corrugated horn [13,14], spline profiled horn [9,15], and horn antennas designed using interpolation [16]. All such configurations have their merits and drawbacks in terms of performance, fabrication complexity, cost, computational effort, etc.

This paper describes the design, fabrication, and measurement of a profiled smooth circular waveguide horn antenna. This horn antenna has been designed using biarc Hermite polynomial interpolation with only 3 node points. The simulated results for this horn are compared with a spline profiled horn [9] to achieve the same performance. The horn has been designed for D-band with potential application in the reflectometry system for plasma diagnostics. The reflectometry system has stringent antenna specifications in terms of high directivity, suppressed sidelobes, and Gaussian-like radiation characteristics. More details on antennas for the plasma diagnostics system can be found in [17]. Based on the performance comparison of various D-band profiles, two of the horn profiles are scaled-down to the V-band frequencies for testing reasons. Then, the V-band horns are fabricated, and the radiation performance has been verified and compared with simulations.