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A MULTIBEAM ANTENNA FOR 22 GHz BAND SATELLITE BROADCASTING

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1. INTRODUCTION

The authors have been studying a satellite broadcasting system[1],[2] using K–band frequencies such as 22 GHz. The aim of this study is to meet the demands of future satellite broadcasting and advanced services such as high definition TV (HDTV), digital broadcasting, integrated services digital broadcasting (ISDB), and regional satellite broadcasting. This study and other satellite communications studies have evolved into a project called COMETS[3] (Communications and Broadcasting Engineering Test Satellite), which was authorized by the government and will be launched in 1997.

Communications Research Laboratory (CRL) and Toshiba have developed a breadboard model (BBM) of the 27/22 GHz band multibeam antenna. This paper describes the antenna configuration and the results of the design work and experiments.

2. MULTIBEAM ANTENNA SYSTEM

The authors have proposed a 6–beam DBS service for K–band satellite broadcasting, as shown in Fig.1. This service can be realized by using a Twinned Antenna System (TAS) consisting of two Cassegrain antennas and a new type of primary feed[1],[2]. In this system, twofold frequency reuse has been proposed as indicated in Fig.1, assuming HDTV services which require a 35dB protection ratio in the case of Frequency Modulation (FM).

For the BBM, a multibeam antenna with two beams, one beam each for the Kanto area and the Kyushu area, where the same frequency is used, is developed. The aperture diameter of the Cassegrain antenna is 2.3 meters. An antenna pointing system is required to control the beam direction precisely. The authors have selected an antenna pointing system in which the subreflector is adjusted because of its pointing accuracy and simple drive mechanism. The requirements of the BBM antenna are summarized in Table 1.

3. BBM CONFIGURATION AND EXPERIMENTAL RESULTS

The most important technical point of this antenna is how to synthesize low sidelobe radiation patterns. The authors have achieved this by using a new type of primary feed, which has a large aperture main horn surrounded by several small aperture subhorns. Figure 2 shows the primary feed for the BBM. Each beam has one main horn and four subhorns. In this feed configuration, the main horn is used simultaneously for transmission and reception, two subhorns are used for transmission, and the other two subhorns for reception. The aperture size of these horns is optimized to maintain high main beam gain and to reduce sidelobes.

The excitation amplitude and phase for these horns are optimized using the pattern synthesis method[4]. During this optimization, the following requirements are considered:

(1) As high a main beam gain as possible.
(2) Reduced sidelobes where high isolation is required.
(3) Excitation weight optimized for the bandwidth of 500MHz.
(4) Optimum weight to maintain low sidelobe patterns during beam pointing in the range of ±0.15 degrees.

Figure 3 is a block diagram of the beam–forming network for the Kyushu beam. The excitation weight can be set separately for transmission and reception. The beam–forming network is shown in Fig.4. In this system, dual mode horns are used for both main horns and subhorns, and slit–coupled directional couplers are used as power dividers to reduce the size of the beam–forming network. The measured frequency characteristics of the feed excitation for the Kyushu transmission beam are shown in Fig.5. These experimental results indicate that the excitation amplitude and phase were regulated within the set values in the error range of ±0.5dB and ±5.0 degrees. The insertion loss of the beam–forming network was less than 1.5dB at 22.75 GHz.

Figure 6 shows calculated beam patterns and isolation patterns at 22.75 GHz. From these figures, it was verified that the gain and isolation requirements were satisfied.

4. SUMMARY

The breadboard model of a K–band multibeam antenna for future satellite broadcasting has been developed. Its feasibility was verified numerically and experimentally. These results will be reflected in the Engineering Model and the Preliminary Flight Model antenna on the K–band broadcasting mission for COMETS.

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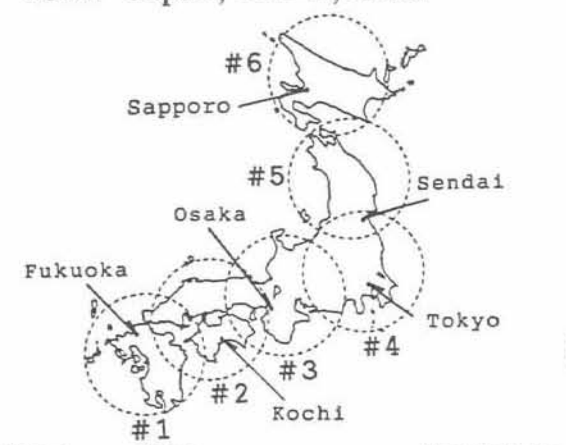

Beam	Name	Frequency
#1	Kyushu Beam	F1
#2	Chugoku Shikoku Beam	F2
#3	Kinki Beam	F3
#4	Kanto Koshinetsu Beam	F1
#5	Tohoku Beam	F2
#6	Hokkaido Beam	F3

Fig.1 Multibeam satellite broadcasting system

Table 1 Requirements of BBM antenna

Frequency	transmission(Tx)	22.5 - 23.0 GHz
	reception (Rx)	27.0 - 27.5 GHz
Antenna gain	Tx & Rx	More than 44 dBi
Isolation	Tx & Rx	More than 35 dB
Polarization		Right-hand circular
Feed network insertion loss		Less than 2.0 dB

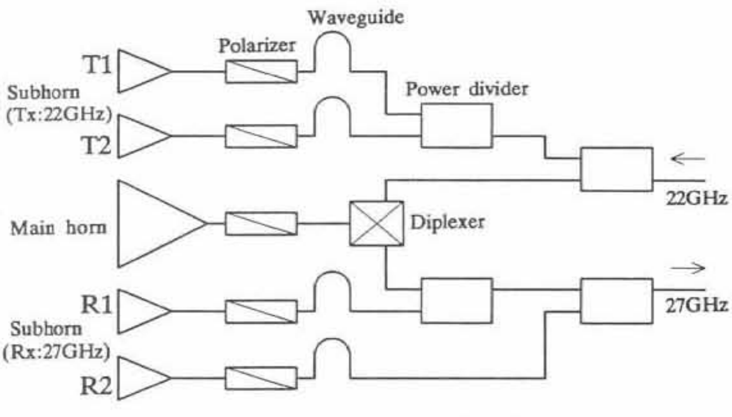

Fig.3 Block diagram of beam–forming network

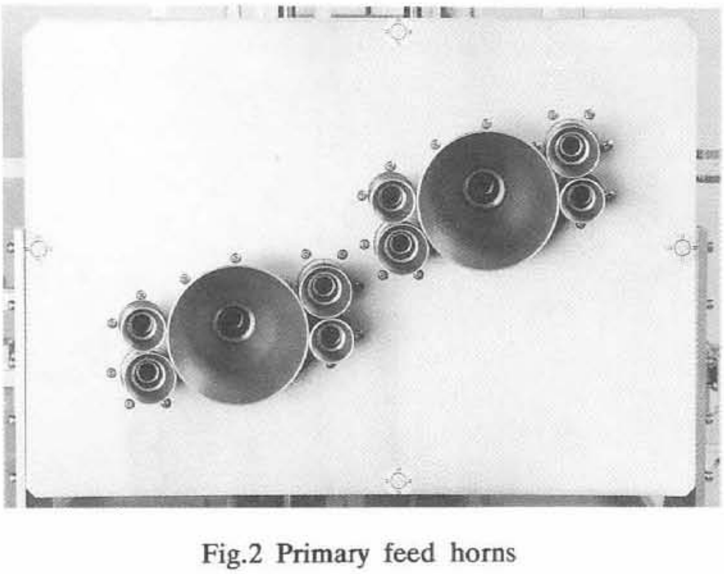

Fig.2 Primary feed horns

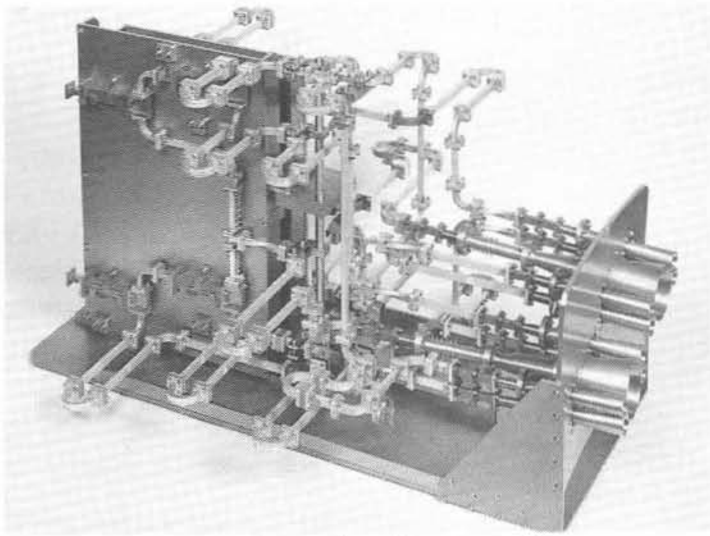

Fig.4 Beam-forming network

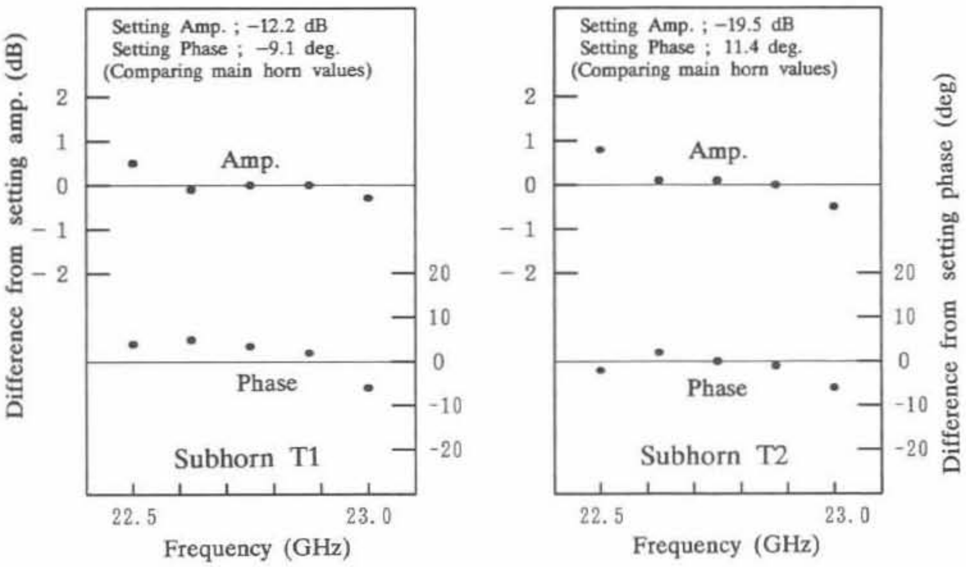

Fig.5 Measured excitation distribution

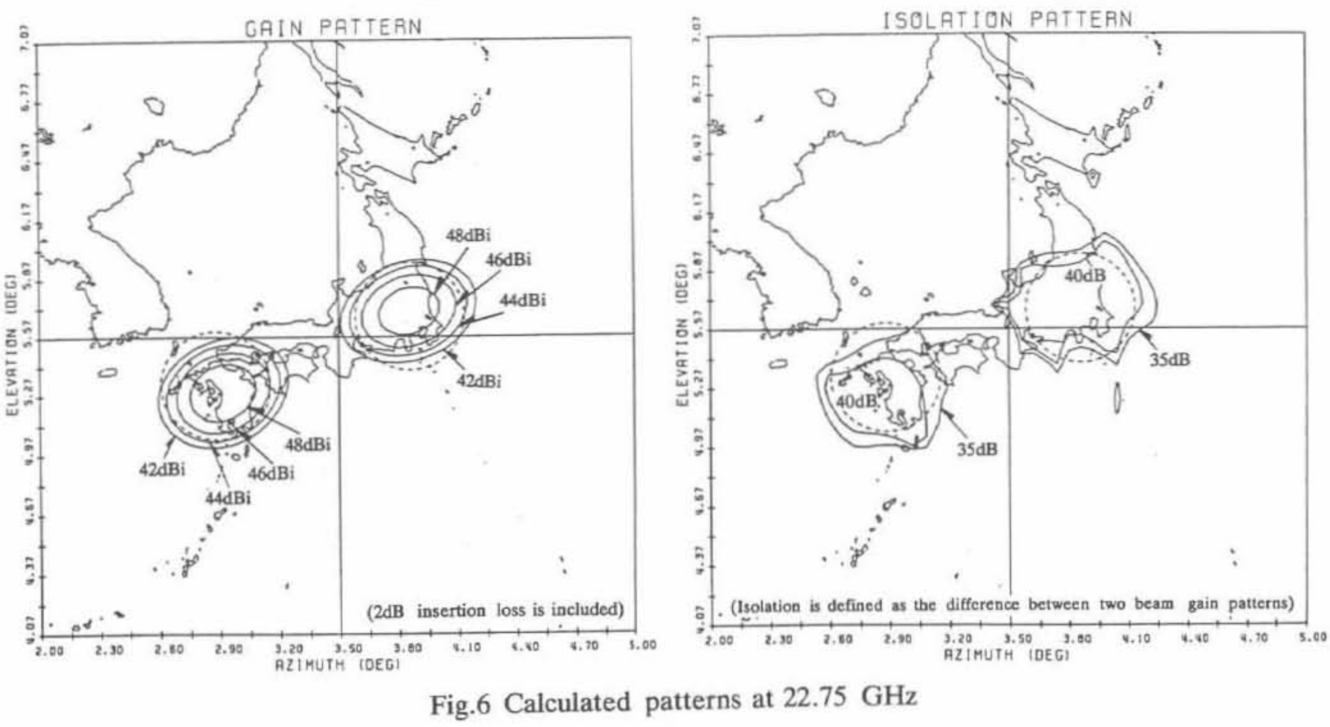

Fig.6 Calculated patterns at 22.75 GHz