A Compact Dielectrically Loaded Quad-ridge Feed Horn for Octave Band Radio Astronomy Application

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***Abstract*—This work presents the design and simulation of an octave band quad-ridge feed horn with a dielectric rod installed in the center of the throat to improve the beamwidth, phase stability, and polarization efficiency, which leads to receiving higher aperture efficiency. The proposed dielectrically loaded quad ridge antenna is designed to meet the next generation Very Large Array (ngVLA) optics. This antenna covers a fractional bandwidth of 66% from 25 to 50 GHz with a return loss better than 20 dB and aperture efficiency higher than 91% over the entire operating frequency range.**

Keywords— feed horn, quad-ridge flared horn, octave-band horn, ngVLA, high-efficiency reflector antenna

I. Introduction

Quad-ridge feed horns are an excellent choice for applications that require a feed horn with equal or greater than 2:1 relative bandwidth. Various quad-ridge feed horns have been designed and proposed over the years. Although they are great candidates for ultra-wideband applications, they suffer from asymmetric beamwidth and lower efficiencies than corrugated feed horns, and that is where the dielectrically loaded quad-ridge antenna steps in for performance improvement.

Recently, octave band feed horns are becoming very popular in the radio astronomy field since they can cover a large continuous bandwidth, consequently reducing the number of feed horns required to cover a large frequency band. For large telescopes like Next Generation very large array with an array of 244 antennas each 18m in diameter, supplemented with a short baseline array of 19 antennas each 6m in diameter dishes covering the frequency range of 1.2 to 116 GHz [1] using octave or multi-octave band systems improve the time and cost-effectiveness by making the maintenance cost in the long term more economical than standard waveguide bandwidth.

This paper proposes a dielectrically loaded quad-ridge feed horn designed for the ngVLA optics; a shaped offset Gregorian reflector optimized to receive a feed with a half angle of 55° and edge taper of 16 dB on the secondary. The primary has a projected aperture of 18 m [1].

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II. Results

This novel design has excellent performance in frequency bandwidth ratio of 2:1 from 25 to 50 GHz:

- Excellent input return loss across the band >20 dB,
- Stable and high phase efficiency,
- High polarization efficiency ,
- Excellent aperture efficiency > 91%,
- Symmetric radiation patterns in E-, H-, and D-planes,

The feed performance makes it a suitable candidate for radio astronomy applications which are seeking high sensitivity. The proposed antenna consists of three main parts, a quad ridge input waveguide, transition from quad-ridge to open space, and a uniquely designed dielectric rod for performance improvements.

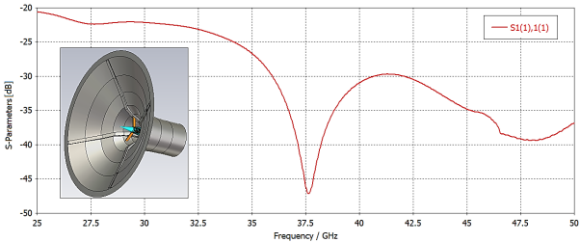

Fig. 1. Feed horn reflection coefficient with a rendering of the horn shown in the inset.

The structure of the compact dielectrically loaded quad-ridge feed horn for the next generation of the ngVLA telescope is shown in Fig. 1. This feed provides a reflection loss of better than 20dB over the band. The ngVLA MTEX optical model is used for the optical analysis using TICRA GRASP. Based on this analysis, the minimum aperture efficiency is 91.3% at 25GHz and the maximum is 96% at 47.5 GHz. The spillover efficiency is better than 93.6% over the entire operating bandwidth.

References

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