DIVERSITY DESIGN FOR SENSOR DATA ACQUISITION AT COMS SOC

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ABSTRACT: COMS will transmit its observed data, Sensor Data, through L-Band with linear polarization. To avoid link loss caused by polarization discrepancy between satellite and SOC DATS, the L-Band antenna at SOC DATS should be linearly polarized. However, SOC DATS is supposed to share single antenna with SOC TTC, so the antenna should be circularly polarized. To cope with about 3dB loss, SOC DATS is designed to receive Sensor Data through two orthogonal circular polarizations, RHCP (Right-Hand Circular Polarization) and LHCP (Left-Hand Circular Polarization). Eventually, SOC DATS can obtain 2.6dB of combining gain through diversity combiner in MODEM/BB. This paper presents the verification on the diversity combining of SOC DATS with test configuration and results in depth.

KEY WORDS: COMS, SOC, DATS, Polarization, Receiving System

1. INTRODUCTION

The first Korean geostationary satellite, COMS (Communication, Ocean, and Meteorological Satellite), is supposed to be launched in 2008. As implied in the name, three different payloads, Ka-Band communication, Meteorological Imager (MI), and Geostationary Ocean Color Imager (GOCI) are implemented in satellite. To communicate with these payloads, ground station consists of Satellite Operation Center (SOC), Meteorological Satellite Center (MSC), Korea Ocean Satellite Center (KOSC), and Communication Test Earth Station (CTES). As a part of ground station, SOC is in charge of transmitting command and receiving telemetry in S-Band to/from COMS for the satellite operation. In addition, SOC provides Sensor Data (SD) receiving in L-Band and LRIT/HRIT transmitting in S-Band for the backup operation of MSC and KOSC. To serve those functions, the frequency range of SOC antenna should be simultaneous L-, and S-Band. Technically, it is possible to implement two frequency bands into one single antenna. That is why single antenna is installed at KARI site with considering cost-effective way. Figure 1 shows the picture of on-going 13m antenna and Table 1 describes the major features of antenna.

The reason why the SD is transferred through linear polarization is related to COMS broadcasting service. It is worldwide that antenna at user station for meteorological data broadcasting is linear-polarized with considering simple integration. This situation leads COMS to transmit LRIT/HRIT through linear-polarized antenna. Since SD is also transmitted through the same antenna for LRIT/HRIT broadcasting, the linear polarization is normally considered at receiving antenna. However, critical issue such as seasonal Faraday rotation is potentially placed in the communication link when linear polarization is applied.

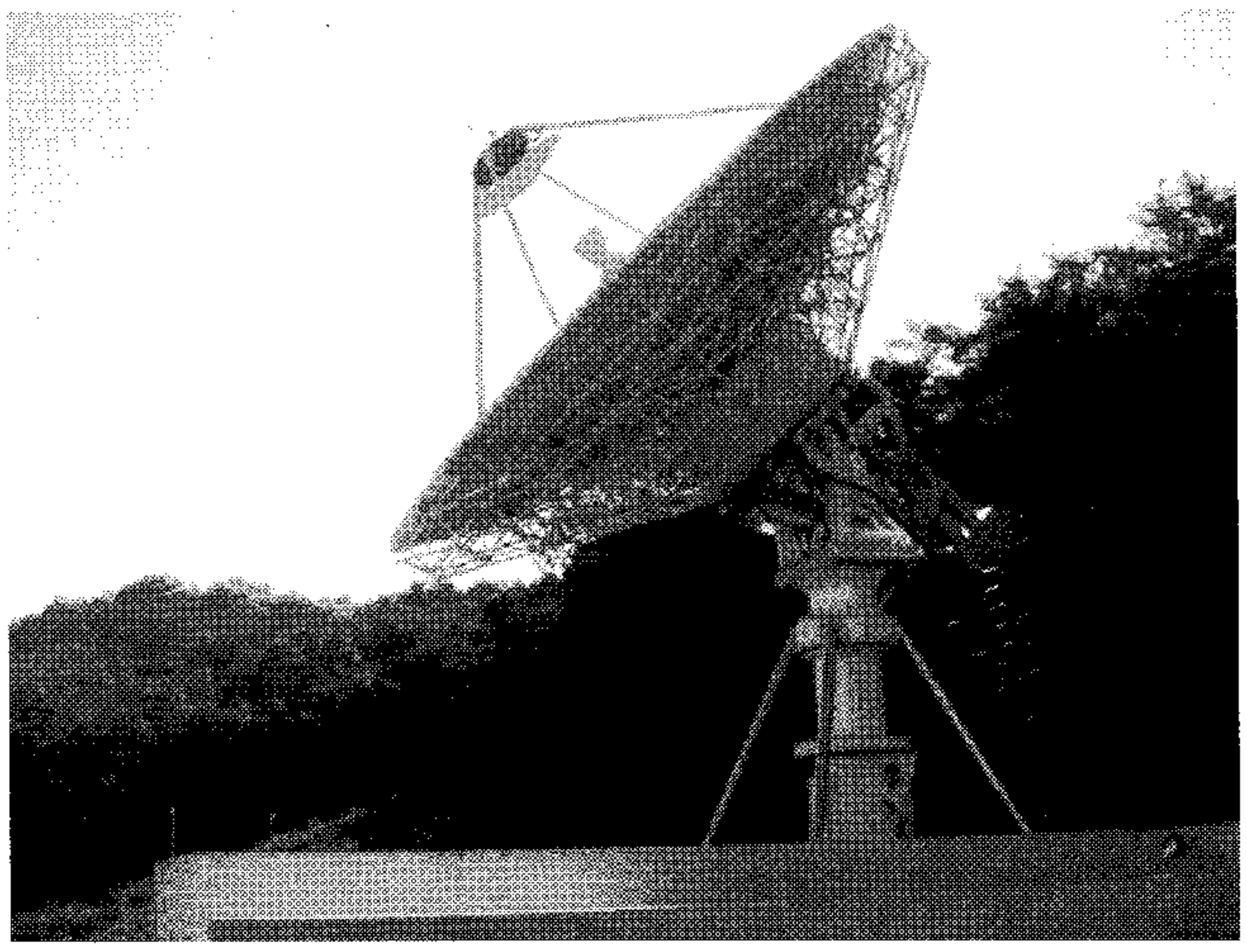


Figure 1 Picture of SOC 13m Antenna at KARI site

Table 1 Major Features of SOC 13m Antenna

Item	Major Characteristics	
Satellite Support	Geostationary Satellite	
Tracking	Autotrack and Program Track	
Reflector	13m L-, S-Band Cassegrain	
	L-Band	S-Band
Frequency		
Receive	1670 to 1710MHz	2025 to 2110MHz
Transmit	Not Applicable	2200 to 2290MHz
Polarization		
Data Channel	RHCP & LHCP	RHCP & LHCP
Track Channel	Not Applicable	RHCP/LHCP
Transmit	Not Applicable	RHCP/LHCP

Faraday rotation can change the direction of linear polarization. It means that the north-south direction of linear polarization can be turned as east-west direction. In that case, the acquisition of SD can be lost if auto-alignment function is not equipped in the receiving antenna. To cope with the limitation in linear polarization, SOC 13m antenna is designed to receives SD through two orthogonal polarizations, namely, RHCP (Right-Hand Circular Polarization) and LHCP (Left-Hand Circular Polarization). Thanks to the circular polarization, SOC 13m antenna has a benefit of no misalignment despite of Faraday rotation. However, there is always about 3dB of loss in the communication link when circular-polarized antenna is used for receiving the linear-polarized SD. To cope with the 3dB of loss caused by polarization discrepancy, diversity design at SOC 13m antenna is described in this paper. In addition, this paper presents the test configuration and results to verify the performance of the designed diversity combining.

2. POLARIZATION LOSS FACTOR

Figure 2 describes polarization loss caused by polarization discrepancy between transmitting antenna and receiving antenna.

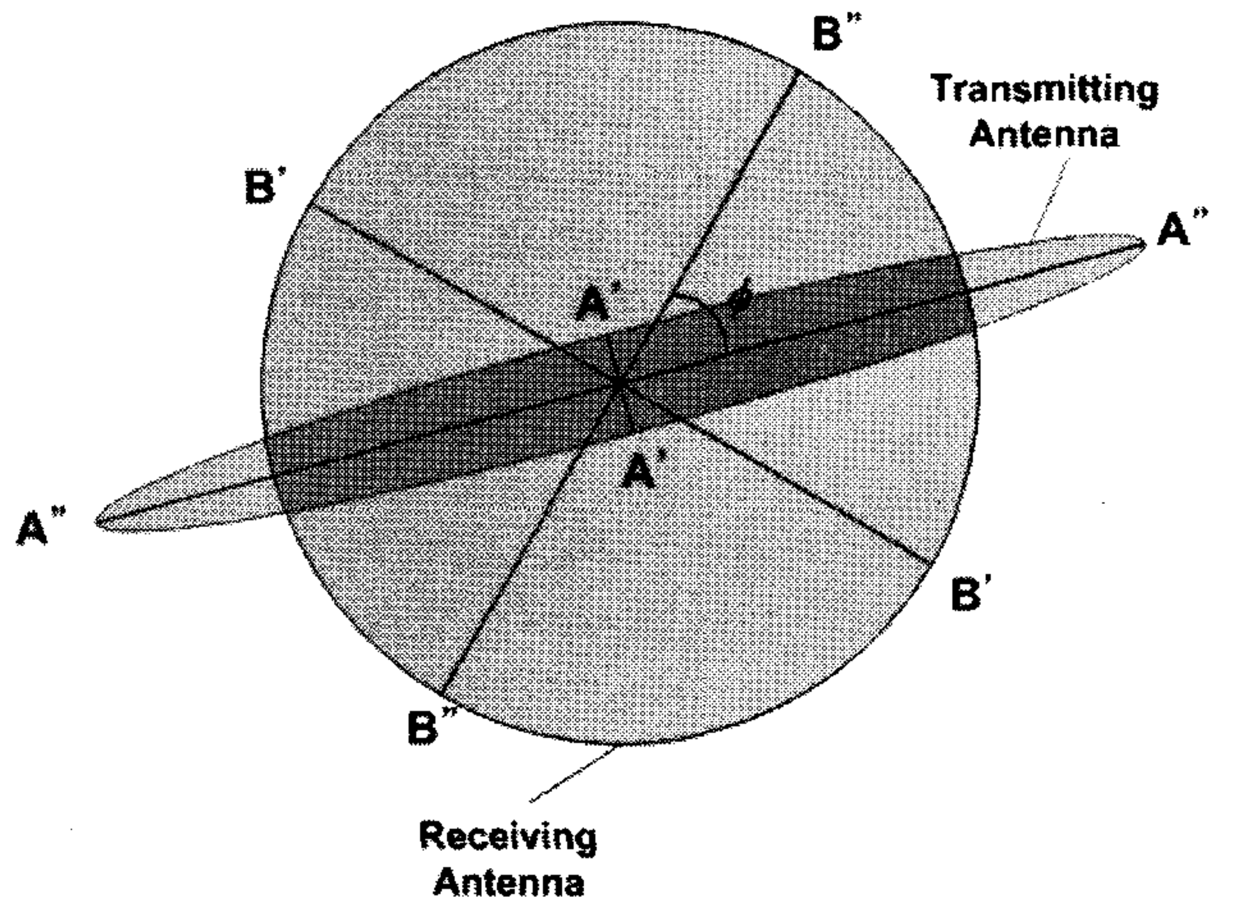


Figure 2 Polarization Loss Factor

When it comes to estimate the polarization loss, two parameters, axial ration and tilt angle, are considered. Axial ratio is the ratio of major axis to minor axis in the shape of polarization while tilt angle is the angle difference between two major axis of transmitting antenna and receiving antenna. Based on two parameters, Polarization Loss Factor (PLF) can be calculated by following equation.

$$PLF = \frac{\left(1+AR_1^2\right)\left(1+AR_2^2\right)+4AR_1AR_2+\left(1-AR_1^2\right)\left(1-AR_2^2\right)COS(2\phi)}{2\left(1+AR_1^2\right)\left(1+AR_2^2\right)}$$

Here is AR_1 is the axial ratio of transmitting antenna, AR_2 is the axial ratio of receiving antenna, and ϕ is the tilt angle. Considering the worst case, the tile angle is assumed as 90 degree. Since the axial ratio of linear polarization is represented as ∞ while that of circular polarization is 1, the PLF is estimated as 3 dB, meaning that only half of transmitting power can be received at receiving antenna. Therefore, it is expected that half of SD power transmitted from COMS is received evenly at the RHCP port and LHCP port of SOC 13m antenna. Therefore, it makes sense that these two SD signals should be combined to cope with the 3dB of polarization loss. Regarding the diversity combining with phase shifter, there is very complicated procedure to check the phase difference between two signals of RHCP and LHCP port. That is why this paper presents the diversity combining with MODEM/BB instead of using a phase shifter.

3. TEST CONFIGURATION

Figure 3 shows the test configuration for the verification on diversity design using MODEM/BB.

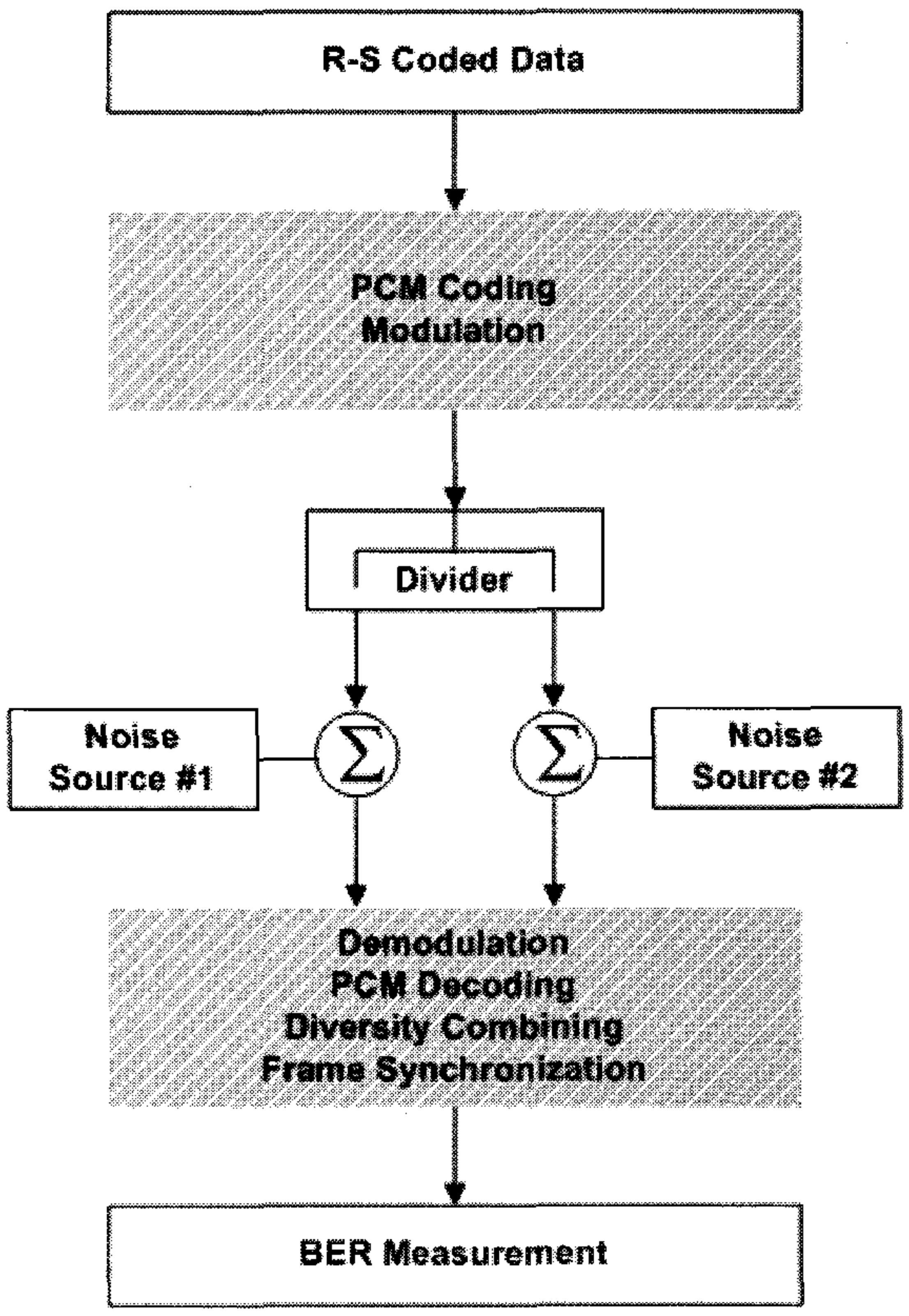


Figure 3 Test configuration for the diversity design

To simulate the SD transmitted from COMS, Reed-Solomon coded data is inputted into MODEM/BB followed by PCM coding and QPSK modulation. Depending on the frame size of SD [1], the Reed-Solomon coded data is structured as followings,

○ R-S Coded Data
MODEM/BB Header + CADU + MODEM/BB Trailer

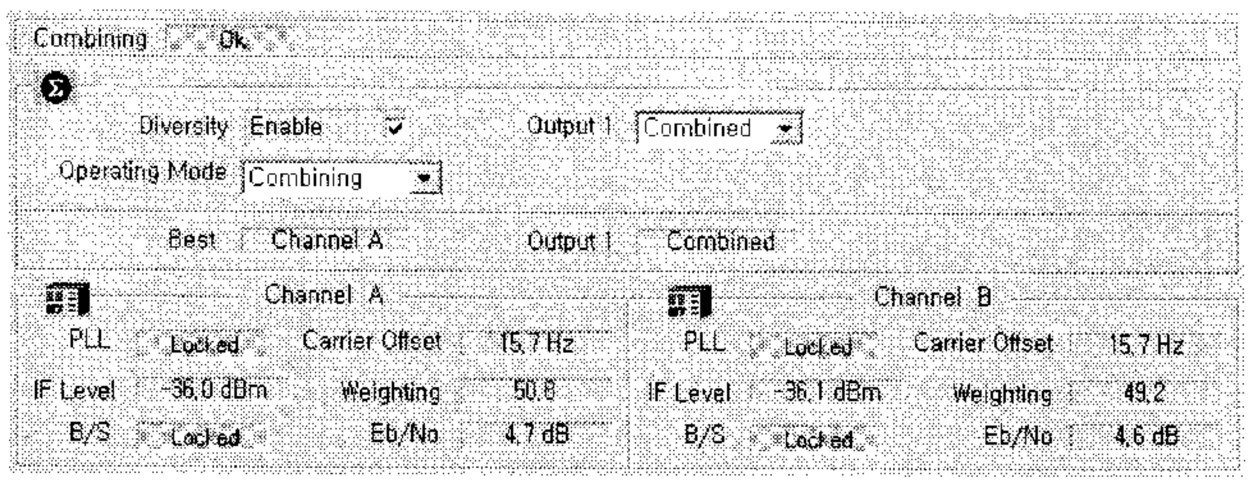
○ CADU
Sync word + Fill data + RS code

○ PN scrambling
Fill data + RS code

Modulated SD in 70MHz is divided by 3dB divider and each signal is combined with independent noise source. These two SD signals with different noise source are represented as two received signals at RHCP port and LHCP port of SOC 13m antenna. MODEM/BB receives two signals and performs QPSK demodulation, diversity combining and PCM decoding. Eventually, BER (Bit Error Rate) or Eb/No of the combined SD is estimated through BER measurement. Combining gain is also calculated from the Eb/No difference between combined SD and non-combined SD.

4. TEST RESULTS

Figure 4 shows the captured GUI (Graphic User Interface) of MODEM/BB when two inputted signals are combined.



Combining Ok

Diversity Enable ☑
Output 1 Combined
Operating Mode Combining

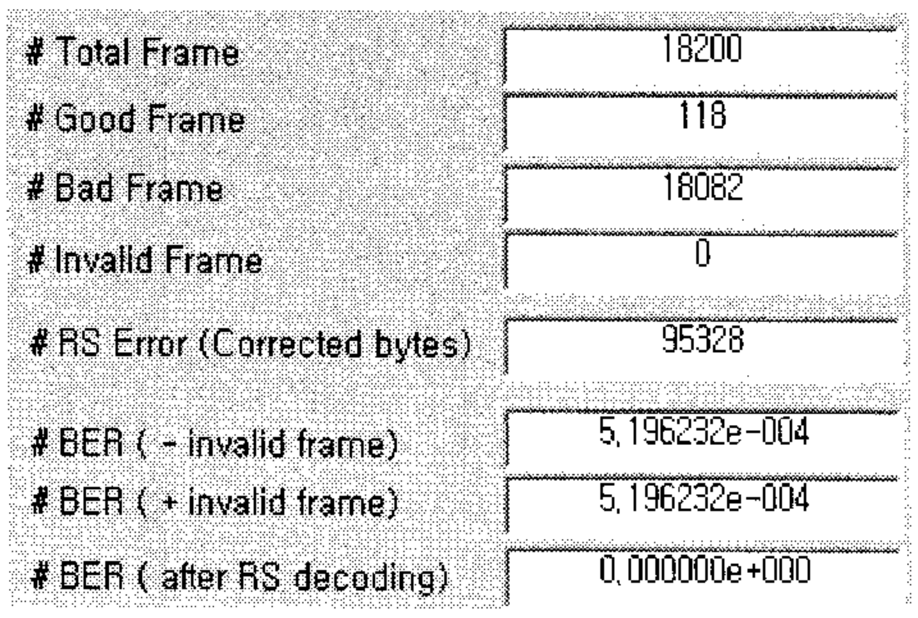
Best Channel A
Output 1 Combined

Channel A
PLL Locked
Carrier Offset 15.7 Hz
IF Level -36.0 dBm
Weighting 50.8
B/S Locked
Eb/No 4.7 dB

Channel B
PLL Locked
Carrier Offset 15.7 Hz
IF Level -36.1 dBm
Weighting 49.2
B/S Locked
Eb/No 4.6 dB

Figure 4 Captured GUI of MODEM/BB

Prior to combining, Eb/No of one of two inputted signals is shown as 4.7dB at channel A while that of the other is displayed as 4.6dB at channel B. Since the operating mode and output is set as combing and combined, it is no doubt that the combined SD is placed at the output of MODEM/BB. Figure 5 shows the results of BER measurement for combined SD.



Total Frame 18200
Good Frame 118
Bad Frame 18082
Invalid Frame 0
RS Error (Corrected bytes) 95328
BER (- invalid frame) 5.196232e-004
BER (+ invalid frame) 5.196232e-004
BER (after RS decoding) 0.000000e+000

Figure 5 Results of BER measurement for combined SD

Before Reed-Solomon decoding, BER of combined SD is shown as about 5.196e-004, which is corresponding to 7.31dB of Eb/No. Thus, combining gain is proved as 2.61dB by subtracting 4.7dB of single SD from 7.31dB of combined SD.

5. CONCLUSION

SOC 13m antenna is supposed to receive SD in L-Band through two orthogonal circular polarizations, RHCP and LHCP. Due to the feature of circular polarization at receiving antenna, there is no concern about the misalignment of direction at linear polarization at transmitting antenna. However, 3dB of polarization loss is expected at SOC 13m antenna. To cope with the loss, diversity combining is designed in this paper. From the test configuration and results with considering normal operation, the combining gain is proven as 2.61dB and diversity combining is effective way without acquisition loss caused by Faraday rotation.

6. REFERENCE

[1] EADS Astrium 2007, MODCS to Ground ICD (Interface Control Document), *COMS critical design review meeting*, Issue 3, Revision 1, Toulouse, France