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# OPTIMIZED CONFIGURATIONS OF KA-BAND TRANSPONDER SUBSYSTEM FOR ETRI'S SATCOM SYSTEM

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## ABSTRACT

In order to optimize the configurations of Ka-band transponder subsystem, the trade-off design has been performed iterately with emphasis on the improving performances of the payload system as well as effectiveness of Satellite Communication (SATCOM) system operation. It is necessary to allocate performance to the transponder equipments and to keep providing the main services. It begins with analyzing the requirements and allocating performance parameters by establishing budgets for electrical and mechanical characteristics. In this paper, introduction of SATCOM system and finally optimized Ka-band transponder configuration that is to be used for preliminary design will be mainly presented.

*Keywords*: Ka-band transponder, optimized design, ETRI's SATCOM system

## 1. INTRODUCTION

The SATCOM system, which to be designed to acquire the communication mission of the Communication, Oceanographic, and Meteorological Satellite (COMS) consists of Communication Payload, Satellite Ground Control System, and Experimental Test Earth Station.

The SATCOM that operates in the geostationary orbit of 128E longitude will provide Ka-band Fixed Satellite Services (FSS). The FSS system provides four 100 MHz wide operational RF channels. The spacecraft will have a service life of at least seven years, however, the design lifetime of the SATCOM system will be at least twelve years to achieve the following main missions (Lee et al. 2004a):

- In-orbit verification of the performance of the advanced communication technologies, and
- Experiment of wide-band multi-media communication services.

The configuration and the main features of SATCOM system are shown in Figure 1 and Table 1.

This paper focuses on the technology development being carried out for the space segment of SATCOM system at the ETRI, principally related to the COMS program.

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Table 1. Main feature of SATCOM system.

| | |
|---|---|
| Service area | Korean peninsula and Northeast area of China |
| Relevant frequency band | Ka-band |
| Orbit and position | Geostationary at 128° E |
| Design lifetime | More than 12 years |
| Reliability | More than 0.856 (TBC) |

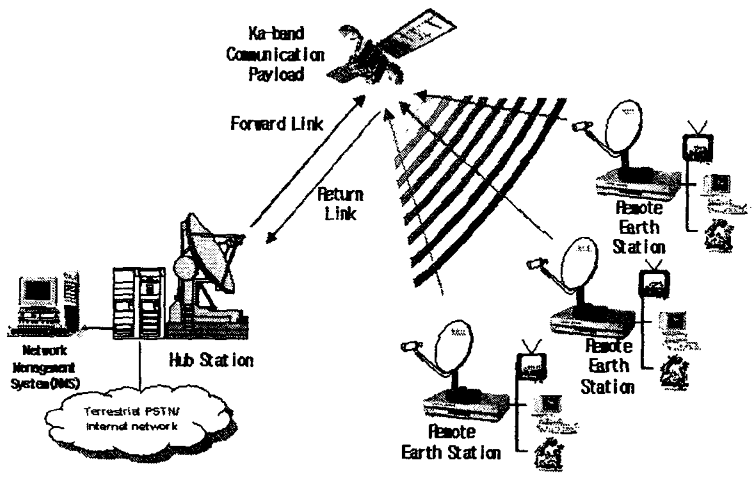


Figure 1. Network configuration of SATCOM system.

## 2. OVERVIEW OF KA-BAND PAYLOAD ARCHITECTURE

The Ka-band communication payload consists of multi-beam antenna and on-board switching transponder subsystems. The Ka-band communication payload system is designed to be capable of the communication service function among the individual 3 beams.

The antenna subsystem generates the three Ka-band multi beams for the coverage areas defined as Figure 2 and simultaneously transmits/receives the microwave signals to and from the Earth Station via beams, respectively.

The transponder subsystem provide four 100 MHz active and one 100 MHz redundant channels as the Ka-band. The three channels of them have the beam switching function for high speed multimedia services including the internet via satellite in the public communication network, and the rest one channel provides a bent-pipe type function for communication services for natural disaster in government communication network (Lee et al. 2004b).

The communication payload includes 3 main parts: 1) Ka-band conventional transponder, 2) Ka-band on board switching transponder and 3) multi-beam antennas.

## 3. OPTIMIZED KA-BAND TRANSPONDER SUBSYSTEM

The transponder design will incorporate redundant on-board systems to achieve reliable operation over the service life. The probability that all transponder channels are operating at specified levels of performance at the end of service life will exceed 86.6 % (TBC).

The four active 30/20 GHz RF channels are to be provided. Table 2 demonstrated the assignment

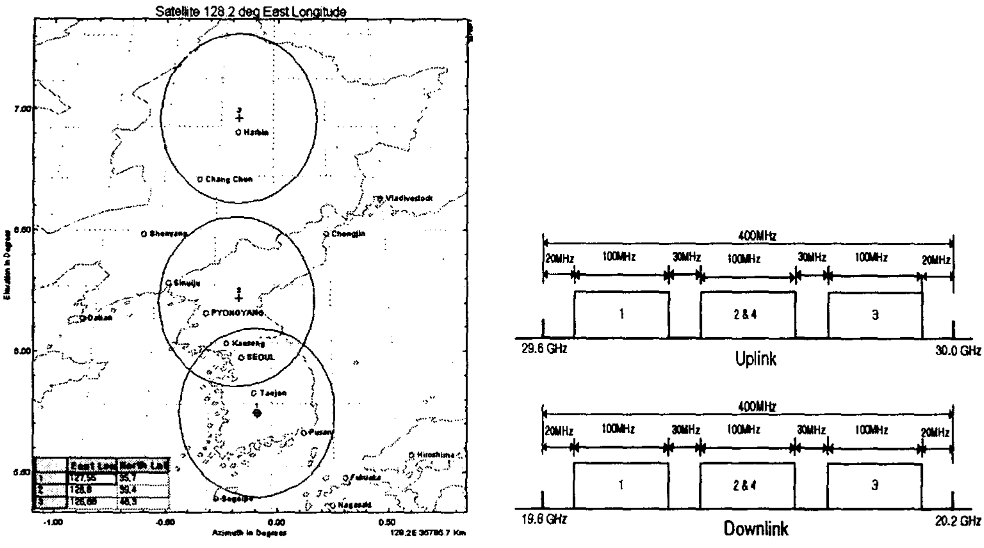


Figure 2. Transmit and Receive Service Coverage and Frequency Plan.

Table 2. Channel center frequency assignments.

| CH | Uplink Center Freq. [GHz] | IF Center Freq. [GHz] | Downlink Center Freq. [GHz] | Remark |
|---|---|---|---|---|
| 1 | 29.67 | 3.14 | 19.87 | Bent-Pipe |
| 2 | 29.80 | 3.40 | 20.00 | On-board Switching |
| 3 | 29.93 | 3.40 | 20.13 | On-board Switching |
| 4 | 29.80 | 3.40 | 20.00 | On-board Switching |

of four active RF channels with a 100 MHz nominal bandwidth in Ka-band and S-band.

The Ka-band on-board switching transponder consists of Input Filter Assembly (IFA), RF-Switch, Low Noise Amplifier (LNA), Down Converter (DNC) Assembly, IF Channel Filter (ICF), IF Switch Network (ISN), On-Board Switch (OBS), IF-Switch, Up Converter (UPC) Assembly, RF Switch Network (RSN), Channel Amplifier (CHAMP), Traveling Wave Tube Amplifier (TWTA), and Output Multiplxer (OMUX).

The on-board switch will be mainly designed for multi-beam switching. The OBS consists of microwave switch matrix (MSM) and digital control unit (DCU).

The MSM provides signal connection for any input to any output. The switching time of switch elements in MSM will be less than 100nsec. The switching sequence data stored in DCU memory is updated to new one by ground command through TT&C interface.

The configuration is optimized for the best performances minimizing the number of equipment. Especially, compared with the previous transponder configuration the redundancy scheme for high power amplifier section, CHAMP and TWTA, is changed from 5 for 4 to 4 for 4 structures.

The challenge with this no redundancy scheme is based around how the redundant equipment are expected to be used for service needs points of view. The TWTA for northeast region of china can be changed for other region as a redundant equipment when a unwanted fail is occurred. For this operation, the transponder can be driven easily by command signal from ground. In addition,

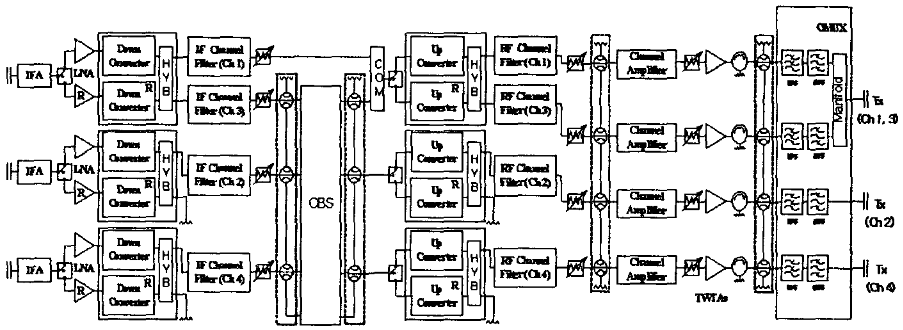

Figure 3. Block iagram of optimized Ka-band transponder subsystem.

the cost effectiveness and overall mass property are also incorporated.

The block diagram of optimized Ka-band transponder subsystem is shown in Figure 3.

## 4. CONCLUSIONS

The ETRI is now aiming to design, develop, and operate the SATCOM system using the heritages and well trained engineers obtained from previous projects, development of EQM Communication and Broadcasting Satellite (CBS). After launching a COMS into a space, the SATCOM system will be used as a network that provides Ka-band Fixed Satellite Services (FSS) for the required coverage areas.

The results of optimized configuration that have iterated trade-off to freeze the Ka-band transponder subsystem design are described in this paper. Based on this optimized configuration, the key technology components for Ka-band transponder being developed by ETRI and co-development companies in Korea.

In conclusions, this study has outlined the feasibility of a reliable payload system which offers significant advantages in terms of improving the rain fading in Ka-band, through the use of multi-beam antennas, on-board switching, and adaptive modulations.

It is expected that the preliminary/critical design and the related analysis will be performed as part of the near term activities and future work based upon this optimized configuration.

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