2.4M X-BAND ACQUISITION TESTS WITH KOMPSAT-2

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ABSTRACT: Even though official G/T for KOMPSAT-2 X-Band downlink acquisition was 32dB/K, KARI performed the data acquisition experiment using 2.4m X-Band antenna to check if popular 2.4m MODIS receiving antenna can receive KOMPSAT-2 MSC data within acceptable quality level. Through several acquisition tests, it was shown that G/T value of 24dB/K can provide the reliable data BER quality, 10-6 for the above the elevation angle of 10 degree. Some plots for Eb/No versus elevation angle are provided.

KEY WORDS: G/T, X-BAND, KOMPSAT-2, BER, Eb/No

1. INTRODUCTION

To receive the X-Band image data with good data quality from satellite system, the ground system operation agency uses the antenna systems which can exceed the minimum G/T value defined by satellite mission systems engineering to be required to receive the signal. The ground antenna G/T value, transmission data rate, and spacecraft transmission power have close relation among them in link analysis.

During system design phase, communication link analysis is done for command, telemetry, and also image data to check the feasibilities of link considering worst case link parameters. Due to its used worst case values, the real link margin we experience during on-orbit operation normally exceeds the expected link margin value.

In fact, in most satellite communication system, the minimum data quality value, BER (Bit Error Rate), can be met using even lower G/T antenna instead of using recommended G/T antenna. This feature can be definitely one of good means for downlink commercialization environment because the initial investment like antenna procurement and installation can be much reduced compared to relatively higher G/T antenna system. Smaller antenna system has several benefits in life cycle cost from procurement, installation, maintenance and operation.

The KOMPSAT-2 systems in early design phase defined 32dB/k for required G/T value meeting 3dB margins in ground antenna for 320Mbps downlink system [1]. But as ground system operator, KARI believed it was worthwhile to perform some acquisition tests for KOMPSAT-2 MSC image data using small antenna to check its possibility.

This paper shows the obtained acquisition test results using operational 2.4m X-Band antenna for KOMPSAT-2.

2. ACQUISTION TESTS

2.1 KARI X-Band 2.4M Antenna

The antenna used in acquisition tests is high-efficient antenna providing higher G/T compared to other equal size antennas due to its high efficient feed design. The high cross-polarization discrimination was achieved using custom-designed septum polarizer. These made X-Band antenna ready to simultaneous dual-polarization reception for future other missions.

The antenna mechanics can meet the pointing and tracking performance required even under the 20m/s wind speed. Conventional 2 axial EL over AZ mechanical system was adopted and program tracking based on TLE was used from 5 deg to 5 deg for operation.

Antenna was re-installed on the roof of KARI ground station building from mobile trailer as shown in Figure 1. The new G/T measurements using solar flux density were performed after installation in early 2007. The measurements value for RHCP and LHCP were shown in Figure 2. For frequency range from 8.0 to 8.4 GHz, the G/T value shows more than 24dB/K.

Figure 1. KARI X-Band Antenna

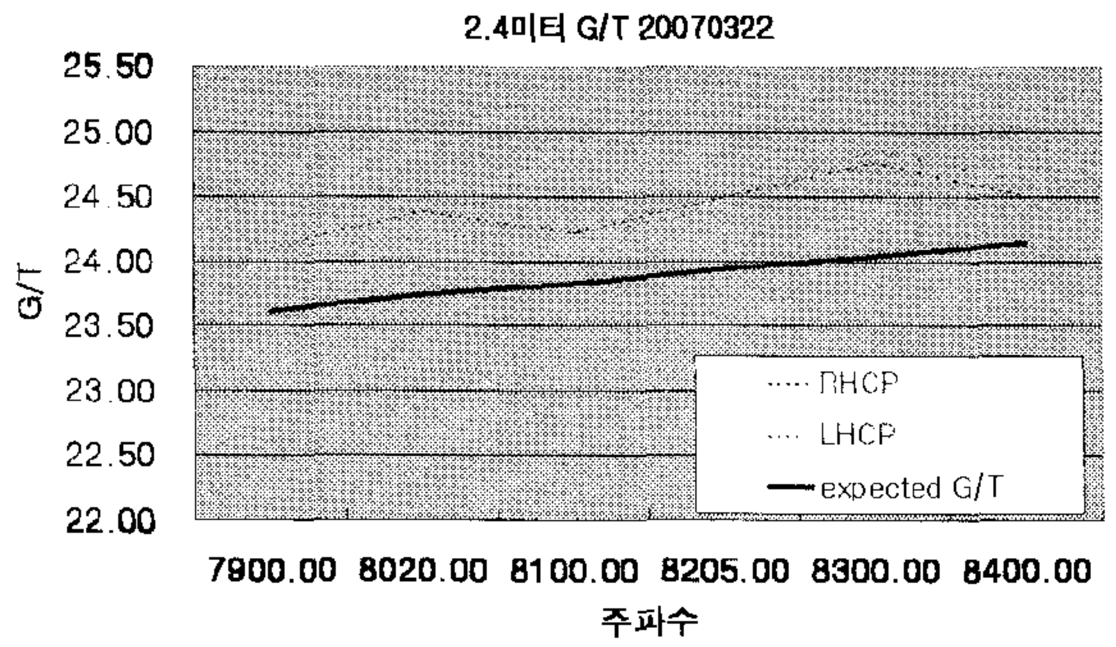

Figure 2. 2.4M G/T Measurements

For automatic test, the all antenna pass scheduling and equipment parameter initialization for KOMPSAT-2 data reception were done automatically by in-house developed GUI software named XCAM_NT.

The captured sample GUI image was shown in Figure 3. Operational Schedule Reservation window shows pass information scheduled for acquisition tests. Date, time, AOS, LOS, and Max EL information was displayed for auxiliary information. The AZ/EL track information is graphically shown.

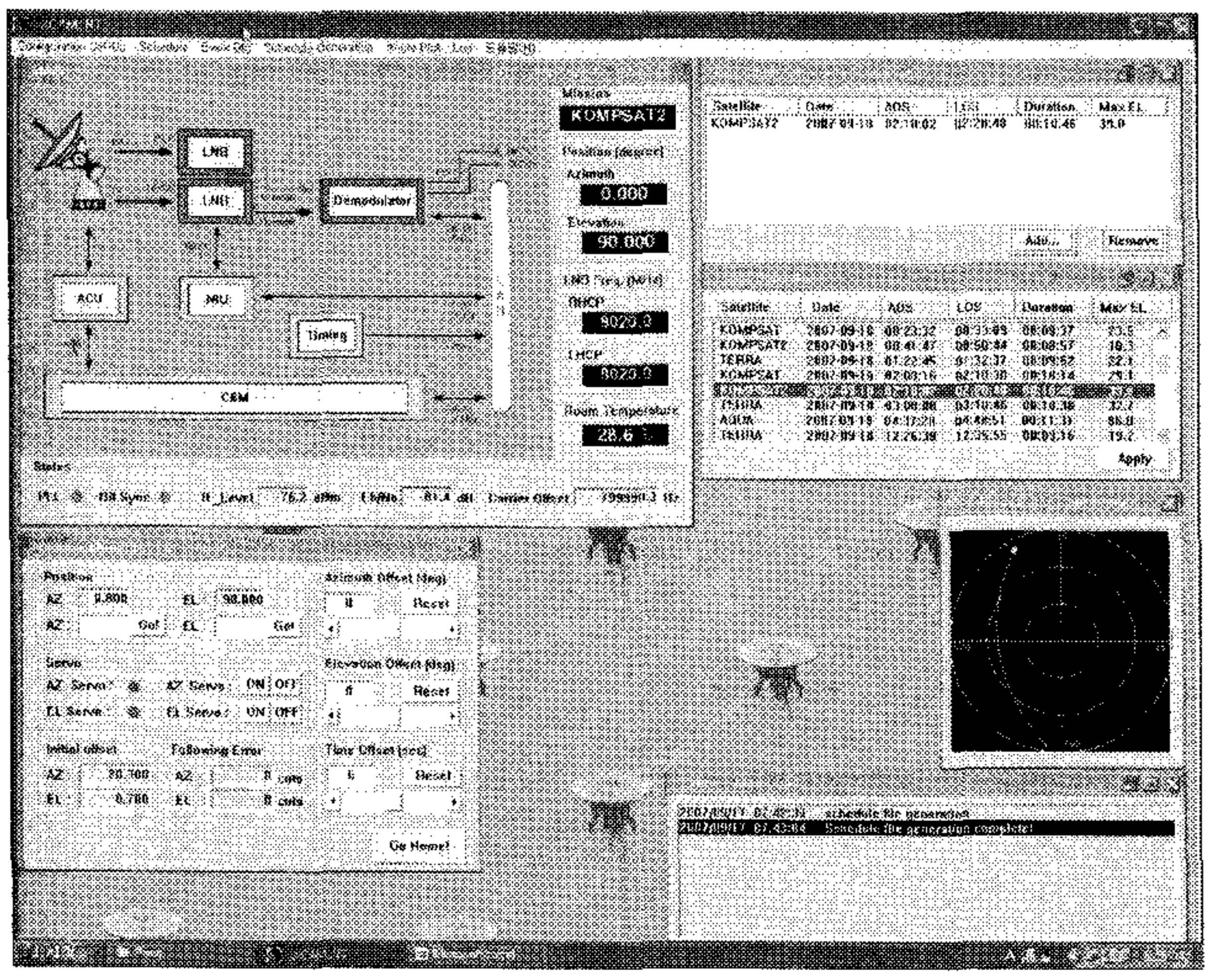

Figure 3. 2.4m Antenna C&M GUI

2.2 Test Pass and Criteria Selection

Since primary mission for 2.4m antenna is to acquire the MODIS sensor data from TERRA, AQUA and KOMPSAT-1, the acquisition test passes for KOMPSAT-2 were selected considering orbital characteristics of TERRA and KOMPSAT-1.

About 2 passes per day in daytime and night time were selected. The recorded image data in mass memory was normally dumped during early beginning contact time or after real-time image acquisition. Maximum 11 dumps for recorded image were down-linked during night pass. This kind of multiple image dumps were considered to be good tests cases for both antenna acquisition tests and receiver functionality tests. These acquisition and receiver functionality tests were done during 17 days from 31 Aug to 16 Sep, 2007.

The Eb/No value in receiver was recorded during entire passes for detail quality analysis. The system level BER of 10^{-6} was considered as criteria for successful acquisition. Also the detail frame information generated and recorded in ingestion system was investigated to check the data integrity like fill frame, recorded frame, error frame, non-correctable error frame, and calculated BER. The Reed-Solomon error check and correction were performed to every frame received. This check and correction were performed to 160Mbps in real-time in software scheme only without hardware involvement. Due to its real-time feature, the Eb/No value of about 10dB was considered as criteria for stable data acquisition and recording using ingest system.

2.3 Results Analysis

During 17 days of test period, total 170 image dumps were considered for acquisition tests. The 157 dump tests were successful for both acquisition and its data quality. But the 13 dumps, about 8% of total passes, were considered to be failure in either acquisition or data quality.

The causes of failures for 13 dumps were summarized in Table 1.

Through detail investigations, all failures were caused by blockage or degraded link due to heavy rain in low elevation angle.

The blockage came from hill near KARI ground station building or 13m antenna next to 2.4m antenna, about 40m apart for certain azimuth and elevation range.

Table 1. The Causes of Failures

Causes of failure	Frequency	Remarks
Natural Blockage	8	Building, hill
Blockage(nearby antenna)	3	13M antenna
Degraded link(heavy rain)	2	Rain effects in low EL

During heavy rain, communication was degraded by about 2 or 3dB in low elevation angle. All 2 cases were occurred in first dump among several dumps in heavy rain environments.

2.3.1 Typical Pass Acquisition Example

Figure 4 shows recorded Eb/No using 2.4m antenna for 9 sequential dumps of KOMPSAT-2 MSC in pass in which AOS was 14:00:14 in UTC on 15 Sep, 2007. Graph shows typical pattern of varying Eb/No, increasing and decreasing, over entire pass with respect to the elevation change.

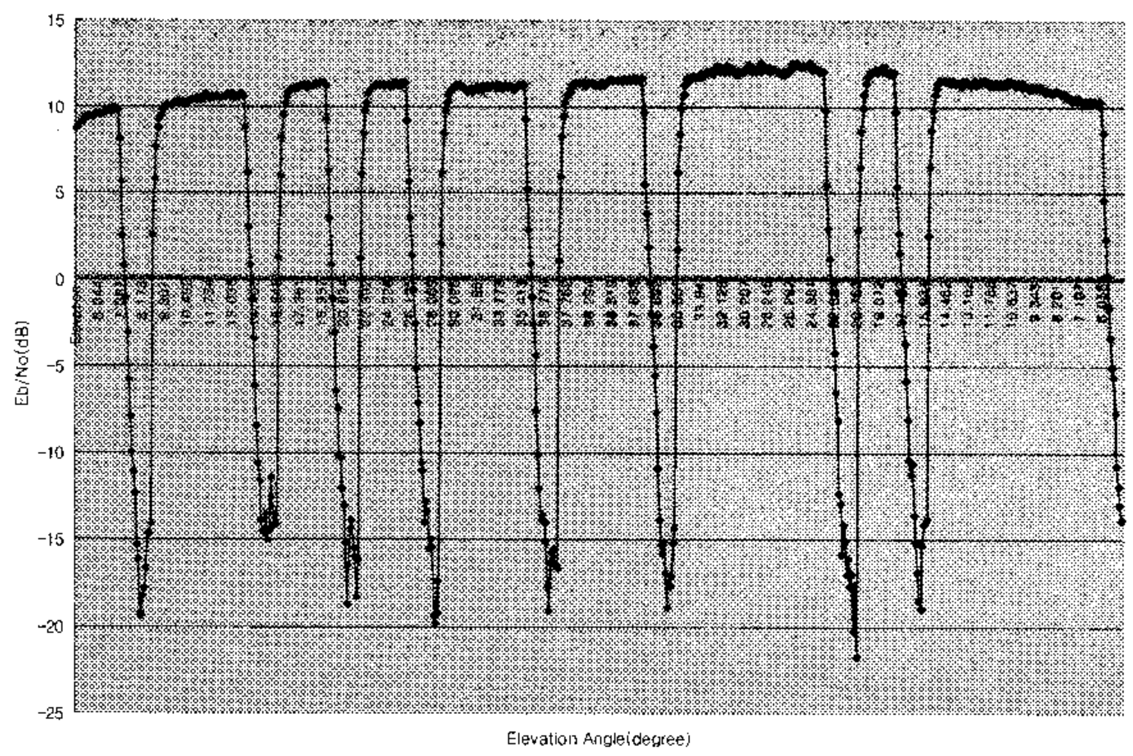

Figure 4. Pass Example

The detail data quality information for each dump is shown in Table 2.

Table 2. Data Quality in 9 sequential dumps

Dump No.	Channel	Expected Data Sector	Received Data Sector	Received Frame	Data Frame	Fill Frame	Error Frame	Error Symbol Count	BER
1	I-CH	1852	1852	428,200	407,440	20,760	4,204	4,210	1.1 * 10-6
	Q-CH	1852	1852	429,400	407,440	21,960	5,209	5,279	1.3 * 10-6
2	I-CH	3684	3684	855,800	810,480	45,320	38	38	4.9 * 10-9
	Q-CH	3684	3684	849,600	810,480	39,120	19	19	2.5 * 10-9
3	I-CH	1768	1768	420,000	388,960	31,040	0	0	0.0
	Q-CH	1768	1768	420,059	388,960	31,099	0	0	0.0
4	I-CH	1780	1780	419,844	391,600	28,244	0	0	0.0
	Q-CH	1780	1780	413,200	391,600	21,600	0	0	0.0
5	I-CH	3348	3348	770,200	736,560	33,640	0	0	0.0
	Q-CH	3348	3348	771,800	736,560	35,240	0	0	0.0
6	I-CH	3396	3396	771,600	747,120	24,480	0	0	0.0
	Q-CH	3396	3396	777,800	747,120	30,680	1	1	1.4 * 10-10
7	I-CH	6156	6156	1,392,800	1,354,320	38,480	0	0	0.0
	Q-CH	6156	6156	1,400,400	1,354,320	46,080	0	0	0.0
8	I-CH	1244	1244	310,800	274,068	36,730	390	1,722	6.2 * 10-7
	Q-CH	1244	1244	310,800	273,805	36,994	126	586	2.1 * 10-7
9	I-CH	7308	7308	1,649,400	1607,935	41,464	616	1,225	8.3 * 10-8
	Q-CH	7308	7308	1,649,525	1,607,760	41,765	427	427	2.9 * 10-8

The data ingest system connected to 2.4M antenna system has 2 channel dedicated serial telemetry systems. These have I-CH and Q-CH systems. Each channel system has capability to receive up to 160Mbps in real-time.

The channel work-station system records the frame-synced frame data and then checks its continuities. Also ingest software checks if there is error in data itself using Reed-Solomon check data. If there is error, error correction is done. The BER calculation is performed based on error symbol count over total received frame data.

Total received frame consists of data frame and fill frame. In dump mode, the fill frame data is transmitted prior to real data dump about minimum 4 sec for ground station receiver's demodulation and bit synchronization operations to provide seamless data transmission. 220 data frames make a data sector, which is basis for encryption.

As shown in Table 2, the BER for data dumps in middle of passes shows around zero, which means there is no error bit at all even though 2.4m antenna receives the 320Mbps downlink data from KOMPSAT-2.

For the data dumps obtained during beginning and ending in pass, we can see the BER value exceeds the minimum 10^{-6}. And this error symbol data can be perfectly recovered through Reed-Solomon Error Correction Algorithm.

3. CONCLUSIONS

In this paper, the test results obtained by acquisition tests using KARI 2.4m X-band antenna for KOMPSAT-2 320Mbps downlink data was described shortly.

Among 170 dumps, the 13 dumps were failed in either acquisition or data quality criteria. Main contributor to these failures was physical blockage induced by hill, tall building, and near by 13m antenna.

The 2 failure were led by the degraded link environment, which happened for the first dump performed at just above the 5 deg elevation in heavy rain. The rain increased the signal attenuation and reduced the G/T value in ground antenna due to increased antenna temperature by rain.

Through acquisition tests, it was shown that the 2.4m antenna, which is popular for MODIS reception, can provide the reliable data acquisition from KOMPSAT-2 when its G/T value is about 24dB/K above the elevation angle of 10deg. This 10 deg usually covers around 2100km.

4. REFERENCES

[1] MSC X-Band to Ground Interface Control Document, GC-4961-0000-00, Rev. E, 22 June 2004