이동형 RF 시험장비를 이용한 RF 호환성 시험

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RF Compatibility Test using RF Suitcase

Eunghyun Kim*, Dae-Won Chung*, Hee-Seob Kim*, Jeong-Heum Im*, Sang-Jeong Lee**

요 약

위성체와 지상국은 위성 운영 전에 접속이 가능한지 여부를 시험한다. 이러한 호환성 시험은 위성체와 지상국의 요구사항이 각각 검증된 후에 위성체와 지상국을 연결하여 시험한다. RF 호환성 시험의 내용은 접속 제어문서에 기술된 요구사항이 잘 개발되었는지 확인하는 것이다. 위성의 초기 운용 기간이나 일시적인 비상 운용상황에서는 항우연 지상국은 해외의 지상국을 이용한다. 해외 지상국은 국내의 특정한 위성 개발 프로그램 하에서 개발된 것이 아니기 때문에 시스템 차원에서 해외 지상국이 접속 요구사항을 만족하는지 검증해야 한다. RF 이동장비를 이용하면 항우연 지상국의 지원없이 해외 지상국에서 직접 접속 요구조건과 통신 내용을 검증할 수 있다. RF 이동장비를 이용한 RF 호환성 시험이 해외지상국과 항우연의 지상국에서 수행되었다. RF 호환성 시험의 항목은 다른 해외 지상국에서 이용할 수 있도록 표준화되었으며 발사 및 초기운용 기간의 운용 개념에 맞추었다. 시험 항목은 RF 특성, 프로토콜, 원격명령 및 원격측정 루프 시험, 지상국 접속 시험 등이다.

Key Words : RF 이동장비, 접속, 지상국, RF 호환성 시험, 운용

ABSTRACT

A satellite and ground stations which are developed in a program are tested whether the interface between the satellite and ground stations is well established before satellite operations. These compatibility tests are performed when the satellite is connected with the ground stations after all satellite and ground stations requirements are verified. The content of the RF compatibility test is to check whether the interface requirements which are described in the Interface Control Document are well developed. During the early operation phase and tentative contingency operations of the satellite, KARI ground station uses other oversea ground stations which are located worldwide according to contract between the KARI and the contractor. Since oversea ground stations were not developed for the designated space program, system integrator should check whether the oversea ground stations are satisfied with interface requirements. Using the RF suitcase, RF interface and the content of RF communications can directly be verified during RF compatibility test on oversea ground stations without KARI ground station's support. The RF compatibility test using RF suitcase was performed oversea ground stations as well as KARI ground station located on Korea. The content of RF compatibility test was standardized in order to be used at any oversea ground stations, especially fitted for the operations concept of launch and early operations phase. The test content would be RF characteristics, protocol, command loop test, telemetry loop test, and ground station interface test.

Key words: RF suitcase, interface, ground station, RF compatibility test, operation

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1. Introduction

The interface test between the satellite and the ground station shall be performed for the verification of the overall system operational readiness before the satellite launch. This interface test is generally called RF compatibility test between the satellite and the ground stationand is tested after the integration test phase of the satellite and the ground station. When the satellite and the ground station antenna are the same site during the test phase, RF test of the system level can be performed easily. However, generally the locations of the ground station and the parked satellite are not the same. In this case,the transfer of the satellite will be necessary up to the antenna site of the ground station for RF compatibility test of the system level. Even though KARI (Korea Aerospace Research Institute) has one ground station which can control the several domestic satellites, the support of the oversea ground stations is needed during early operation phase and tentative contingency operations of the satellite. The role of these oversea stations is to extend the contact coverage with the satellite. However since oversea ground stations were not developed for the designated satellite, system integrator should check whether the oversea ground stations are satisfied with interface requirements. Using RF suitcase, RF interface and the content of RF communications wereverified during RF compatibility test on oversea ground stations site without KARI ground station's support. The RF compatibility test using RF suitcase was performed Svalbard oversea ground stations, Norwayas well as KARI ground station located on Korea. The content of RF compatibility test was standardized in order to be used at any oversea ground stations, especially fitting for the operations concept of launch and early operations phase.

2. RF Suitcase Design

2.1. General Concept

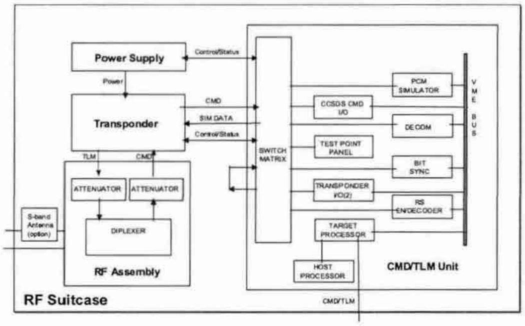

Figure 1: RF Suitcase Diagram

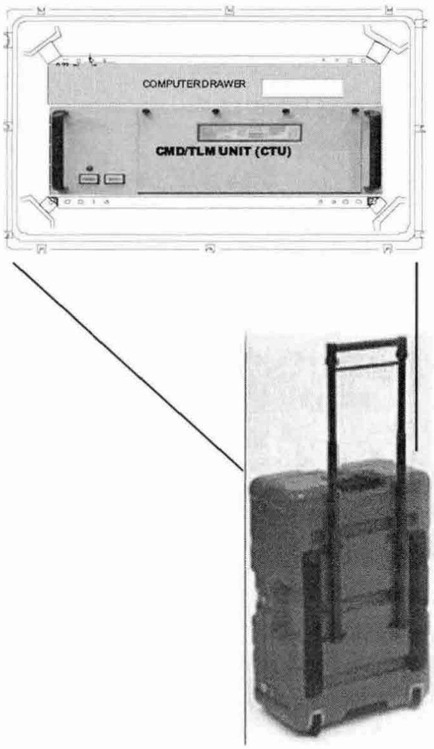

Figure 2: RF Suitcase Layout

RF suitcase consists of RF assembly, transponder, and suitcase CMD/TLM processor unit. RF assembly consists of telemetry attenuator, command attenuator, and diplexer. Also RF assembly is connected with the external units via coaxial cable. The transponder of the suitcase is

EM (Engineering Model) of the transponder. The suitcase CMD/TLM processor unit consists of switch matrix, PCM simulator, CCSDS CMD I/O, decommutator, test point panel, bit synchronizer, transponder I/O, RS encoder decoder, target processor, and host processor. The suitcase CMD/TLM processor unit possesses ethernet line which can exchange command and telemetry with the ground station of the KARI insteadof the command and telemetry database itself. This concept is due to the operational configuration which is interfaced between KGS and the oversea ground station through the bent pipe.

2.2. RF Assembly

RF assembly attenuates the signal between the rack input/output and transponder. RF assembly is controlled manually from 0 dB to 120 dB.

2.3. Transponder

RF suitcase includes the 28V power supplier and the I/O card for controlling the transponder. The command list for the transponder is as followings.

Ranging	on/off
Coherent mode	enable/disable
Transmitter	on/off
Playback telemetry	on/off
Real-time telemetry	enable/disable

The telemetry for the check of the transponder status is as followings.

Receiver carrier lock
Command data rock indication
Receiver carrier strength
Receiver converter voltage
Receiver static phase error
Ranging on/off
Coherent/Non-coherent mode
Transmitter temperature
RF output power
Transmitter power converter
Playback on/off
Real-time enable/disable
Transmitter on/off

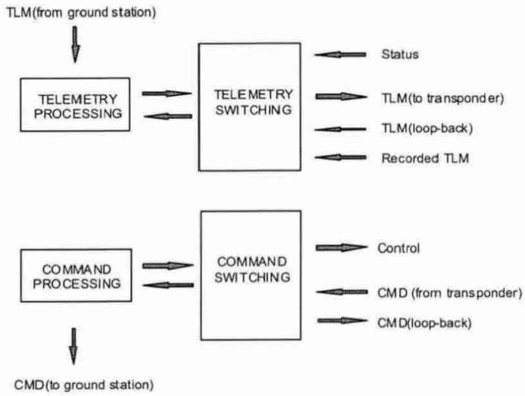

Figure 3: Suitcase CMD/TLM Processor Unit

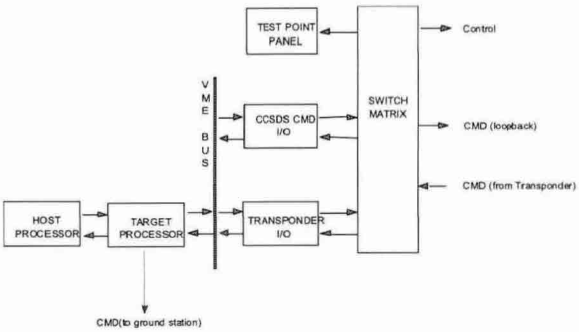

Figure 4: Command Processing

2.4. Suitcase CMD/TLM Processor Unit

The suitcase CMD/TLM processor unit consists of command processing part and telemetry processing part. The function of command processing is as followings.

- Receive and process command from transponder
- BCH encoding/decoding and frame synchronization
- Support uplink rate of 2 Kbps and NRZ-M format
- Generate command according to CCSDS recommendation and transmit it to ground station via ethernet
- Transmit command for loop back
- Control transponder using transponder I/O card

The function of telemetry processing is as followings.

- Transmit telemetry to transponder
- Telemetry formatting according to simplified

format based on CCSDS recommendation and RS coding/decoding
- Support downlink rate of 2 Kps, 1.5 Mbps and NRZ-L format
- Receive telemetry for loop-back
- Receive status from transponder using transponder I/O card
- Process recorded telemetry
- Receiving the telemetry from ground station via ethernet

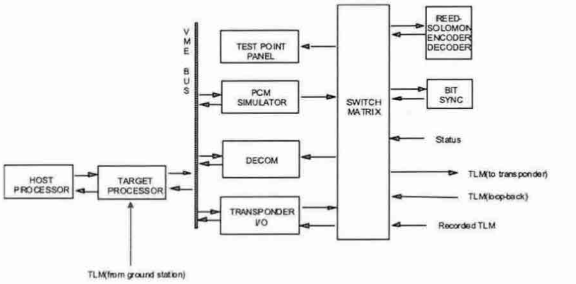

Figure 5: Telemetry Processing

3. Test Contents

RF compatibility test using RF suitcase consists of radio frequency test, telemetry test, uplink signal test, and tracking test for real-time telemetry.
- Antenna G/T performance
- S/C output power
- S/C transmitter frequency
- S/C transmitter RF spectrum
- Frame acceptance threshold for real-time TM
- Frame acceptance threshold for playback TM
- S/C receiver carrier unlock threshold
- S/C receiver carrier lock threshold
- S/C receiver carrier lock capability
- Uplink frequency
- Uplink modulation index
- S/C receiver TC frame rejection and acceptance threshold
- S/C receiver TC PM sensibility for nominal link
- S/C receiver TC PM sensibility for worst link case
- S/C turn around ratio
- Overall ranging function and ranging delay
- Ranging delay versus modulation index
- Ranging signal spectrum
- Tracking receiver threshold for real-time telemetry

4. Test Result

RF compatibility was verified using RF suitcase and the antenna system of Svalbard ground station on June 2005.

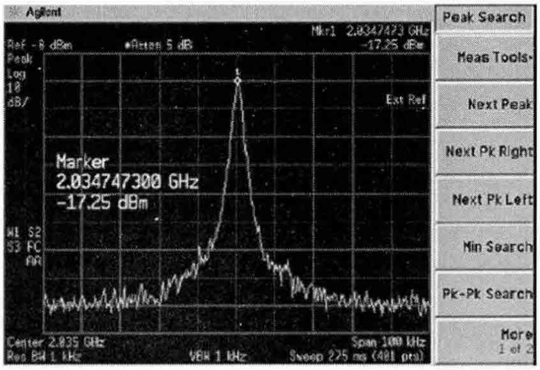

Figure 6: S-band Unmodulated Uplink

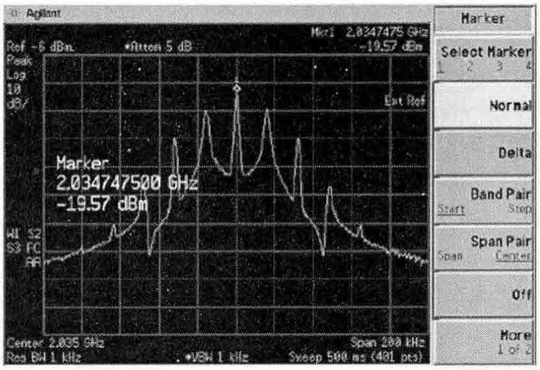

Figure 7: S-band Modulated Uplink

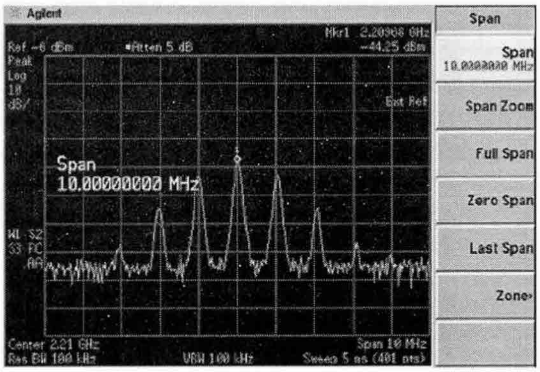

Figure 8: Modulated RF Real-time 10M Span

Several test results were describedto Figure 6 to Figure 12 as the example. Figure 6 shows S-band unmodulated uplink signal pattern at wide band spectra. Figure 7 shows modulated uplink signal. Downlink spectrum at RF level was plotted at Figure 8 and Figure 9. Signal at real-time contact is Figure 8 and signal at playback mode is Figure 9. Figure 10 is the spectrum as TC modulation index is 1.0 and carrier suppression measured to be 2.3dB on Cortext NT. Figure 11 is the spectrum at 0.4 ranging modulation index. Figure 12 shows the ranging signal spectrum.

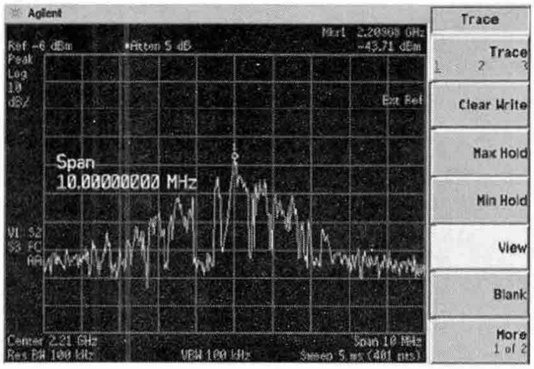

Figure 9: Modulated RF Playback 10M Span

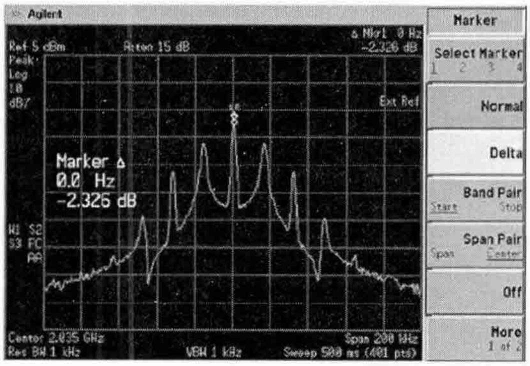

Figure 10: TC Modulation Index

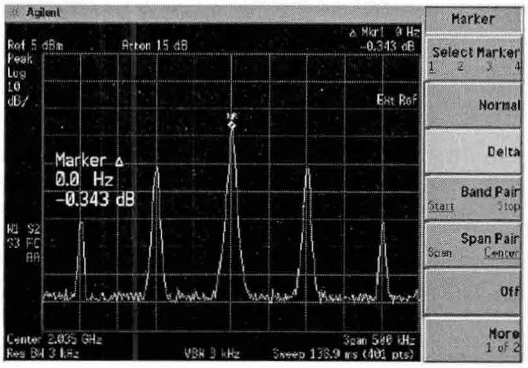

Figure 11: Ranging Modulation Index

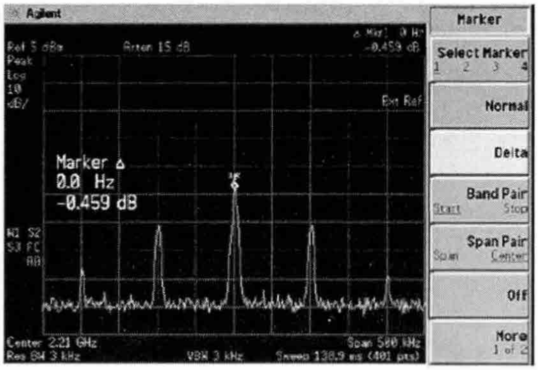

Figure 12: Ranging Signal Spectrum

5. Conclusions

RF suitcase was developed for the system level RF compatibility test between the satellite and the oversea ground stations. The functional characteristics of the developed RF suitcase were described. The contents of RF compatibility test were established and were performed using the RF suitcase and the Svalbard ground station antenna system. The RF suitcase can be employed as the RF test equipment of other satellite system development program.

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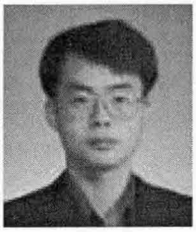

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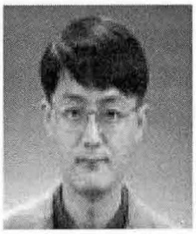

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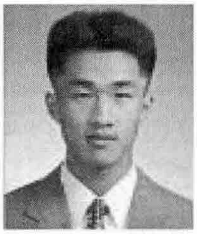

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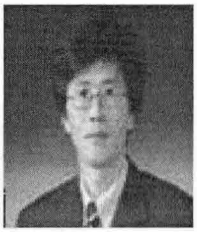

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