ANALYSIS ON RECEIVING PERFORMANCE FOR KOMPSAT-5 X-BAND IMAGE DATA

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ABSTRACT
Band-limited filtering will be applied to remove interference resulted from two neighbored channels in the transmission of KOMPSAT-5 X-Band image data. In that case, receiver in ground station should prepare righteous matched filter to avoid huge BER degradation depending on the matched filter of COTS receiver. As an effort to simulate the band-limited filtering, test filter was designed and manufactured on the basis of main specification for output filter of KOMPSAT-5 satellite. Consequently, 1.8dB of BER degradation was measured at the output of test band-pass filter, but the degradation was downsized up to 0.4dB thanks to the adaptive matched filter of COTS receiver.

KEY WORDS: KOMPSAT-5, SAR, X-Band, DLS

1. INTRODUCTION

Thanks to SAR (Synthetic Aperture Radar) payload, KOMPSAT-5 scheduled to be launched in 2010, has a benefit of continuously conducting its missions even though the region of interest is cloudy or at night. The SAR payload is a spaceborn X-Band SAR, capable of operating in three imaging modes, standard, high resolution and wide swath, where each mode provides different characteristics in terms of geometrical resolution and swath-width. The SAR payload system is composed of three basic subsystems as followings;

- SAR Sensor Subsystem (SSS), which is the SAR instrument composed from the SAR Sensor Electronics (SSE) and the SAR antenna subsystem (SAS)
- Data Link Subsystem (DLS), which is the down-link instrument composed from the solid state mass memory, the RF modulation and transmission and DLS antenna
- SAR Payload Module Subsystem (PLM), which is the structure able to hoist, mechanically and thermally, the electronics boxes of both SSS and DLS with their related harness as well as to sustain and support payload antenna.

The transmission of X-Band image data is conducted through two independent channels, namely Link1 and Link2, in single polarization, RHCP (Right-Handed Circular Polarization). For the receiving of X-Band image data transmitted by DLS, 7.3m antenna system in KARI site is now ready to be available. Image processing software linked with 7.3m antenna system makes valuable products from the received X-Band image data.

Figure 1 and Table 1 shows the picture of 7.3m antenna system and its major performances, respectively.

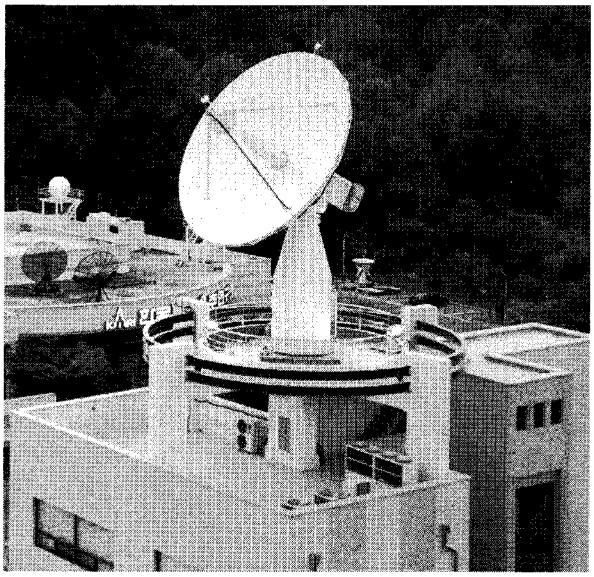


Figure 1Picture of 7.3m Antenna System at KARI Site

Table 1 Major Performances of 7.3m Antenna System

Item	Performance	
Satellite Support	LEO > 250km, GEO	
Tracking	Autotrack and Program Track	
Reflector	7.3m X-Band Cassegrain, S-Band Prime Focus	
	X-Band	S-Band
Frequency Receive Transmit	 8000 to 8500MHz Not Applicable	 2200 to 2300MHz 2025 to 2120MHz
Polarization Data Channel Track Channel Transmit	 RHCP&LHCP RHCP/LHCP Not Applicable	 RHCP&LHCP RHCP&LHCP RHCP/LHCP
Data G/T	32.0dB/K	19.0dB/K
EIRP	Not Applicable	53dBW
Axial Ratio	0.5dB, max	1.5dB, max

The function and performance of 7.3m antenna system entirely meets to the requirements for S-Band satellite operation and X-Band image data receiving. In addition, the 7.3m antenna will be operated for KOMPSAT-3 in parallel with 13m antenna system in KARI site.

This paper presents test configuration and results to estimate the degree of degradation on link performance when band-limited filtering is applied to X-Band image data in KOMPSAT-5 satellite. The band-limited filtering is usually way to reduce interference produced by adjacent channels. Then, band-limited filtering is performed by output band-pass filter placed between transmitter and antenna. Since the bandwidth of output band-pass filter is narrower than that of interested signal, the interference of adjacent channels can be effectively removed, but the spectral shape of interested signal which are characterized by baseband filtering in modulator are also changed depending on the amplitude response and group delay response of output band-pass filter. Furthermore, the characteristics of output band-pass filter can be easily changed by environmental temperature. In terms of receiver, adaptive matched filtering which is different from the scheme of satellite baseband filtering should be prepared to avoid degradation on link performance. The degradation on link performance eventually causes image processing software system to make wrong products. As an effort to justify the design of receiving system for KOMPSAT-5 satellite, this paper describes test configuration and results to estimated BER degradation caused by band-limited filtering. From the results, it is shown that link performance can be improved by using adaptive matched filtering of COTS(Commercial Off-The-Shelf) receiver.

2. BAND-LIMITED FILTERING IN KOMPSAT-5 SATELLITE

Figure 2 shows the expected bandwidth of modulated signal in two neighbored channels of KOMPSAT-5 satellite.

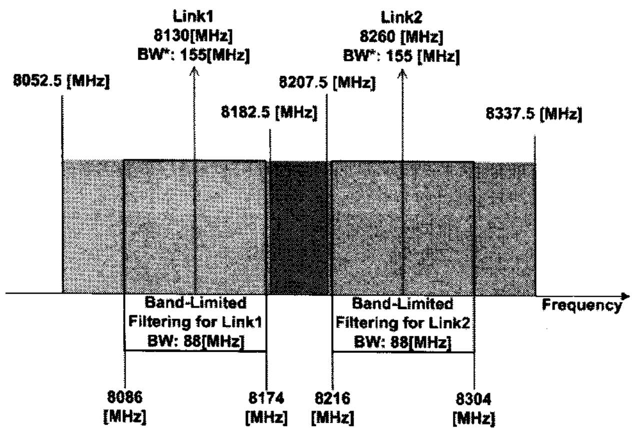


Figure 2 Bandwidth of Link1 and Link2

Assuming an integral filter as baseband filter in satellite, the bandwidth of Link 1 and Link2 is identically 155MHz. However, the gap between each center frequency of two channels is 130MHz, meaning that there is overlapping region up to 25MHz (8182.5 to 8207.5MHz). To remove the overlapping event of two adjacent channels, band-limited filtering with 88MHz of bandwidth is supposed to be applied as described in in X-Band satellite/ground ICD (Interface Control Document) [1]. Due to the band-limited filtering, the bandwidth of modulated signal in Link1 and Link2 is downsized up to 88MHz, meaning that the spectral shape of baseband filtered signal is also changed.

3. TEST BAND-PASS FILTER

To estimate the degradation of link performance caused by band-limited filtering, it was raised to prepare test band-pass filter which was nearly identical to the amplitude and group delay response of output band-pass filter in KOMPSAT-5 satellite. Table 2 shows the specification of test band-pass filter based on descriptions in the ICD

Table 2 Specification of Test Band-pass Filter

Item	Specification
Center Frequency (Fc)	720MHz
Bandwidth	88MHz
Insertion Loss (Max)	0.3dB
Return Loss (Min)	18dB
Rejection (Min)	20dBc at Fc ± 86MHz
Group Delay (Max)	20ns

Since receiver is mainly unit to determine link performance under the band-limited filtering, the center frequency of test band-pass filter was fixed as 720MHz, not X-Band. Other specifications are similar to the descriptions in the ICD. Figure 3 and 4 shows the picture of manufactured test band-pass filter and its measured data about amplitude and group delay response, respectively.

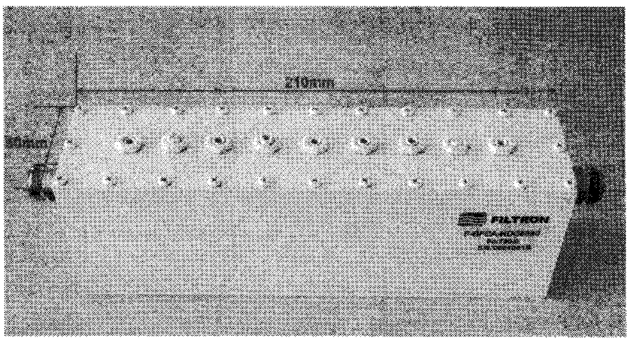
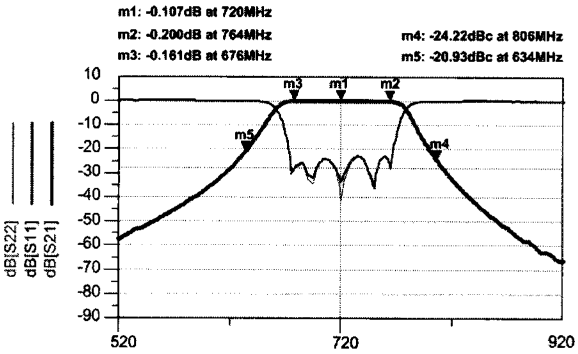
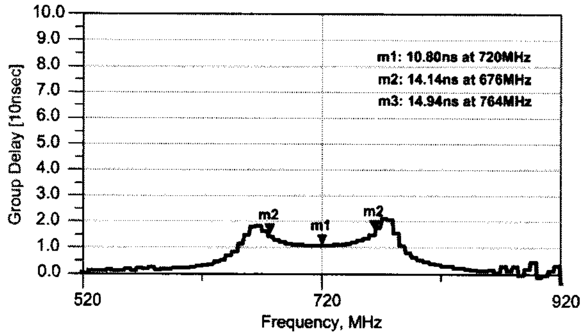


Figure 3 Picture of Test Band-pass Filter



(a) Amplitude Response



(b) Group Delay Response

Figure 4 Measured Data of Test Band-pass Filter

Measured data said that test band-pass filter has maximum 0.2dB of insertion loss in pass-band and 20.93dB of rejection at 720MHz±86MHz. Test band-pass filter also has maximum 4.14ns of deviation regarding group delay. From the measured data, it can be concluded that specifications in Table 2 are entirely satisfied.

4. TEST RESULTS

Figure 5 shows test configuration to estimate BER degradation on link performance when X-Band image data is under band-limited filtering.

For test modulator and demodulator, COTS receiver, HDR-XXL™ manufactured by IN-SNEC, was applied in the test configuration. Basically, COTS receiver equips with test modulator conducting modulation as performed by DLS in KOMPSAT-5 satellite. Aimed at BER measurement, PN (Pseudo Noise) coded data was applied as a test data. Noise source was also injected to simulate communication environment between satellite and receiving antenna system. For checking the Eb/No of test signal, 1st BER measurement was performed at the output port of test modulator. The output signal of test modulator was then delivered to test band-pass filter characterized as output band-pass filter in KOMPSAT-5 satellite. Then 2nd BER measurement was conducted to know the degree of BER degradation caused by band-limited filtering.

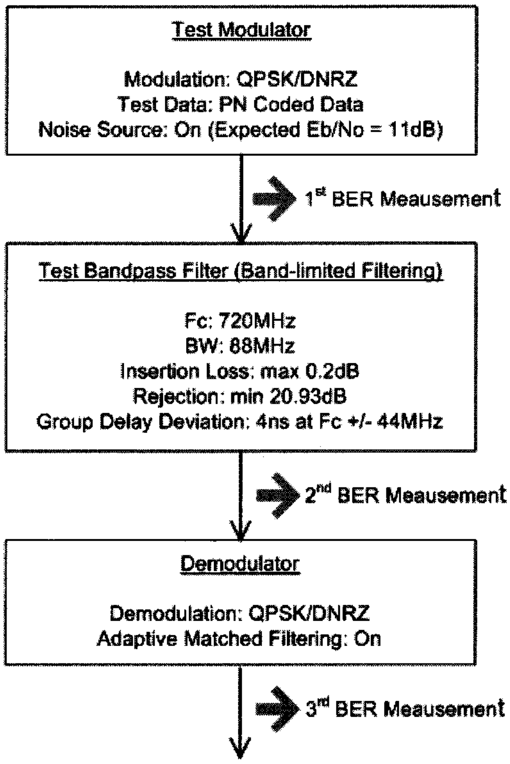
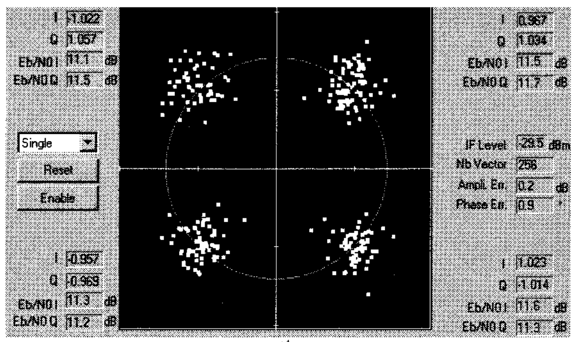


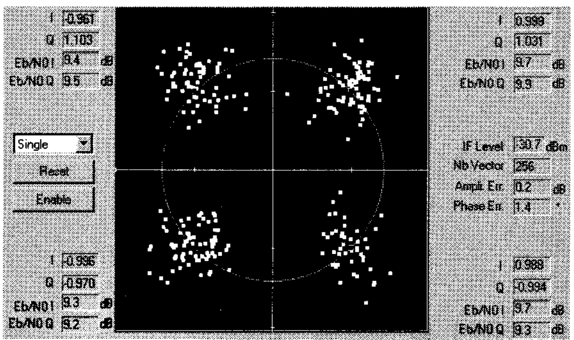
Figure 5 Test Configuration with COTS Receiver

After that, the output signal of test band-pass filter was delivered to COTS receiver where adaptive matched filtering was already on. The last BER measurement was conducted to measure how much improvement is achievable thanks to the adaptive matched filtering of COTS receiver.

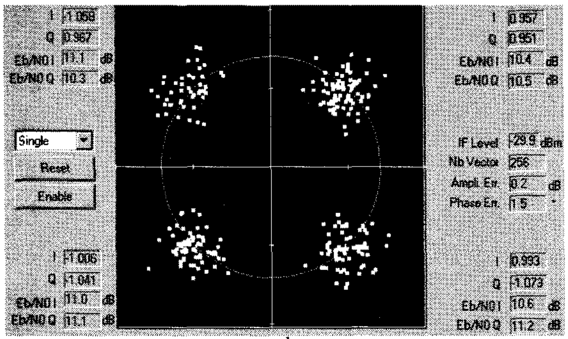
Figure 6 shows the vector status displayed on COTS receiver according to the BER measurement step.



(a) Vector Status of 1st BER Measurement



(b) Vector Status of 2nd BER Measurement



(c) Vector Status of 3rd BER Measurement

Figure 6 Results of BER Measurement

Due to the band-limited filtering, the output signal of test modulator with 11dB of Eb/No (as described on 1st BER measurement) was degraded up to 9.2dB (as described on 2nd BER measurement). Test result said that the BER degradation caused by band-limited filtering was about 1.8dB. On the other hands, COTS receiver displayed 10.6dB of Eb/No, meaning that improvement is achievable up to 1.4dB thanks to the adaptive matched filtering of COTS receiver. Consequently, the degradation caused by band-limited X-Band image data of KOMPSAT-5 can be expected as 0.4dB at COTS receiver during normal operation.

5. CONCLUSIONS

This paper shows the BER degradation on the link performance caused by band-limited filtering aimed at downsizing interference in two neighbored transmission channels. To simulate band-limited signal, test band-pass filter was designed and manufactured as an output band-pass filter in KOMPSAT-5 satellite. Through the test modulator in COTS receiver, test signal was modulated same as DLS in satellite. Then, noise source was also injected to simulate communication environment between satellite and ground. As a result, the degraded link performance caused by band-limited filtering is expected was 1.8dB, but this degradation can be improved up to 0.4dB thanks to the adaptive matched filter in COTS receiver. This result will be reflected on the link analysis to estimate more practical link margin for the receiving of X-Band image data in the future.

6. REFERENCE

[1] Thales Alenia Space-Italy (TAS-I), 2008, SAR Payload Interface Control Document, Volume 4-P/L to Ground X-Band ICD (ID-KMPS-0001-AASI)