DESIGN OF CORRUGATED HORN ANTENNAS FOR THE SPACEBORNE RADIOMETER (DREAM) ON STSAT-2

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ABSTRACT:

This paper presents the design of two antennas for the Dual-channel Radiometers for Earth and Atmosphere Monitoring (DREAM) the main payload, will be launched at NARO space center in Korea in 2007. The antennas are designed to meet stringent requirements of a very high beam efficiency, good pattern symmetry, and low VSWR, at 23.8 GHz and 37 GHz bands. Corrugated horn antennas are used. The simulation results of the electrical performance are presented.

KEY WORDS: DREAM, Radiometer, Corrugated horn antenna

1. INTRODUCTION

Space borne microwave radiometers are being employed for remotely sensing the geophysical parameters. Integrated values along the beam of the antenna are retrieved from measurements of brightness temperature. But confusion may occur when the retrieved data is interpreted. For instance, confusion that may occur while deciding whether the data indicate liquid or water vapor. This confusion of interpretation can be reduced by operating radiometers of two different frequencies simultaneously, one more sensitive to water vapor, the other to liquid. DREAM is a two-channel microwave radiometer with the center frequencies of 23.8 and 37 GHz. For accurate interpretation, beam geometry is also important. Data, measured from a region covered with the antenna of 13° 3 dB beamwidth over a band and from a region covered with the antenna of 8° 3 dB beamwidth over another band are inappropriate to be compared and evaluated into information. This means the antenna beamwidths should be the same at the two frequencies. A number of antenna designs were considered for this application. The antenna requirements are listed in Table 2.1, 3.1. It was concluded that with these constraints, the corrugated horn is best choice for the antenna to meet these requirements.

Corrugated horn antennas have two main characteristics compared to horns with smooth walls. First, They exhibit radiation pattern symmetry, and secondly, they radiate with very low cross-polarization. For the purpose of the radiometers which should have circular foot-print, corrug-ated horn antennas are usually used.

For DREAM's operation, one of the two horns will measure the brightness temperature over a 2.52 % bandwidth at 23.8 GHz and the other over a 2.70 % bandwidth centered at 37 GHz.

The following of the paper is divided into 3 parts. Part 2 explains the 23.8 GHz corrugated horn antenna design procedure and the simulation result, Part 3 is about the 37 GHz corrugated horn antenna and the simulation result, and the paper is summarized in Part 4.

2. CIRCULAR CORRUGATED HORN ANTENNA CENTERED AT 23.8 GHZ

The 23.8 GHz antenna requirements for DREAM are listed in Table 2.1.

The design procedure for the horn antenna is as follows. First, Decision of the inner radius dimension of circular waveguide, so to make the field exists inside the horn be mainly TE_{11} mode. But using a standard circular horn for feed is not always an appropriate choice. Since an antenna which consists of a waveguide part (the feed of an antenna) and a flare part, VSWR of an antenna depends on the inner radius of the waveguide. For this reason, simulation of the circular waveguide itself should precede the design of the flare part.

Secondly, decision of aperture size. Maximum available gain for the horn antenna depends on the aperture size. The horn has the aperture of 90 mm diameter. Maximum available gain with this size is about 26 dB [1]. And the gain and the 3 dB beamwidth are decided by adjusting length of the antenna.

Finally, the design of corrugation, according to C. A. Mentzer and L. Peters, Jr. [2], surface current most rapid-

Gain [dB]	25
HPBW (E-plane, H-plane [°])	10, 10
Sidelobe-level [dB]	< -20
Return loss (23.5~24.1GHz [dB])	< -20

Table 2.1. Requirements for 23.8 GHz antenna

Gain [dB]	24.48
HPBW (E-plane, H-plane [°])	10.8, 11.3
Sidelobe-level [dB]	< -31
Return loss (23.5~24.1GHz [dB])	< -25.27

Table 2.2. Simulation results of 23.8 GHz antenna

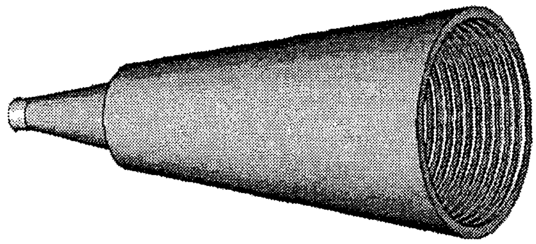


Fig 2.1. 23.8 GHz antenna overview

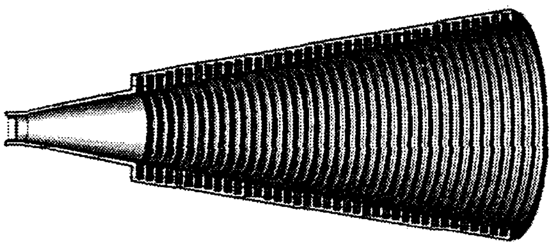


Fig 2.2. Corrugations of 23.8 GHz antenna

ly decays on corrugated surface when the slot depth is $\lambda_c/4$, which means corrugated wall forces the energy away from the wall. James [3] revealed that transition yields lowest return loss when depth is varied from $\lambda_c/2$ at the throat entrance towards $\lambda_c/4$ at the exit. Matching is performed with consideration of decision of first slot position and slot depth-control [4]. Many theories and the references about corrugation can be found in [4]. The antenna has 90 mm diameter, 229 mm length, 1.523 mm ridge length, 3 mm slot length and 38 teeth. The Figures are in Fig 2.1, 2.2.

Table 2.2, Fig 2.3 and 2.4 Show the simulation result using CST MICROWAVE STUDIO.

As shown in Fig 2.1, circular feed is used for the antenna, but it requires standard rectangular waveguide for the connection to the rest of the circuits. A number of methods exist for transforming between a circular waveguide propagating TE_{11} mode and a rectangular waveguide propagating TE_{10} mode. The bandwidth of stepped transition in which the rectangular waveguide is matched to the circular waveguide via one or more intermediate stru-

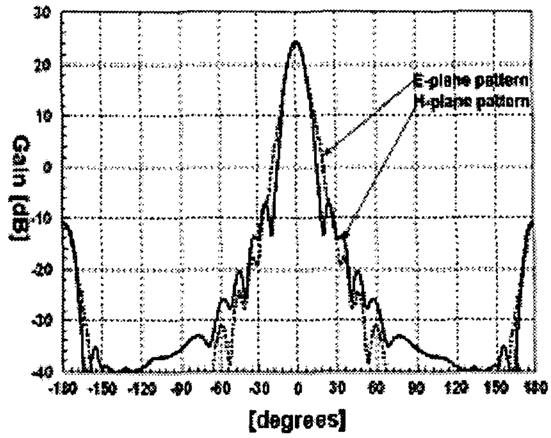
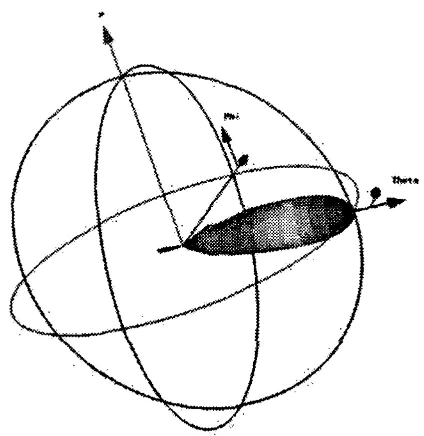
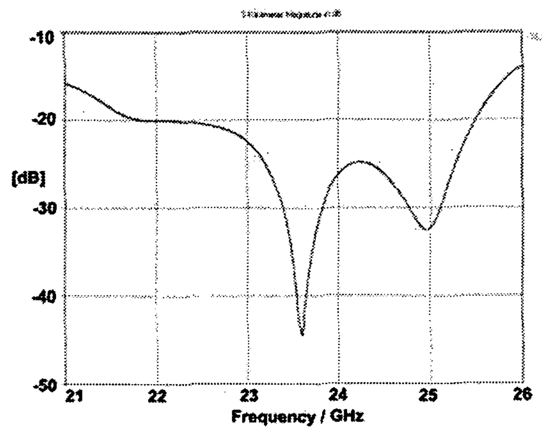


Fig 2.3. Radiation pattern of 23.8 GHz antenna in Simulation

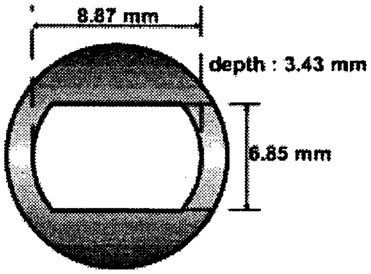


(a)

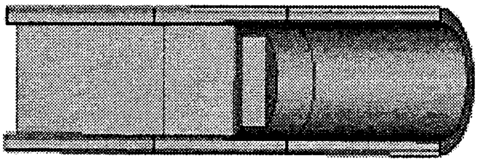


(b)

Fig 2.4. Simulation results of 23.8 GHz antenna (a) 3-D Radiation pattern, (b) Reflection coefficient



(a)



(b)

Fig 2.5. One step circular to rectangular waveguide transition (a) front view of the transition (b) cross-section of the rectangular to circular transition

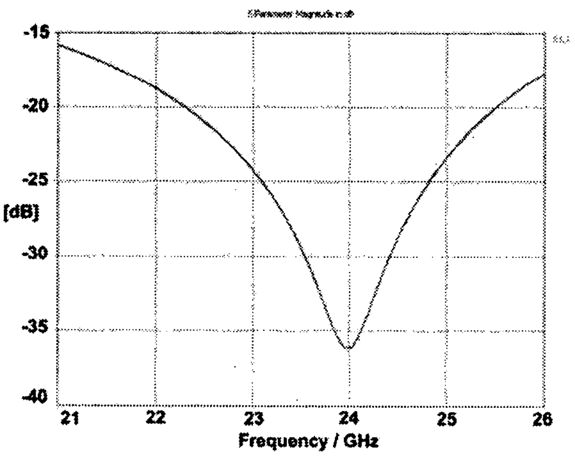


Fig 2.6. Reflection coefficient of the transition

ctures of constant cross section, increases with the number of steps [5]. For our horn, we designed the one-step transition dominant mode circular to rectangular waveguide. The rectangular waveguide is WR-42 and the circular waveguide is WC-44. Front-view of the step transition is shown in Fig 2.5 (a) and the cut-view of the transition portion including the WR-42, WC-44 waveguide is shown in Fig 2.5 (b).

Simulated input match is shown in Fig 2.6. The transition's measured return loss is greater than 20 dB over a 7.3 % centered at 23.8 GHz.

3. RECTANGULAR CORRUGATED HORN ANTENNA CENTERED AT 37 GHZ

The 37 GHz antenna requirements of DREAM are shown in Table 3.1.

Since the volume of DREAM in STSAT-2 is limited, available antenna aperture size is a constraint. For this reason a rectangular type horn is used.

For pyramidal horn antennas, the tangential components of the electric field are vanished in the conductive side walls. The top and bottom walls, however, do not affect the tangential magnetic field. This causes the asymmetry of the E-, H-plane patterns. The effect of the corrugations in the electric wall is to make the magnetic field negligible. As a result the E-plane beamwidth is broadened and sidelobes are suppressed.

The design procedure is quite the same as explained in part 2. The antenna has a aperture of 56.156 mm^2, 237.6 mm length, 0.805 mm ridge length, 2 mm slot length and 82 teeth. The Figures are in Fig 2.1, 2.2.

The simulation results are listed in the Table 3.2 and shown in the Fig 3.3, 3.4.

Gain [dB]	25
HPBW (E-plane, H-plane [°])	10, 10
Sidelobe-level [dB]	< -20
Return loss (36.5~37.5 GHz [dB])	< -20

Table 3.1. Requirements for 37 GHz antenna

Gain [dB]	25.51
HPBW (E-plane, H-plane [°])	9.7, 9.8
Sidelobe-level [dB]	< -22
Return loss (36.5~37.5 GHz [dB])	< -25.86

Table 3.2. Simulation result of 37 GHz antenna

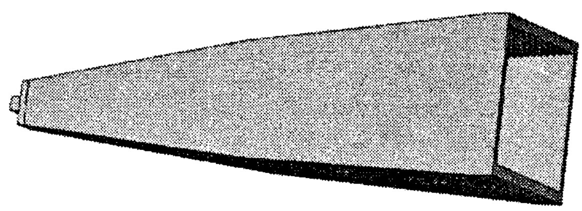


Fig 3.1. 37 GHz Antenna overview

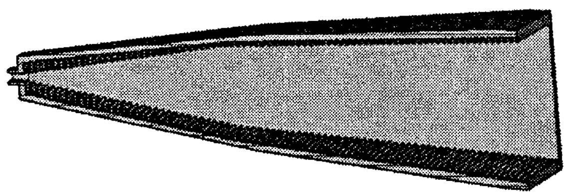
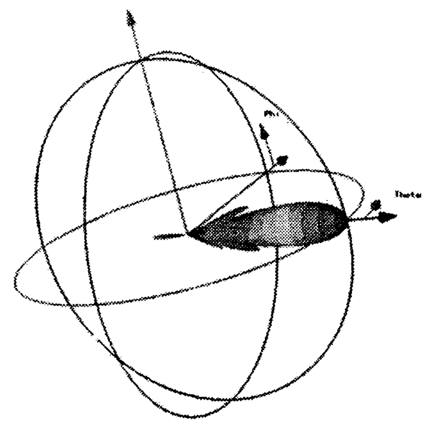


Fig 3.2. Corrugations of 37 GHz antenna



(a)

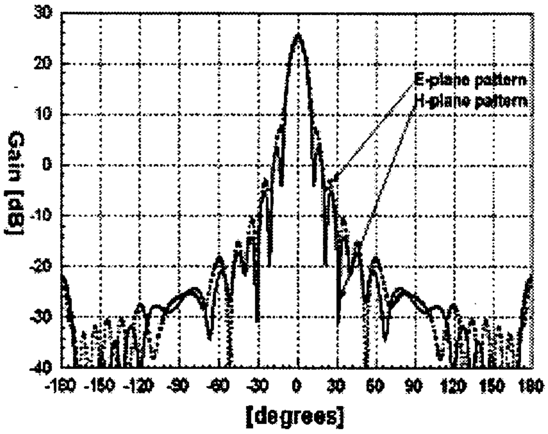
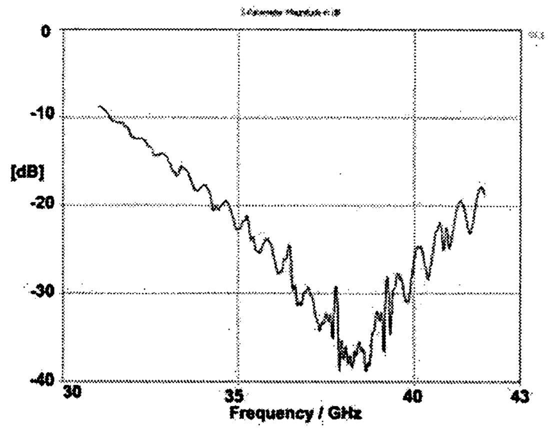


Fig 3.3. Radiation pattern of 37 GHz antenna in simulation



(b)

Fig 3.4. Simulation results of 37 GHz antenna (a) 3-D radiation pattern, (b) reflection coefficient

4. CONCLUSIONS

Two horn antennas of the same beamwidth are designed for DREAM. These antennas are under fabrication work. Circular type centered at 23.8 GHz and rectangular type, centered at 37 GHz are both corrugated in the walls for making axial beam symmetry, low side lobe.

Circular horn has gain of 24.48 dB, 3 dB beamwidth of 10.8, 11.3 for each E-, H-plane, sidelobe-level is lower than -31 dB. Return loss is lower than -25.27 dB over a 23.5~24.1 GHz band. Rectangular horn has gain of 25.51 dB, 3 dB beamwidth of 9.7, 9.8 for each E-, H-plane. Sidelobe-level is lower than -22 dB, and return loss is lower than -25.27 dB over a 36.5~37.5 GHz band.

ACKNOWLDEGEMENT

This work was conducted as a part of the project DREAM which is to develop the main payload radiometer for the Science and Technology Satellite-2 (STSAT-2), and has been supported by the Ministry Of Science & Technology (MOST).

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