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X/X/Ka-BAND HORN DESIGN

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INTRODUCTION

The NASA's Deep Space Network has a need for a multi frequency horn for simultaneous X/X/Ka. band operation in a beam waveguide antenna. The multi frequency horn will receive X-band downlink (8.4-8.5 GHz) and Ka-band downlink (31.8-32.3 GHz), and transmit X-band uplink ("/.145-7.2.35 GHz) signals simultaneously. The horn is designed for circularly polarized wave operation. Low loss (noise) and high power (up to 20 kilowatts) operation are consider-ed in the horn design.

DESIGN

The X/X/Ka-band horn is a common aperture corrugated horn (Figure 1). The three frequencies are input/output to different parts of the common aperture horn. The Ka-band downlink port is at the throat of the horn where the corrugations are shallow. The horn is gradually tapered up to a corrugated straight section which is cutoff for X-band uplink. The X. band downlink is extracted from this straight section.

The X-band downlink input junctions consist of four rectangular- ports intersecting a cylinder. Two ports are located 180 degrees apart in order to cancel out the higher order modes generated at the junction. A second pair of ports, located 90 degrees with respect to the first pair of" ports, are necessary for circular polarization. The X-band downlink ports include a Ka-band choke ring to stop Ka-band leakage and matching irises to reduce the return loss. The. horn is gradually tapered up to a 14-degree half flare angle. The X-band uplink four-port junction is located at a circular wave.guide larger than the corrugated straight section, which is cutoff for X-band uplink. The X-band uplink ports include one Ka-band choke, two X-band downlink chokes and X-band uplink matching irises.

The shallow corrugations support the HE_{11} mode for Ka-band and are electromagnetically nearly invisible to both the X-band downlink and uplink signals, which are predominantly in the TE_{11} mode. Just beyond the X-band uplink injection point there is an X-band mode converter. It is required to convert the X-band uplink and downlink signals from TE_{11} to HE_{11} with low mismatch. In addition, the X-band mode converter must not disturb the established Ka-band HE_{11} mode or cause mismatch. In order to support the HE_{11} mode at these three frequencies, the grooves following the X-band mode converter must be deeper than the preceding grooves which only support the Ka-band HE_{11} mode.

The mode converter consists of a series of stepped grooves. There are two different depths in each stepped groove, a deep step followed by a shallow step. The width of the deep step of these grooves gradually increases to the full width, while the width of the shallow step decreases to zero width (see mode converter section of Figure 1). This provides a matched transition for all three frequencies while retaining the mode characteristic of the Ka-band signal and providing the necessary X-band mode conversion (TE_{11} to HE_{11}). Traditionally the stepped grooves, which are periodic grooves with constant dimensions, were used to support the HE_{11} modes at multiple frequency bands [1]. In this design stepped grooves, with continuous varying dimensions, are used to support the HE_{11} mode at Ka-band, and convert the X band uplink and downlink signals from the TE_{11} to HE_{11} mode,

The analysis is based on the mode matching method [2]. The horn patterns and the return loss are calculated using the circular waveguide mode matching program. The calculated patterns are symmetrical with cross polarization lower than -35 dB at .32, 8.45 and 32 GHz, respectively (Figure 2-4).

CONCLUSION

The analysis of the X/X/Ka band horn shows symmetric radiation patterns with low cross polarization. The prototype of this design has been fabricated. Measurements of the actual performance in all three frequency bands will be completed. The Ka-band downlink port and the X-band down link junction will be in cryogenic package for low noise when the. horn is implemented in NASA's beam waveguide antennas.

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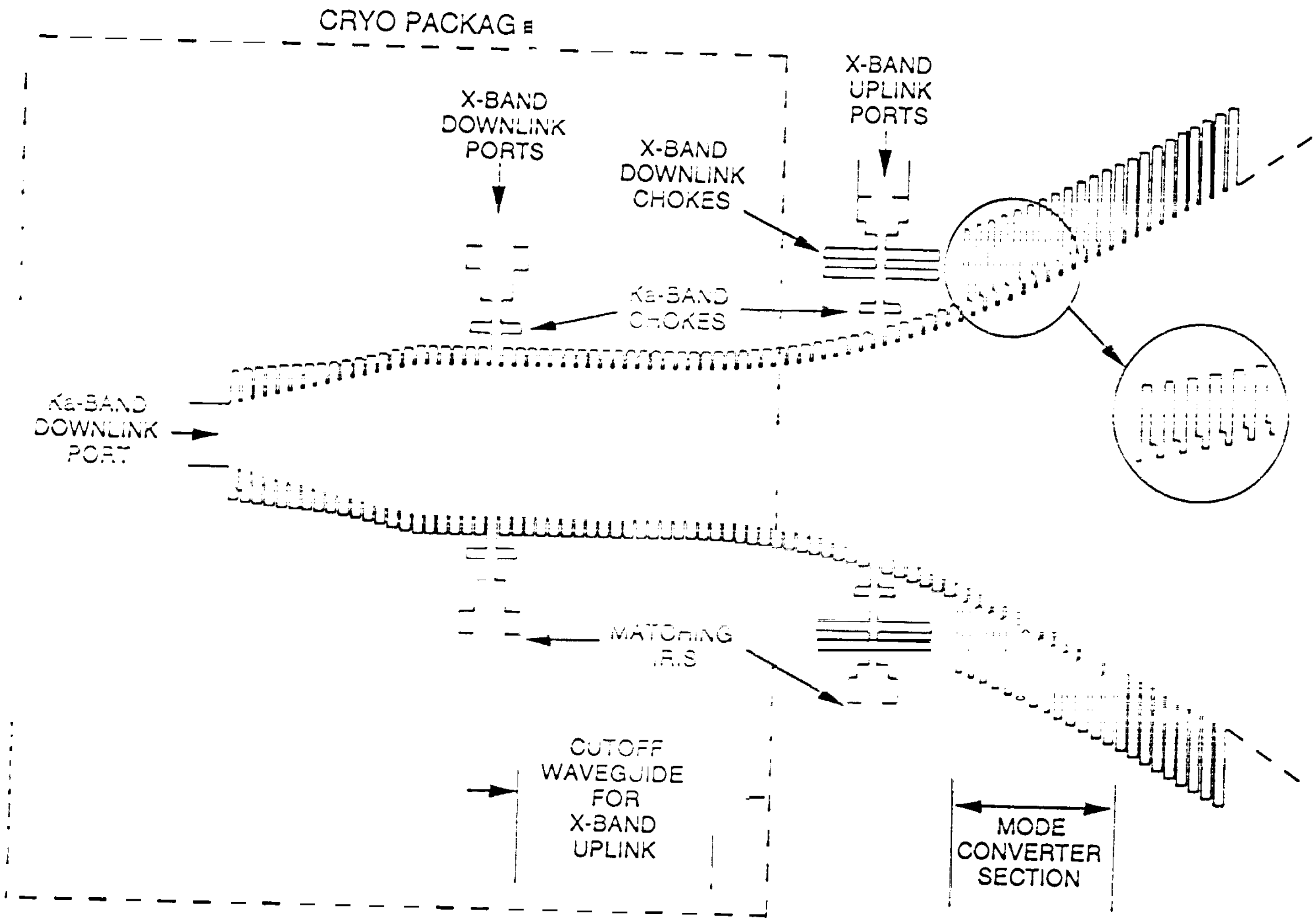

Figure 1. X/X/Ka-band horn geometry

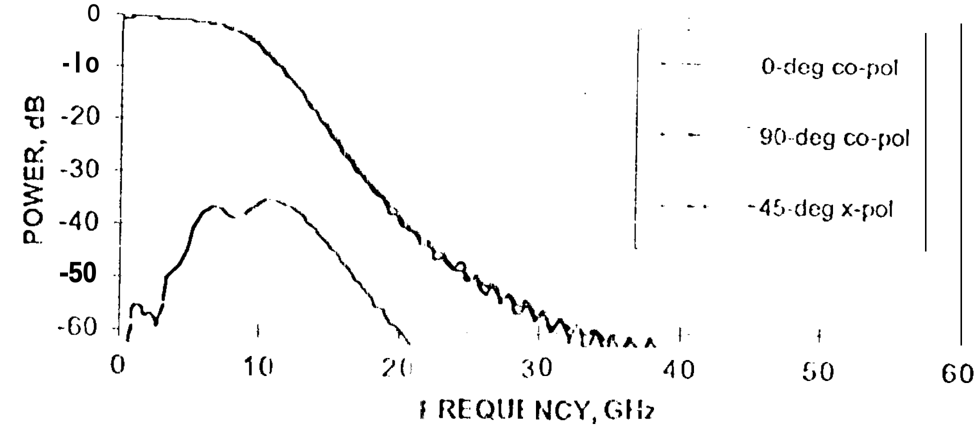

Figure 2. X/X/Ka-band horn radiation pattern at 32.0 GHz

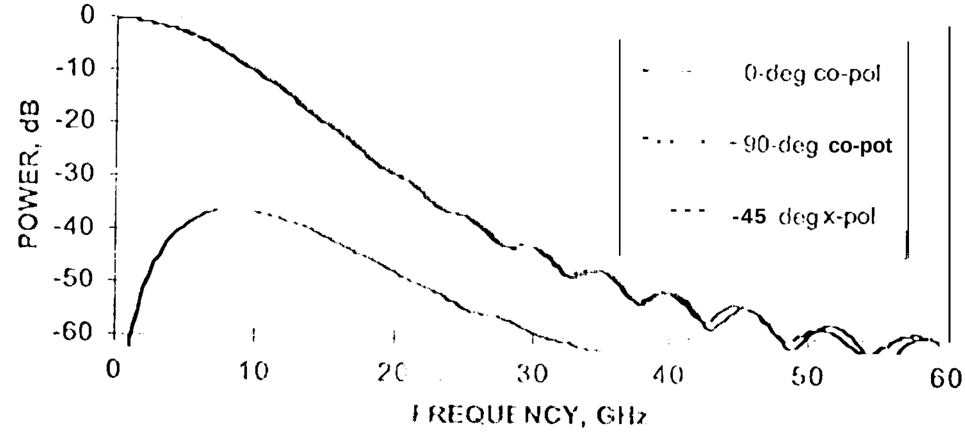

Figure 3. X/X/Ka-band horn radiation pattern at 8.45 GHz

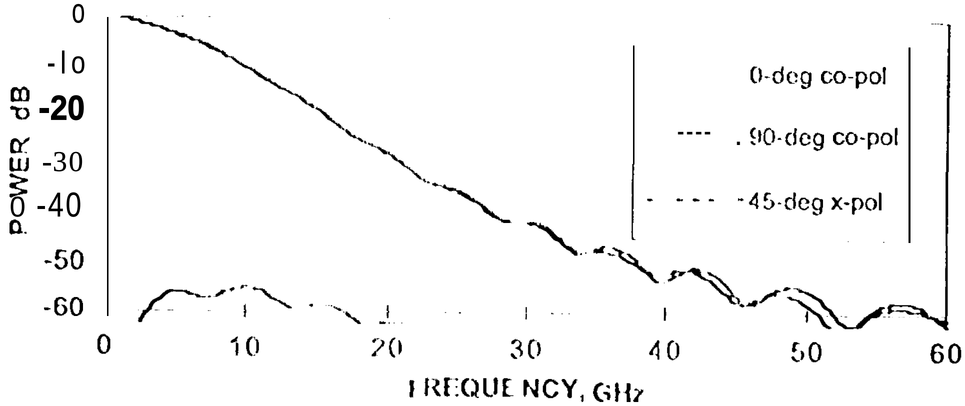

Figure 4. X/X/Ka-band horn radiation pattern at 7.2 GHz