ISSN: 9772477798001

Journal of Measurement, Electronic, Communication, and Systems (2016) CS0216~02

www.jmecs.org/vol2

Determination of Operational Threshold for Coding and Modulation Combination to Improve The Quality of High Troughput Satellite in Ka-Band Frequency in Indonesia

M. Pasaribu[1], H. Wijanto[1], and B. Prasetya[1]

[1] *School of Electrical Engineering,Telkom University, Bandung, 40287, Indonesia*

Abstract

The vast enhancement of telecommunication technology has encouraged the increase of demand for more satellite capacity. HTS in Ka-Band frequency, that can deliver more capacity up to 50 GHz, can be a solution. Unfortunately, Ka-Band is susceptible to rain attenuation which is potentially difficult to be implemented in Indonesia because of its high rain rate. But, According to the previous research by Suwadi, Marrudani, and Lye, the combination of coding and modulation technique can be used as a solution to improve the performance of service dealing with rain attenuation.

In this research, the writer will try to improve whether the combination of coding and modulation is also able to improve HTS Ka-Band communication link here in Indonesia with the high rain rate per year and to determine threshold of which the combination of coding and modulation that is best suited to each weather condition, in order to get the minimum required performance with BER min = 10 − 8. The conclusion of this research shows that the quality of HTS in Ka-Band frequency in Indonesia with BER = 10 − 8 can be improved by using QPSK, 8-APSK, 16-APSK, and 9 types of FEC. Furthermore, the 17 pairs of ModCod can be categorized into 8 thresholds that will determine with that ModCod that should be used in order to get the link quality of BER = 10 − 8 for each certain rain condition.

Keywords: HTS, Ka-Band, ModCOd, Rain Attenuation, Satellite

1. Introduction

The vast enhancement of telecommunication technology has encouraged the increase demand for more satellite capacity. But the C-Band frequency filling for Indonesia is has been already filled by other satellite and already fully occupied so there is no chance to develop new capacity. Satellite operators must look at other band frequency that is less orbit-congested band.

According to the research [1], [2], [3], there is a new satellite technology that can deliver higher capacity due to the implementation of frequency reuse technique that can make the satellite deliver wider bandwidth capacity. The new satellite is called High Throughput Satellite (HTS). Furthermore, the implementation of HTS that works Ka-Band frequency in Indonesia has a weakness due to its susceptibility for rain attenuation.

Several studies have improved a technique to improve this problem. The research in 2009 [5] presents the performance evaluation of the adaptive coded modulation as the rain fading compensation method to increase link availability and channel capacity for millimeter-wave fixed cellular systems operating at 30 GHz systems. The research in 2011 [4] is comparing the performance of Ka-Band wireless communication system in tropical area with several channel coding schemes. The Research in 2012 [6] describes that an AMC scheme which utilizes a simple moment based SNR estimator M 2M 4 and punctured convolutional coding for the spectral and quality

ISSN: 9772477798001

improvement for the wireless channel can give gains over fading channels and can prove to be able to give a better image transmission compared with an image that is not using AMC.

From the previous researches, it can be learned that communication link that is susceptible with rain attenuation, especially for the system above 30 GHz, can be improved by combining and modulation technique.

2. The Model Presentation, Data Analysis, and Data Interpretation

2.1 The System Model

The system of Ka-Band HTS system that will be used in this research is described in Fig. 1.

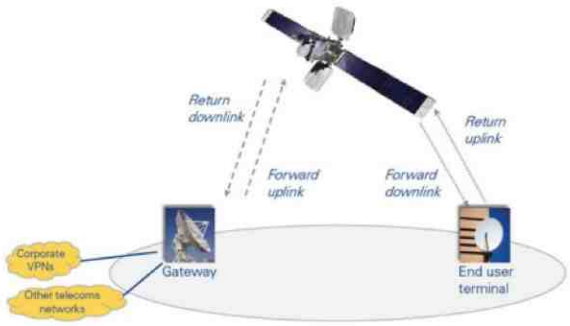

Fig 1. Configuration of HTS System [7]

Table 1. Assumptions of Satellite Parameters

Parameter	Value	Unit
Longitude Position	118	deg
EIRP	57.68	dB
G/T	0.5	dB/K
Pad	18.00	dB
SFD	-102.00	dBW/m^2
Transponder Bandwidth	36.00	MHz
Uplink Frequency	21.135	MHz
Downlink Frequency	18.910	MHz
Operational Band	Ka-Band	

The satellite parameters that will be used in this research is are as follows.

Table 2. Assumption of Gateway and End User Parameters

Parameter	Value	Unit
Gateway Terminal		
Antenna Diameter	9.3	m
Antenna Efficiency	60.00	%
IFL Loss	0.5	dB
End-user Terminal		
Antenna Diameter	0.9	m
Antenna Efficiency	60.00	&
IFL Loss	0.5	dB

2.2 Link Budget Calculation

The research will use the rain rate of BMKG database from 2011 until 2015, which will be categorized into 3 types, there are minimum, average, and maximum. This research will be carried out by calculating the three link budgets between a gateway terminal and an end-user terminal. Each terminal will represent the worst, average, and favorable condition. The worst condition is representing the gateway location that has the highest average rain rate per year. The average condition is representing the gateway location with the rain rate per year equal to the mean value from the highest to the lowest rain rate per year.

The link budget then will be put into further calculation by measuring the performance of each link for each rain condition by using 26 combinations of ModCod based on the DVB-S2 technique. The scenario of the link budget calculation process is shown in Table 3.

From the Table 3 we will get the real data about the HTS implementation quality performance in Indonesia according to the value of C/N total of each link budget. Furthermore, the data will be used to determine the characteristic of the ModCod combination for each rain condition state. By knowing the characteristic, then we can determine the threshold of which ModCod is best suited for each condition that gives the minimum required performance with $BER = 10^{-8}$.

ISSN: 9772477798001

Table 3. Link Budget Scenario

No	Rain Rate (mm/hr)		C/N_{req}	C/N_{req}	Quality
	Gate-way	End-user			
1	0	0	Based on Ideal Calculation	Based on Link Budget with real attenuation calculation	
2	Min.	0			
3	Avg.	0			
4	Max.	0			If $C/N_{total} \geq C/N_{req}$ OK
5	0	Min.			
6	0	Avg.			
7	0	Max.			If $C/N_{total} \geq C/N_{req}$ OK
8	Min.	Min.			
9	Avg.	Avg.			
10	Max.	Max.			

This is the example of the theory overview. In this section, generally the author must divide the related theory into a few subsections. In this section, there is an example of figure command, so hopefully it will help the author who wants to put some images that are related to their paper. In this section it will be also explained how to insert any figure in your manuscript.

2.3 Data Analysis and Interpretation

The simulation of the link budget performance of HTS in KaBand frequency will be carried out between the Gateway and the Enduser terminal. There will be 3 link budgets that present the worst, average and favorable condition.

Link Budget for the Worst Condition

The link Medan (Gateway) - Padang (end-user terminal) will represent the performance in the worst condition. The threshold determination to each ModCod for the worst condition follows Table 4.

Link Budget for the Average Condition

In this section, the link that will be calculated between Gateway at Makassar and End-user terminal at Sorong. The threshold determination to each ModCod for average condition follows Table 5.

Table 4.The ModCod Threshold for the Worst Condition

No	Mod	FEC	C/N_{req} (dB)	Rain Rate (mm/hr)
1	QPSK	2/5	2.95	31<RR<44
2	QPSK	1/2	3.27	31<RR<44
3	QPSK	3/5	3.7	31<RR<44
4	QPSK	2/3	4.11	31<RR<44
5	QPSK	3/4	4.53	31<RR<44
6	QPSK	4/5	4.9	31<RR<44
7	QPSK	5/6	5.22	31-0/0-28.6
8	QPSK	8/9	6.98	31<RR≤5.4
9	QPSK	9/10	7.64	31<RR≤5.4
10	8-PSK	3/5	5.95	31<RR≤5.4
11	8-PSK	2/3	6.12	31<RR≤5.4
12	8-PSK	3/4	8.41	5.4 - 5.4
13	8-PSK	5/6	9.99	5.4 - 0
14	8-PSK	8/9	10.72	0<RR≤5.4
15	8-PSK	9/10	11.26	0<RR≤5.4
16	16-APSK	2/3	9.39	0 - 0

Table 5.The ModCod Threshold for the Worst Condition

No	Mod	FEC	C/N_{req} (dB)	Rain Rate (mm/hr)
1	QPSK	2/5	2.95	≥44
2	QPSK	1/2	3.27	0 - 44
3	QPSK	3/5	3.7	31<RR≤44
4	QPSK	2/3	4.11	31<RR≤44
5	QPSK	3/4	4.53	31<RR≤44
6	QPSK	4/5	4.9	31<RR≤44
7	QPSK	5/6	5.22	37 - 0
8	QPSK	8/9	6.98	5.6<RR≤37
9	QPSK	9/10	7.64	5.6<RR≤37
10	8-PSK	3/5	5.95	5.6<RR≤37
11	8-PSK	2/3	6.12	5.6<RR≤37
12	8-PSK	3/4	8.41	5.6 - 5.6
13	8-PSK	5/6	9.99	0 - 5.6
14	8-PSK	8/9	10.72	0.4 - 0
15	8-PSK	9/10	11.26	0<RR≤0.4
16	16-APSK	2/3	9.39	0 - 0

Link Budget for the Favorable Condition

The link that will be calculated is between the Gateway in Denpasar and the End-user terminal in Mataram. The threshold determination to each ModCod for the favorable condition is as follows.

Table 6. The ModCod Threshold for the Favorable Condition

No	Mod	FEC	C/N_{req} (dB)	Rain Rate (mm/hr)
1	QPSK	2/5	2.95	20<RR<44
2	QPSK	1/2	3.27	20<RR<44
3	QPSK	3/5	3.7	20 - 20
4	QPSK	2/3	4.11	20<RR<40
5	QPSK	3/4	4.53	20<RR<40
6	QPSK	4/5	4.9	20<RR<40
7	QPSK	5/6	5.22	20<RR<40
8	QPSK	8/9	6.98	20<RR<40
9	QPSK	9/10	7.64	20<RR<40
10	8-PSK	3/5	5.95	20 - 0
11	8-PSK	2/3	6.12	0 - 17
12	8-PSK	3/4	8.41	0.01<RR<17
13	8-PSK	5/6	9.99	0.01<RR<17
14	8-PSK	8/9	10.72	0 - 0.01/ 0.5 - 0.5
15	8-PSK	9/10	11.26	0-0 / 0.5-0

From all link budget calculations for the worst, average and favorable condition, we can find out the threshold of the minimum ModCod that can still give C/NT OT AL higher than C/N required for each rain condition as shown in Table 4-6. The threshold of each condition apparently is almost the same either both locations are in the same beam coverage or in different one. The comparison of three configurations is as follows. For instance, Eq. (1) is used to calculate a response surface as shown in Table 7.

3. Conclusions

This research has been carried out as a gesture to anticipate the future plan of the High Throughput Satellite (HTS) implementation in Indonesia that has high rain rate. The HTS will work in the frequency of Ka-band that is very susceptible to rain attenuation. From this research, the quality of HTS in Ka-Band frequency in Indonesia with BER = 10 − 8 is can be reached by using the highest possible Modulation and Coding (ModCos) 16-APSK, FEC 3/4 when the condition is clear sky (rain rate = 0 mm/hr), and ModCod QPSK, FEC 1/2 when the rain rate condition is higher up to 44mm/hr.

When the rain rate is higher than 44 mm/hr, the BER performance of the link will be lower than 10 − 8 or it will totally be down for certain period of time. According to the link budget calculation with 3 link samples in the worst, average, and favorable condition from the total 26 pairs in DVB-S2 technique, there are only 17 pairs of ModCod that can be used to improve the HTS performance in Indonesia that consists of 3 types of the modulation (QPSK, 8-APSK, 16-APSK) and 9 type of FES.

Table 7. The ModCod Threshold Detemination

MOD	FEC	Gateway - Enduser Rain Rate (mm/hr)			Threshold
		Worst	Avg	Favor	
QPSK	2/5				
QPSK	1/2		0-44		Th-1
QPSK	3/5			20-20	
QPSK	2/3				Th-2
QPSK	3/4				
QPSK	4/5		37-0		Th-3
QPSK	5/6	31-0 / 0 - 28.6			
QPSK	8/9				Th-4
QPSK	9/10				
8-PSK	3/5			20-0	Th-5
8-PSK	2/3			0-17	
8-PSK	3/4	5.4 - 5.4	5.6-5.6		Th-6
8-PSK	5/6	5.4-0	0-5.6		
8-PSK	8/9		0.4-0	0-0.01/ 0.5-0.5	Th-7
8-PSK	9/10			0-0/ 0.5-0	
16-APS K	2/3	0-0			Th-8
16-APS K	3/4		0-0		

The 17 pairs of ModCod can be categorized into 8 thresholds that will determine which ModCod should be used in order to get the link quality of BER = 10 − 8 for each certain rain condition.

Acknowledgment

This work is supported by School of Electrical Engineering Telkom University, Indonesia

Nomenclature

C/N : Carrier to Noise Ratio

AMC : Adaptive Modulation and Coding

Reference

[1] Iida, Takeshi, 2008, "Satellite Broadband System: Its Needs and Technology", IEEE

[2] Fenech, H., Tomatis, A., Amos, S., Soumpholphakdy, V., & Serrano-Velarde, D., 2012. "Future High Throughput Satellite Systems", IEEE

[3] Vidal, O. et. Al., 2012, *Generation High Throughput Satellite System*. IEEE.

[4] Maruddani, B., Kurniawan, A., Sugihartono & Munir, A., 2011, "Performance Evaluation of Ka-band Satellite Communication System in Rain Fading Channel at Tropical Area", International Conference on Electrical Engineering and Informatics, Indonesia

[5] Suwadi, Hendrantoro. G. & Wirawan, 2013, "Performance of Various Combining Techniques and Adaptive Coded Modulation in Milimeter-Wave Fixed Cellular Systems under The Impact of Rain Attenuation in Indonesia", IEEE

[6] Lye, S. C. K., Tan, S.E., Siew, Z. W., Yew, H. T., & Teo, K. T. K., 2012, "Analysis and Performance Measurement of Adaptive Modulation and Coding", IEEE International Conference on Control System, Computing and Engineering, Malaysia.

[7] Swinford, R. and Grau, B., 2015, "High Throughput Satellites". Little, A. D.