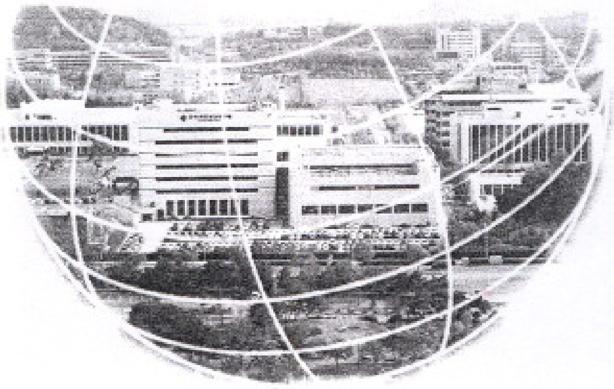
Proceedings of

The 3rd ETRI-CRL Joint Conference



November 5~6, 2002

ETRI, Daejon, Korea

Organized by

Electronics and Telecommunications Research Institute, Korea

Communications Research Laboratory, Japan

The 3rd ETRI-CRL Joint Conference

November 5–6, 2002
ETRI, Daejon, Korea

Program

1st Day, November 05, Tuesday

Opening Session

Chairperson: Seong Pal Lee (ETRI)

09:30 Opening & Welcome Address

Jae Moung Kim (Vice President, ETRI)

09:40 Congratulatory Address

Tadashi Shiomi (Vice President, CRL)

09:50 Break

Session I : Broadband Communications

Chairperson: Soo-Young Kim (ETRI)

10:00 Carrier Frequency and Timing Offset Tracking Scheme for OFDM Systems with Pilot Subcarriers

Heejung Yu, Taehyun Jeon, Myung-Soon Kim, Eun-Young Choi, and Jae-Young Ahn (ETRI)

10:20 Development Status of B-WLL/BMWS System in ETRI

Seung-Hwan Lee, Nam-Il Kim, Eun-Jeong Shin, Seung-Eun Hong and Eung-Bae Kim (ETRI)

10:40 Millimeter-Wave Wireless Access Systems

Hiroyo Ogawa (CRL)

11:00 Introduction of Ultra-Wideband R&D in ETRI

Sangin Cho, Sangsung Choi, Cheolho Shin, Seungsik Lee, and Hyungsoo Lee (ETRI)

Session II : Satellite Communications

Chairperson: Hiroyo Ogawa (CRL)

11:20 BSAN System Implementation based on DVB-RCS

Gwang-Ja Jin, Hoon Jeong, Ho-Jin Lee and Deock-Gil Oh (ETRI)

11:40 Preliminary Flight Tests for Stratospheric Platform Systems

Yoshiya Arakaki, R. Miura, H. Tsuji, M. Oodo, M. Nagatsuka, Y. Hase,
M. Maruyama, Y. Morishita, M. Suzuki, and Y. Nishi (CRL)

12:00 Lunch

ETRI Restaurant

13:30 Ku/Ka band Feed Assembly for the CBS Antenna Subsystem

Sohyeun Yun, Jeomhun Lee, Yeongcheol Kim, Jae-Hung Han,
Jongheung Park and Seongpal Lee (ETRI)

Ku/Ka band Feed Assembly for the CBS Antenna Subsystem

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Abstract

Communications and Broadcasting Satellite (CBS) antenna subsystem has been developed to provide the multimedia services in the Korean peninsula and its subordinates. The CBS antenna subsystem comprises Ku/Ka band antennas, and each antenna consists of reflector and feed assembly.

After ETRI and co-developer, Telwave successfully completed Critical Design Review (CDR), Manufacturing Readiness Review (MRR) and Test Readiness Review (TRR) were held for the production and testing of Engineering Qualified Model (EQM) of CBS antenna subsystem. Initial Functional Performance Test (IFPT) of the EQM Ku/Ka band feed assembly was performed before the environmental exposure. The design, analysis and test results of the Ku/Ka band feed assembly are described in this paper. Upon the completion of IFPT, the environmental test is being currently carried out for the Ku/Ka band feed assembly.

Keywords

satellite, antenna, feed assembly, horn, OMT, polarizer

1. Introduction

To keep pace with the worldwide trends of developing the satellite, and to provide the suddenly increasing demands for multimedia service, Korean government already established the national space development plan to develop the various satellites [1].

Based on the national plan, ETRI has been developing the communication and broadcasting satellite (CBS) payload and its core technologies in order to meet the increasing demand of multimedia services via satellite. At this moment, ETRI completed TRR (Test Readiness Review) at equipment level, and the test of the CBS antenna feed assembly is being carried out.

The CBS Ku/Ka band antenna subsystems are briefly described in Section 2. The analysis and test results of the feed equipment are detailed in Section 3. The IFPT results of the Ku/Ka band feed assembly are presented in Section 4. Finally, the conclusions are presented in Section 5.

2. Ku/Ka band Antenna Subsystem

2.1 Configuration

Ku band antenna subsystem employs deployable single offset reflector geometry and a single feed. The Ku band antenna reflector was designed with a honeycomb structure employing graphite/epoxy composite face skins. The reflector backing structure supports the reflector and will be interfaced to the spacecraft for the FM stage through two antenna deployment mechanisms (ADM). The horn, Orthomode Transducer (OMT) and waveguide runs are assembled into the one feed assembly, and installed through specially devised brackets onto the spacecraft panel. The overall configuration of the Ku band antenna is shown in Figure 1.

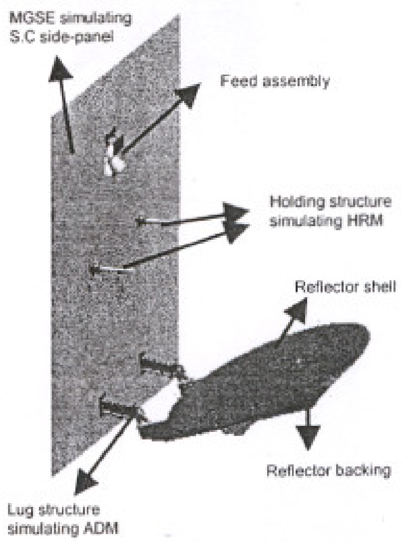


Figure 1. Ku band Antenna Subsystem Configuration

Ka band antenna subsystem has dual reflector gregorian geometry and a single feed as shown in Figure 2. Both main and sub reflectors were designed with the same materials as those of the Ku band. The main and sub reflectors are supported with backing rib structure to ensure the antenna shape stability. The tower panel structure supports the main and sub reflectors, the feed assembly, and the waveguide runs, and interfaces to the spacecraft earth panel through four point fixed mounts. The feed assembly is installed through specially devised brackets onto the tower panel.

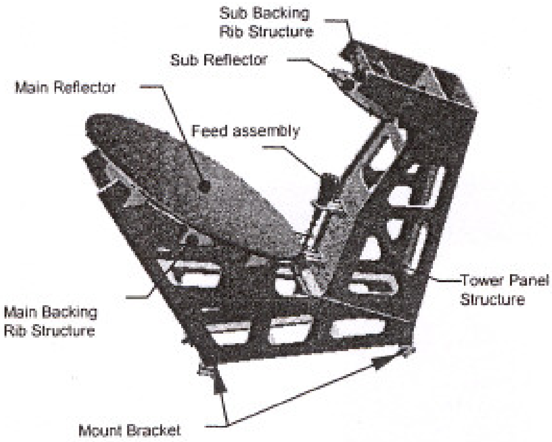


Figure 2. Ka band Antenna Subsystem Configuration

2.2 Requirements

The antennas are bore-sighted to 128°E longitude and 37.75°N geodetic latitude from an equatorial geostationary orbital location of 113°E longitude. The service coverage is circular, 1.2°×1.2° for both transmit and receive, centered the bore-sight defined above. Additionally, ±0.15° pointing uncertainty is considered beyond edge of coverage for determination of antenna specification compliance. The key RF performance requirements are summarized in Table 1.

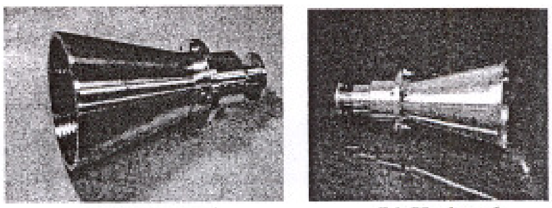
Table 1 RF Performance Requirements

Parameter		Ku band Antenna	Ka band Antenna
Frequency	Tx	12.25-12.75GHz	20.8-21.2GHz
	Rx	14.0-14.5GHz	30.6-31.0GHz
Polarization	Tx	HP	RHCP
	Rx	VP	LHCP
EOC gain (w/ P.E.)	Tx	>37.4dB	>37.9dB
	Rx	>37.5dB	>37.4dB
Sidelobes Level	Tx	<-30dB	<-28dB
	Rx	<-28dB	<-26dB
Cross-pol Discrimina-tion	Tx	>20dB	>18.8dB
	Rx	>20dB	>18.8dB
VSWR	Tx	<1.28:1	<1.28:1
	Rx	<1.28:1	<1.28:1
Gain Slope	Tx	<10.5dB/deg	<12dB/deg
	Rx	<10.5dB/deg	<12dB/deg
Tx/Rx Isolation	Tx	< -35dB	< -40dB

3. Ku/Ka band Feed Equipment

3.1 Ku/Ka band Horn

The Ku/Ka band horns for the CBS antenna subsystem are circular corrugated horns as shown in Figure 3. The corrugations are internal, and the circumferential ridges are machined perpendicular to the horn centerline. The horns were machined from aluminum and had a chromate finish inside.



(a) Ku band (b) Ka band

Figure 3. Circular Corrugated Horn

The horn is corrugated to provide low cross-polarization. The length of the horn was designed to minimize the phase error introduced at the aperture; thus the overall efficiency of the antenna is not degraded due to poor reflector illumination. Design experience has shown that the corrugations are $\lambda/2$ deep near the throat, and taper to $\lambda/4$ deep at the aperture in order to produce an efficient wideband corrugated horn.

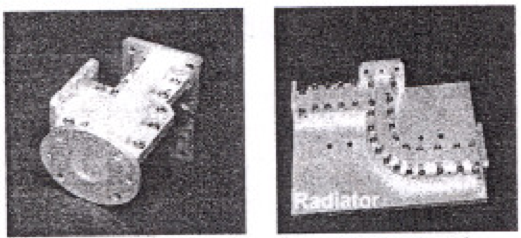
The aperture diameter of the Ku band horn is 110mm and that of the Ka band horn is 70.2mm. The analysis and test results of Ku/Ka band horn are presented in Table 2. The computed and tested results are compliant with requirement, except x-pol discrimination. The x-polarization pattern test is complicated because this test needs the rigorous facility. Although the x-pol discrimination of the horns is non-compliant, the performance of the feed assemblies are satisfied as shown in section 4.

Table 2. Ku/Ka band Horn Performance Summary

Para	Freq		Spec	Compute	Test
Return Loss (dB)	Ku	Tx	>25	>29.4	>28.5
		Rx	>25	>32.9	>30.7
	Ka	Tx	>25	>33.1	>26.6
		Rx	>25	>33.9	>28.1
Sideble Level (dB)	Ku	Tx	<-30	<-32.4	<-31.6
		Rx	<-30	<-31.6	<-31.5
	Ka	Tx	<-25	<-35.1	<-33.9
		Rx	<-25	<-30.4	<-29.9
X-pol Discri.(dB)	Ku	Tx	>35	>36.8	>29.6
		Rx	>35	>38.3	>25.9
	Ka	Tx	>30	>39.1	>31.0
		Rx	>30	>31.4	>27.4

3.2 Ku/Ka band OMT

The OMT combines transmit and receive signals to the antenna port and provides an isolated receive for uplink signals. The Ku/Ka band OMT were designed in taper/branching type with square to rectangular waveguide stepped transformer, without tuning screw as shown in Figure 4. The OMT was machined from aluminum and silver plated inside. The radiator was designed as a part of the Ka band OMT.



(a) Ku band (b) Ka band

Figure 4. Orthomode Transducer

The OMT was based on a longitudinal taper section providing an asymmetrical transition of the common waveguide cross section to the standard waveguide interface of one fundamental mode. The taper was designed a continuous contour function along the longitudinal axis. The location of the branching within the taper section was determined such that the TE01 mode – coupled by the rectangular port – can propagate to the common port, while it becomes evanescent within the branching region, which is directed to the dedicated TE10 mode port. The computed and tested results are summarized in Table 3. All performances are compliant.

Table 3. Ku/Ka band OMT Performance Summary

Para	Freq		Spec.	Compute	Test
Return Loss (dB)	Ku	Tx	>23	>28.2	>27.3
		Rx	>23	>24.8	>23.4
	Ka	Tx	>25	>31.8	>30.4
		Rx	>25	>25.2	>27.5
Inser. Loss (dB)	Ku	Tx	<0.1	<<0.1	<0.05
		Rx	<0.1	<<0.1	<0.09
	Ka	Tx	<0.2	<<0.1	<0.07
		Rx	<0.2	<<0.1	<0.05
Tx/Rx Iso. (dB)	Ku		<-35	<-68.9	<-37.6
	Ka		<-40	<-73.6	<-56.1

3.3 Ka band Polarizer

The polarizer for the CBS antenna consists of 3-dB power splitter, square waveguide iris polarizer and mode transformer as shown in Figure 5. The polarizer was electroformed in copper.

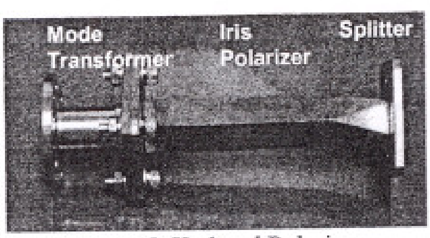


Figure 5. Ka band Polarizer

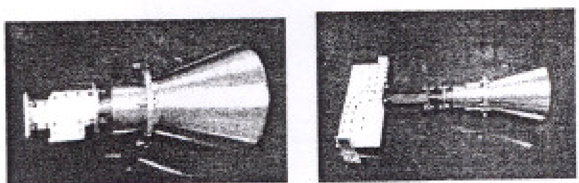
The 3-dB splitter connects the iris polarizer to OMT and combines two linear polarizations from OMT. The phase difference of these two signals becomes 90° and generates the circular polarization through iris polarizer. Mode transformer is square to circular transition that converts two dominant modes of the rectangular waveguide to the dominant mode of the circular waveguide. The computed and tested results are compliant with specification as shown in Table 4.

Table 4. Ka band Polarizer Performance Summary

Para	Freq	Spec.	Compute	Test
Return Loss (dB)	Tx	>25	>27.7	>28.2
	Rx	>25	>28.3	>27.9
Insertion Loss (dB)	Tx	<0.15	<<0.15	<0.06
	Rx	<0.15	<<0.15	<0.08
Axial Ratio (dB)	Tx	<1.0	<0.4	<0.6
	Rx	<1.0	<0.2	<0.7

4. Test result of Ku/Ka band Feed Assembly

The Ku band feed assembly mainly consists of a horn and an OMT, while the Ka band feed assembly comprises a horn, a polarizer and an OMT. The feed assembly was carefully assembled with guide pins to align the feed equipment each other.



(a) Ku band (b) Ka band

Figure 6 Feed Assemblies

The radiation patterns of the Ku and Ka band feed assemblies were measured in the Near Field Range (NFR) at ETRI. The return loss and isolation were measured by using HP8510C Vector Network Analyzer (VNA).

The tested radiation patterns over Ku band are presented in Figures 7 and 8. The radiation patterns in the two principle planes are similar and the maximum x-pol discrimination of linear polarization appears in 45°-cut plane.

For the Ka band feed assembly, the radiation patterns in the two principle planes are similar and maximum x-pol discrimination of circular polarization also appears in principle planes. The tested radiation patterns are presented in Figures 9 and 10 over Tx and Rx bands, respectively.

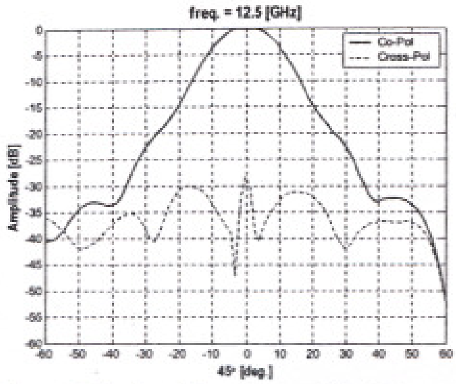


Figure 7. Ku band Feed Assembly Tx Pattern

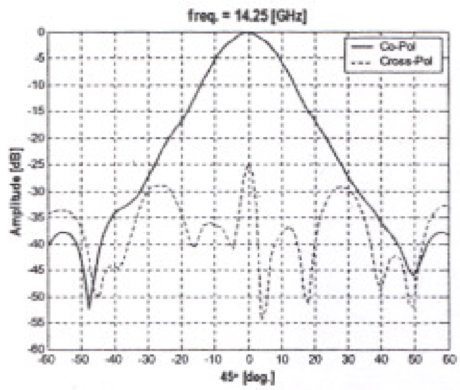


Figure 8. Ku band Feed Assembly Rx Pattern

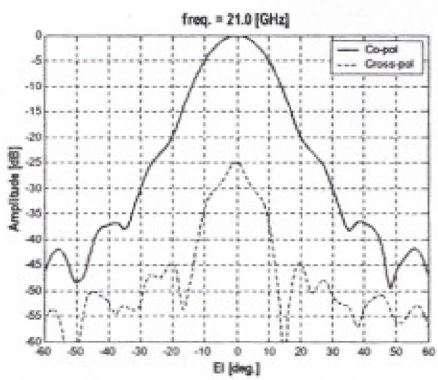


Figure 9. Ka band Feed Assembly Tx Pattern

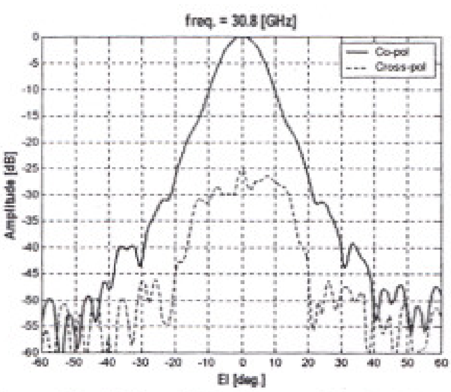


Figure 10. Ka band Feed Assembly Rx Pattern

All RF performances under test are satisfied with respect to the specification as summarized in Table 5.

Table 5. Ku/Ka band Feed Assembly Test Results

Para	Freq		Spec.	Test
Return Loss (dB)	Ku	Tx	>21	24.6
		Rx	>21	25.9
	Ka	Tx	>21	23.8
		Rx	>21	31.7
Sidelobe Level (dB)	Ku	Tx	<-30	-30.6
		Rx	<-30	-30.8
	Ka	Tx	<-30	-35.0
		Rx	<-30	-38.7
X-pol discrimination (dB)	Ku	Tx	>25	30.1
		Rx	>25	26.6
	Ka	Tx	>23	23.0
		Rx	>23	24.3
Tx/Rx Isolation (dB)	Ku		<-38	-49.5
	Ka		<-43	-45.7

5. Conclusions

This paper briefly shows the configuration and performance requirement of the Ku/Ka band antenna subsystem for the CBS payload system. The test results of the Ku/Ka band feed assembly are also described in detail. The IFPT of feed assembly was performed and will soon be delivered to environmental test site.

In view of the results shown, we conclude that design, analysis and test results of the Ku/Ka band feed assembly well comply with the performance requirements.

References

[1] Seong-Pal Lee, et al, "Payload Technology Development for Domestic Communications and Broadcasting Satellite", The Korea Society of Space Technology, Vol. 10, No 1, pp99-113, May, 2002.

[2] CDR Data Package for Communications and Broadcasting Satellite, ETRI, Apr., 2002.

[3] Jae-Hung Han, So-Hyuen Yun, Jong-Heung Park, Seong-Pal Lee, "The Development Procedure for the Communication and Broadcasting Antenna Subsystme", The Korea Society of Aeronautical and Space Sciences Conference, pp532-535, Apr., 2001.

[4] Jae-Hung Han, So-Hyeun Yun, Jong-Heung Park, Seong-Pal Lee, "Ka band Antenna Design Using Reflector Shaping Method for the Communication and Broadcasting Satellite", The 12th JCCI, Session V-C 3.1-4, Apr., 2002.