A New Technique for Vernier Pointing of a Beam-Waveguide Antenna

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ABSTRACT

This paper presents a new and simple approach for the Ka-band vernier pointing of a 34m beam-waveguide (BWG) antenna (also applicable to a 70m antenna). In this study, rotation of a BWG flat mirror, located at the elevation axis, is used to scan the beam instead of using the very large tipping structure of the antenna. The rotation of a BWG flat mirror at another location is also investigated. The advantages of scanning the drastically smaller mirror with a less precise mechanism will be discussed. RF performance predictions will be presented.

INTRODUCTION

The NASA Deep Space Network (DSN) is interested in future Ka-band (32 GHz) deep space communications using present and future large ground antennas in the 34- and 70-meter-diameter class. One of the challenges of operating large antennas routinely at high frequency is the achievement of nearly loss-free pointing of the very narrow antenna beam. Further, the DSN generally receives very weak spacecraft signais, and techniques to achieve reliable pointing must avoid virtually any SNR penalty due either to gain reduction or noise increase.

At X-band (8 GHz), the precision vernier pointing can be achieved without significant SNR penalty to the telemetry channel via the use of a conscan technique. This technique nutates the entire tipping portion of the antenna in elevation and cross elevation, intentionally offset about 0.1' dB from perfect pointing (boresight). Nutating with the intentional offset results in a receiver output error signature, in magnitude and "phase." The "phase" is related to the relative amounts of elevation and cross elevation correction required. However, at Ka-band (32 GHz), scanning angles of 0.0016 and 0.0008 degrees are needed for 34m and 70m antennas, respectively. Obviously, it would be very difficult to achieve such a small scanning angle by nutating the very large tipping structure of the antenna, An alternative technique is needed.

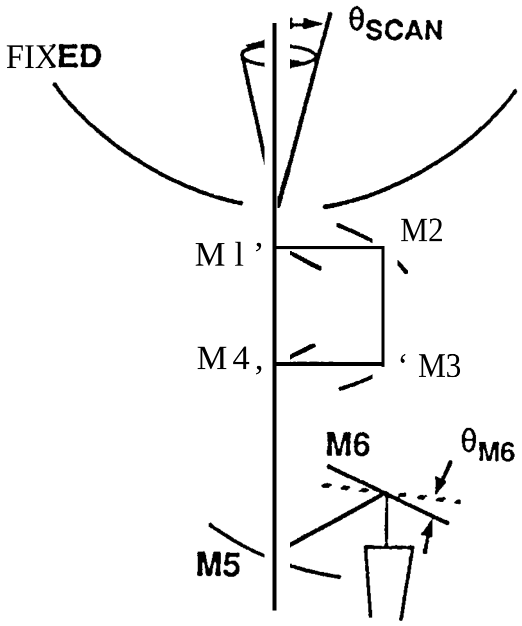
VERNIER POINTING BY ROTATING A FLAT PLATE

A BWG antenna configuration is shown in Figure 1a. Theoretically, any mirror can be used for the vernier pointing. Selection of mirrors depends largely on mirror size, easy access, and available space for modification. In this study, a rotation (or scanning) of a BWG flat mirror located at the elevation axis (see Figure lb) is used to scan the beam. The rotation of a B WG flat mirror located at the basement (M6) is also investigated (see Figure 1a). For a beam scanning at 0.1 dB from the peak gain, a scanning angle radius of 0.0016 degree is needed. The half-power beamwidth (HPBW) of a 34m antenna at 32 GHz is about 0.0167 degree. The required 0.0016 degree scanning angle represents about a tenth of the HPBW. Obviously, it would be very difficult to achieve such a small scanning angle by moving the entire main reflector.

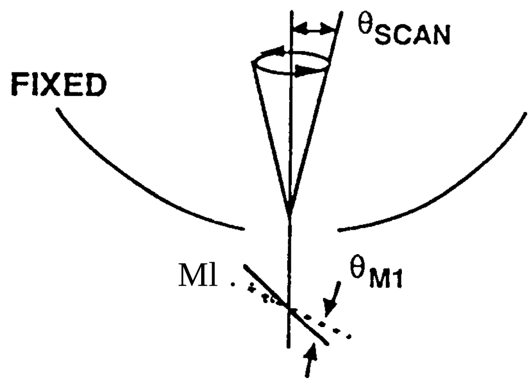
The relationship between flat plate angles of rotation and beam pointing angles is shown in Figure 2 for both Ml and M6 rotations. Results in Figure 2 reveal some interesting points. In order to have beam scanning of 0.0016 degree, the flat plate Ml or M6 has to be rotated about 0.0375 or 0.0760 degree, respectively. It is seen that the flat plate rotation is far less sensitive than the rotation of the tipping structure (0.0375 or 0.0760 degree compares to 0.0016 degree). Also the mirror M6 is less sensitive than the mirror Ml (0.0760 degree compares to 0.0375 degree). Antenna gain loss due to the flat plate rotation is extremely small. For example, for 0.0375-degree rotation, a peak gain loss is about 0.01 dB.

CONCLUSION

The major advantage of this technique is the achievement of vernier pointing or beam conscan without moving a large tipping structure. Not only is a drastically smaller mirror used, but also it is used with a less precise mechanism with practically no gain loss, The potential value of this technique to the DSN or any large antenna design is very high. A mechanical feasibility study is underway.



a. Beam conscanning by M6



b. Beam conscanning by Ml

Figure 1. Geometry of a BWG antenna with beam conscanning by Ml and M6.

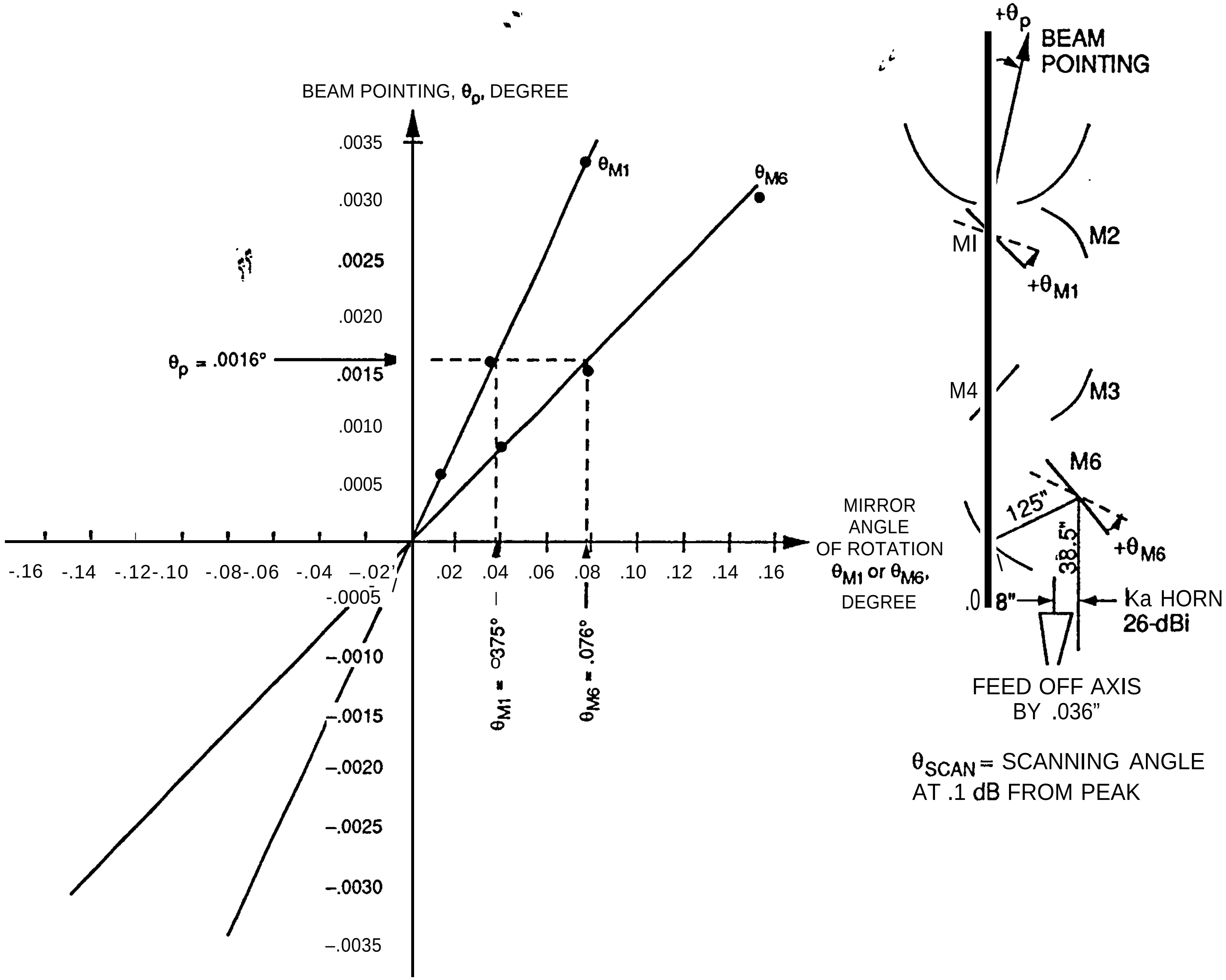


Figure 2. Ka-band vernier pointing of 34-meter BWG antenna by rotating mirror Ml or M6 (feed off-axis).