A SIMULTANEOUS S/X/Ka FEED-SYSTEM FOR F/D=0.45 PARABOLIC REFLECTORS

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With the proliferation of small-sat, cubesat, and pico satellites currently being launched or about to be launched in low or medium earth orbit (LEO or MEO), there is a push to have simple antenna systems with good performance. The simplest reflector system is the prime focus parabolic reflector and the most common F/D ratios are somewhere between 0.3 and 0.45 (F: focal distance, D: diameter). There are three main frequency bands commonly cited for the LEO and MEO applications: S-band, X-band and Ka-band.

A procedure to design triaxial horn antennas was presented in [1]. The preliminary design of a simultaneous S/X/Ka triaxial horn was also presented. As in [1], we assume the following sub-bands in circular polarization (CP) (Rx:Receive, Tx:Transmit): S-Tx: 2.025 – 2.12 GHz, S-Rx: 2.2 – 2.3 GHz, X-Rx: 8 – 8.5 GHz and Ka-Rx: 25.5 – 27 GHz. The chosen reflector is a typical 3.7m-diameter, F/D=0.45, prime focus parabolic reflector (subtended angle ±58° from the focus).

However, in [1], only the triaxial horn design was considered and it was assumed that a theoretical pure TE_{11} mode was excited at the various input waveguides (circular, coaxial, triaxial) for all sub-bands for all frequencies. We have now designed the feed networks required in all three sub-bands to finalize this simultaneous S/X/Ka feed-system.

The S-band is extracted from the triaxial waveguide using a set of four probes connected to N-type connectors. An external network in semi-rigid cables will be required to generate the two ports CP ports using two 180deg hybrids and a 90deg hybrid. A commercial coaxial diplexer can then be used to separate S-Tx and S-Rx. This technique has been used previously for the design of simultaneous S/X feed-systems, one example being discussed in [2][3]. From [3], we can see that an axial ratio (AR) of about 1.2 dB can be achieved at S-band.

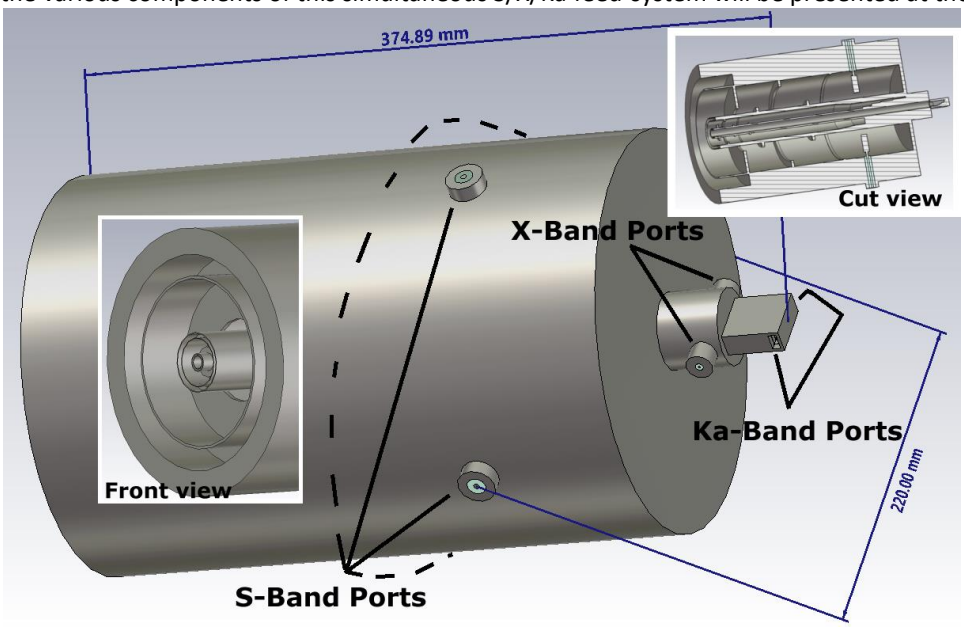
The X-band is extracted from the coaxial waveguide using a coaxial septum polarizer that has two sets of probes connected to SMA connectors, hence providing the required two CP ports at X-band. The AR achieved using the coaxial septum polarizer is better than 1.2 dB. Should a high-performance AR be required, a coaxial OMT with four slots recombined through a -3dB E-plane hybrid coupler would be needed and this could be designed to offer an AR < 0.3 dB.

The Ka-band is extracted from the inner circular waveguide of the triaxial horn, using a circular-to-square transition connected to an optimized square-waveguide septum polarizer. The outputs of the septum polarizer are two WR34 waveguide ports, so we would need to use two commercial WR34-to-coaxial adapters to generate the required two Ka-band ports. The AR is calculated as < 0.1 dB at Ka-band.

The design of the feed-system was done with compactness in mind as it is aimed at being a feed for a prime focus parabolic reflector with an F/D ratio of 0.45, which is a common type of prime focus reflector commercially available.

Note that, at this stage, we have not done a full mechanical design and that the geometry shown below is a CAD from our CST Microwave Studio model. As the design was kept simple, no issues with manufacturability are envisaged.

The design of the various components of this simultaneous S/X/Ka feed-system will be presented at the ASA'2024.



[1] C. Granet, M. Olszewska-Placha, "Optimization of Triaxial Horns: A Simultaneous S/X/Ka Example", 5th Australian Microwave Symposium, Melbourne, Australia, 16-17 February 2023, 2 pages.

[2] C. Granet, J.S. Kot, K.W. Smart, H. D'Costa, R. Shaw, "Theoretical design of a simultaneous S/X feed system for an F/D=0.45 parabolic reflector", Asia Pacific Microwave Conference 2021 (APMC'2021), 28th of November - 1st of December, 2021, Brisbane, Australia, 3 pages.

[3] K.W. Smart, R. Shaw, M. Bourne, M. Death, C. Granet, J.S. Kot, "Manufacture and test of a simultaneous S/X Feed", Asia Pacific Microwave Conference 2021 (APMC'2021), 28th of November - 1st of December, 2021, Brisbane, Australia, 3 pages.