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Optimization Info Rate Using APSK Modulation Scheme for Delivery GSM ABIS over Satellite Communications

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Abstract - **Mobile operators move quickly from 2G GSM networks in urban areas to remote rural areas, which are 2G networks by offering voice connectivity. As a result, more and more technology is optimizing cellular operators that reduce and perform bandwidth efficiency that will be implemented. The optimization solution for this cellular operator produces voice communication on GSM, in a cost-effective application for satellites. This paper discusses and applies to creating GSM links via satellite communication. The ABIS interface on GSM, which is defined between the Base Transceiver Station (BTS) of GSM remote cells and the Base Station Controller (BSC), is considered here to be transferred via GSM communication with the Modulation and Coding scheme 16 APSK 5/6. The MODCOD scheme determines the efficiency of what MHz is needed to send one Mbps. The efficiency value achieved by allocating, bandwidth (MHz) generated by 1.0 Mhz is an efficiency of 3.222 [bit / baud]. And Info Data Rate is generated from the value (Mbps) of 3,175. The highest traffic intensity with the value of Traffic Volume (Hours) = 3.5, Traffic Intensity (Erlang) 0.145833333. While the lowest traffic intensity with the value of Traffic Volume (Hour) = 2.6, traffic intensity = 0.108333333 (Erlang). The value obtained on Traffic Volume and Traffic Intensity is 0.1%. Service levels are very good at grade of service, because of the small possibility of access fail. Calculation of the availability of link network availability links, using ACM 16APSK LDPC 5/6 techniques that can increase up to 100%.**

Keywords-2G, Grade of Service, ABIS, APSK, ACM, MODCOD, LDPC, Roll-off

I. INTRODUCTION

Cellular phones bring clear economic and social benefits to users, especially in rural Indonesia. When 2G GSM cellular phones become more affordable, ownership has reached a staggering number, even in the most remote areas of the world. However, network coverage is ten shortages of low population density and low-income rural areas in developing countries, where large telecommunications often delay the use of expensive infrastructure [1]. Voice communication is very important in rural areas in developing countries. Lack of transportation infrastructure, high illiteracy rates, and migrant workers are some of the characteristics of rural areas that emphasize the need for real-time voice communication [2]. In addition, even more than in developed countries, voice communication in developing countries is a strong supporter of political freedom [3], economic growth [4] and efficient health care [5].

This paper proposes efficiency for adaptive and returning link forwarding coding and modulation (ACM). The detailed design for the ABIS GSM 2G communication satellite system to improve network reliability is in the form of effective IP system speed and throughput. In the ACM scheme, the coding scheme and modulation are changed as much as the channel can provide depending on the quality of the communication link. To implement the ACM forward link and return link system in C-band, channel prediction and modulation for the coding decision method are proposed and applied. Important points to consider when designing satellite communication systems with adaptive ACM modulation and modulation schemes are round-trip time (RTT) and service coverage. In satellite communication systems, RTT and system processing delays from satellite links take more than 500-700 m/s. In addition, network satellite communications cover a large area, and each terminal experiences different channel conditions. The MODCOD standard includes the standards that will be proposed and implemented is the MODCOD scheme 16 APSK 5/6. In this paper we will implement amplitude phase shift keying (APSK), a modulation method in which large capacity data can be transmitted without additional bandwidth. APSK is the right method for satellite communication and space using high power amplifiers such as traveling wave tube amplifiers (TWTA) [6]. The APSK modulation method can have various types of MODCOD according to the level. 16APSK 8/9-16APSK 5/6-16APSK 4/5-16APSK 4/5-16APSK 3/4-16APSK 2/4-16APSK 2/4-16APSK 2/ 4-16APSK 2/ 4-16APSK 2/ 4-16APSK 2/3 [7] [8]. In this paper, for reliable telemetry, ABIS 2G GSM transmission technology in space communication at C-Band, we propose ACM levels that apply LDPC recommended by CCSDS and 5/6 to overcome performance losses due to weakening transmission. For this purpose, the optimal ring ratio for 5/6 signals is investigated for each LDPC, and the required E_S / N_0 is obtained for all modulation methods by analyzing the bit error rate (BER). Finally, we decide on the ACM level through the spectral efficiency required by E_S / N_0 and Forward Error Correction (FEC). Getting communication link margins to improve network reliability is an effective IP rate (bit rate) efficiency (Mbps/Mhz) system Grade of Service (GOS) and network link availability.

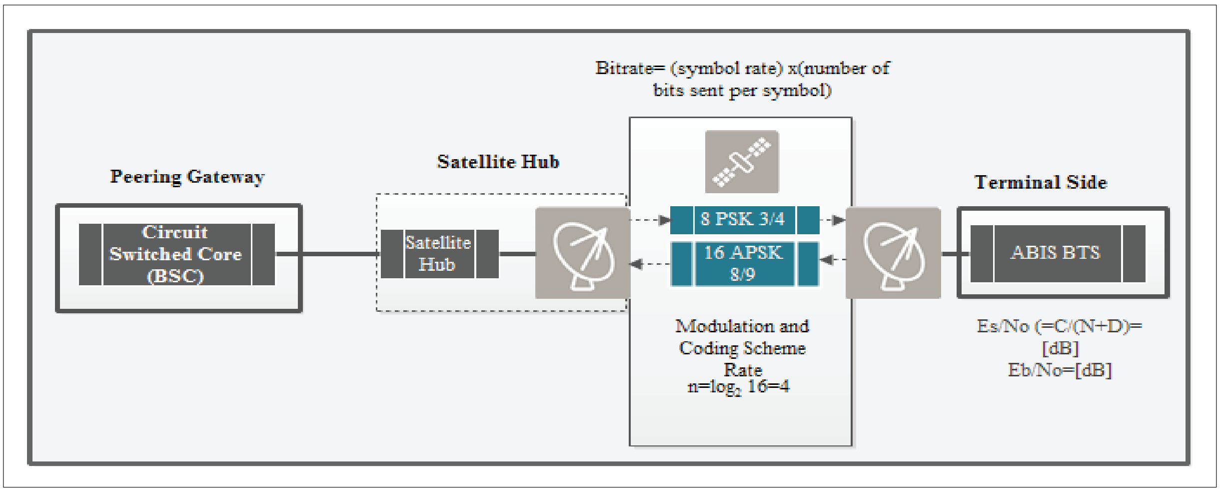

Figure 1. ACM Schema for GSM 2G in Rural Area

II. PROPOSED METHOD CONFIGURATION

A. ACM (Adaptive Coding and Modulation) Level

Adaptive coding and modulation (ACM) was then introduced to the DVB-S2 (second-generation) standard for broadband satellite network service profiles, replacing conventional DVB-S with constant coding and modulation (CCM). The use of ACM makes it unnecessary for service operators and system designers to exchange the desired link availability and throughput. When compared with links designed using fixed coding, ACM can increase strong link throughput by allowing it to dynamically adjust with modulation coding (MODCOD), which is less powerful so as to produce higher throughput in bright sky conditions [9]. In this paper, the use of ACM in 2G GSM communication will be applied. The ACM technique that will be proposed is as follows:

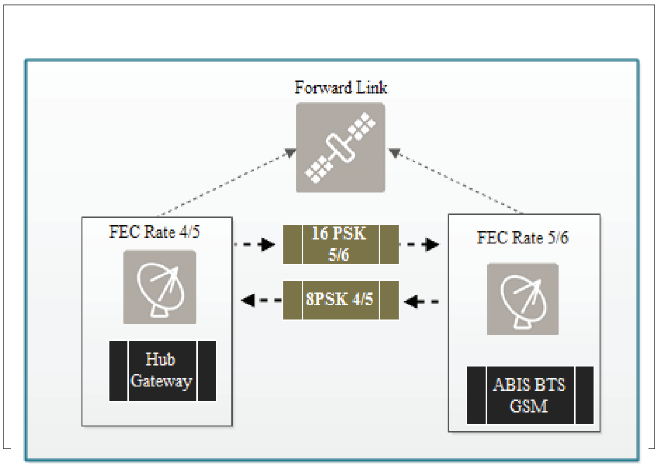

Figure 2. Architecture for providing ACM GSM 2G (16APSK LDPC$^{5/6}$)

B. MODCOD Decision Algorithm

In the scheme of cases where MODCOD is to be selected, MODCOD ranking that is lower than required is still safe. However, it can reduce the spectral efficiency of the efficiency value. In addition, a higher MODCOD with a small fade margin is selected for ACM operations. This MODCOD can save capacity and efficiency on satellite throughput values at bits/s, but the possibility of successful packet delivery can be reduced [10][11]. Therefore, the MODCOD decision algorithm must be applied. In this paper, the MODCOD to be applied 16APSK LDPC 5/6 is used for the ACM scheme. As shown in Figure2, the threshold margin E_s/N_o (=C/ (N+D) [dB] is applied to avoid MODCOD changes that often occur.

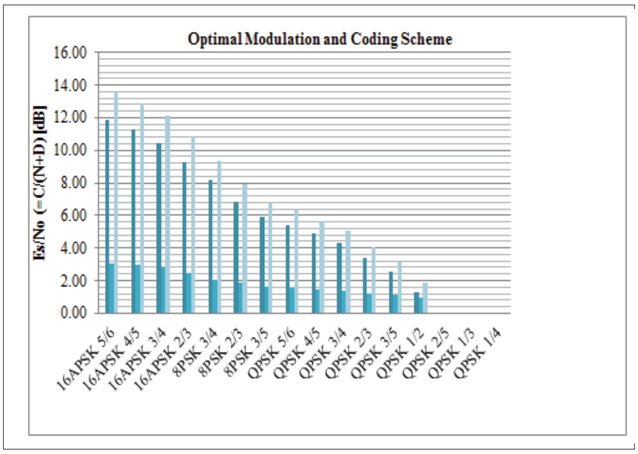

Figure 3. Available MODCOD Optimal Ranking 16APSK FEC Rate 5/6

C. FEC Code and Modulation Schema

FEC (Forward Error Correction) mechanisms can detect and correct a (certain) number of errors without retransmitting the data stream; this is done utilizing coded extra bits added to the transmitted data blocks [12]. In the FEC technique, the rate of information that will be sent is a reference for determining the data rate and symbol rate, where the data rate will be greater through the ratio number determined and compared to the rate of information, or information rate. The FEC Rate has a value of 1/4, 1/3, 2/5, 1/2, 3/5, 2/3, 3/4, 4/5, 5/6, 8/9 and 9/10. The FEC ranking that will be applied to the paper is 5/6 with APSK modulation, with following equations:

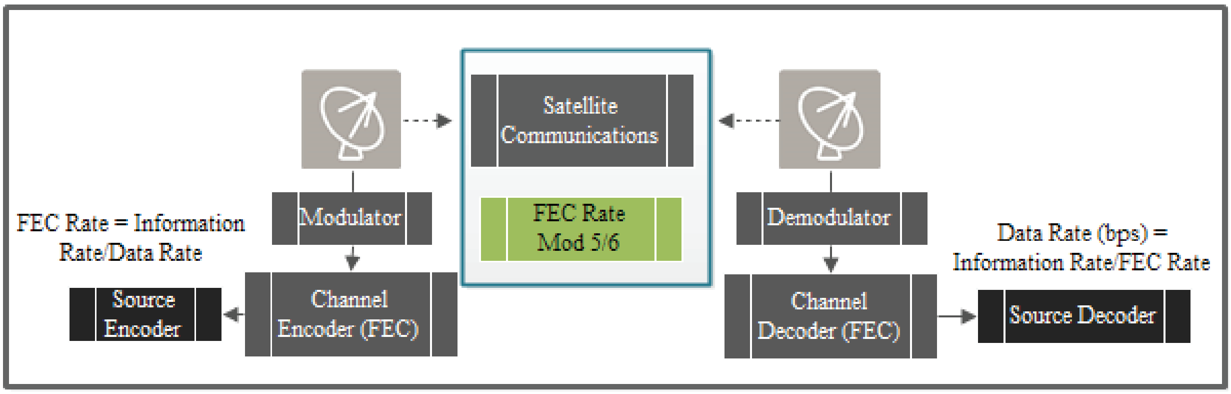

Figure 4. FEC Code and Modulation Schema

$$FEC\ Rate = \frac{Information\ Rate}{Data\ Rate} \quad (1)$$

Information rate (IR) is the rate of information generated through transmission connectivity from the remote to the satellite hub in Mbps units, while the data rate is the rate of data to be transmitted also with Mbps units, based on the above equation of course the data rate is greater than the information rate. Based on the FEC-Rate ratio, Data-Rate is determined based on equation 3:

$$Data\ Rate\ (bps) = \frac{Information\ Rate}{FEC\ Rate} \quad (2)$$

Figure4. FEC decoder at the receiver uses the knowledge of these rules to identify and, if possible, correct any errors that have accrued during transmission. FEC codes take a group of g data packets and generate h= n−g parity packets. The total block size n consists of the g data and h parity packets. Once the parity packets have been computed, the block is then transmitted. The block format may vary according to the application. Typically, one has to be concerned with the following parameters [13]:

g Number of data packets per block

h Number of parity packets per block where h= n−k"

n Number of total packets per block

R % of total BW used for redundancy

TFEC FEC latency

III. PROPOSED METHOD RESULT

Methodology that will be applied is in term of efficiency for adaptive coding and modulation (ACM) forward link and return links, from terminal node (remote) to satellite hub. To continuously sending data GSM 2G traffics connected via satellite, with error-free space communication. The following is explained the methodology that will be applied is as follows:

A. System Model Integration and Optimization with 16 APSK

1. Amplitude and Phase-Shift Keying 16 (APSK) Modulation Scheme

APSK modulation scheme is in many variations (4 + 12 APSK, 5 + 11APSK, 6 + 10 APSK, 1 + 5 + 10 APSK, 4 + 12 + 16) having different signal constellations. Among them, 4 + 12 APSK and 4 + 12 + 16 APSK, which is a modulation scheme achieving the best performance in terms of considering nonlinear amplifier characteristics, adopted in DVB-S2 and they are denoted as 16APSK and 32APSK techniques. In the research this paper will be applied, the 16APSK modulation constellation (see Figure 5) is consists of two concentric rings with a uniform distance of 4 and 12 PSK points with the radius of the inner ring R1 and outside the R2 ring. Where voice data on GSM 2G communication, will be passed with the APSK Modulation Scheme technique [14].

$$\gamma = \frac{R_2}{R_1} \quad (3)$$

The ratio of the outer and inner radius can be adjusted according to the FEC channel coding method that allows optimization of performance in accordance with the characteristic channel.

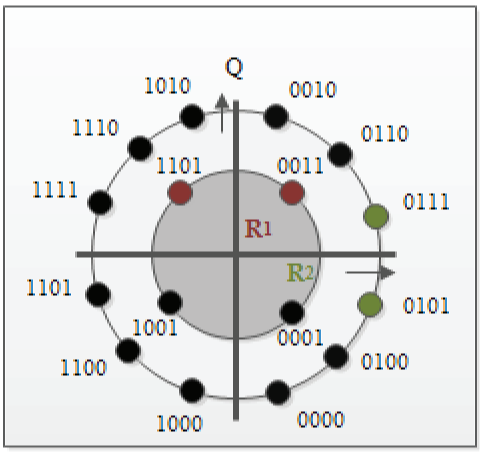

Figure 5. Proposed 16-APSK Constellation Scheme

Based on figure 6, the 16APSK constellation diagram, with the number of points is 16, then the data bits can be

defined each point can be obtained through calculation as follows:

$$n = \log_2 16 \qquad (4)$$
$$n=4$$

APSK 16 modulation, each one carrier wave can define 4 bits of data. In the calculation of 16APSK modulation to be applied, an input symbol rate is used to determine the amount of data that can be transmitted every second on connectivity from the remote to the hub [15].

In this paper, we assume the ACM system, to continue to send telemetry voice to the GSM 2G, with a satellite bandwidth capacity of 1.0 Mhz. with these capacities, parameter values will be analyzed in transmission modulation, which will produce and improve network reliability, an effective IP rate (bit rate) efficiency and Grade of Service (GOS) system.

2. Link Budget Calculation (Modulation Code)

1. *Efficiency Output Data ($\frac{Mbps}{MHz}$)*

On the importance of efficiency the bandwidth required in MHz for the rate of information provided is directly related to the modulation and coding scheme (MODCOD).

- The higher the modulation sequence (2^n), the less bandwidth is required.
- The higher the Forward Error Correction (FEC) ratio, the less bandwidth is required.
- Other parameters also matter: roll-off factor (α). The roll-off factor is a measure of the excess BW of the filter.

The efficiency is defined as the ratio $\frac{Mbps}{MHz}$ that is the number of Mbps that can be transmitted in a given MHz. The unit is bit per second. The higher the efficiency, the more cost-effective a service is:

$$BW = \frac{IR\ X\ (1+\alpha)}{n\ x\ FEC\ x\ RS} \qquad (5)$$

Table 1 is the result of the Info Data Rate efficiency that results from the value (Mbps) of 3.068. On the other hand, the efficiency value in the bandwidth (MHz) 1.0 produced is efficiency is 3.222 [bits / baud]. With calculation calculations as follows: 3.068 Mbps link using APSK 5/6 (order 4 = 2^4), with 5% roll-off factor.

- Required bandwidth is: $1 \times (1 + 0.05) \times \frac{6}{5} \div 4 = 1.00\ MHz$.
- Efficiency is 3.222 [bits/baud]

Table1. Result Output info data rate

Output Info Data Rate Result		
Info rate	[Mbps]	3.068
Baud rate	[M baud]	0.952
Bandwidth	[MHz]	1.0
Efficiency	[bits/baud]	3.222
	[bits/Hz]	3.068
Effective IP efficiency	[bits/Hz]	3.020
Info rate	[Mbps]	3.068
Info rate Efficiency	[bits/Hz]	3.068
Raw data rate	[Mbps]	3.175
Raw data efficiency	[bits/Hz]	3.175

2. *Link Availability*

In this paper, link availability, will produce a large percentage of system continuity in keeping the link running (uplink and downlink). Where the total link shows the total time when the communication link can run well. Fail links indicate the total time when a communication link was interrupted or dropped.

Link availability is stated in the following equation:

Link end to end(uplink and downlink)

$$Availability(\%) \frac{\sum \begin{matrix}\text{Link Total-}\\ \text{-Total Link is Lost}\\ \text{(up and down)}\end{matrix}}{\sum \text{ Link Total (up and down)}} * 100\%$$

Table 2. Link Availability

Link Availability Result			
Total Link (Minutes)	Downtime Link Lost (Minutes)	Down Percentage	Availability
8640	0	0%	100%

3. *Calculation of Network Traffic*

Multi Router Traffic Grapher (MRTG), is a facility of monitoring tools used. Total bandwidth usage data in units of bits in an observation period. The volume of traffic in hours can be determined by dividing the total bandwidth, during an observation period with the average bit rate on each channel. Calculations are used by the formula:

$$Traffic\ Volume = \frac{Average\ Total}{Bit\ Rate\ Bandwidth} \qquad (6)$$

Then, the value of traffic intensity in an observation period is obtained by using the equation:

$$\textit{Traffic intensity} = \frac{\textit{Traffic volume}}{\textit{Period}} \quad (7)$$

Grade of service value (GOS) is taken at the busiest hour on 2G GSM voice traffic. Table 3 shows the daily traffic intensity value used on remote Node B, on the 2G GSM voice traffic that is applied. The highest traffic intensity occurs on 4/6/2019. While the lowest traffic intensity occurs on 4/1/2019.

Table 3. Daily Traffic Intensity

Result of Traffic Intensity		
Daily Period	Traffic Volume (Hours)	Traffic Intensity (Erlang)
Monday, April 01, 2019	2.6	0.108333333
Tuesday, April 02, 2019	3.2	0.133333333
Wednesday, April 03, 2019	3.1	0.129166667
Thursday, April 04, 2019	3.4	0.141666667
Friday, April 05, 2019	3.4	0.141666667
Saturday, April 06, 2019	3.5	0.145833333
Sunday, April 07, 2019	3.4	0.141666667
Monday, April 08, 2019	3.4	0.141666667

IV. RESULT AND PERFORMANCE EVALUATION

1. Link Budget Calculation

A. *Index ACM Info Rate Efficiency Output Data($\frac{Mbps}{MHz}$)*

Index ACM Info rate Efficiency Output Data (Mbps/MHz) parameters in this implement is done by MRTG monitoring, it can be seen info rate (Mbps) values generated in the transmission connectivity from the Node-B (ABIS BTS) source to the Backhaul Satellite Hub.

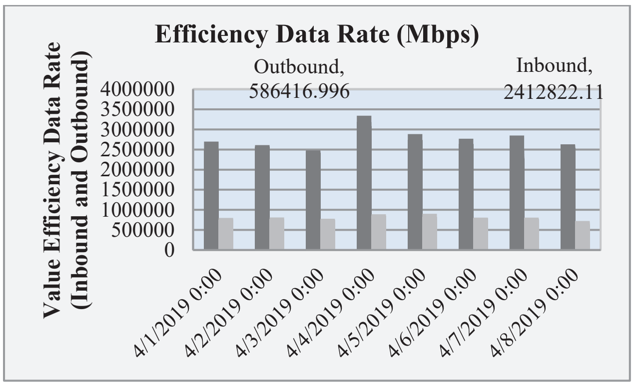

Figure 6. Index ACM Info rate Efficiency Output Data (Mbps/MHz)

Figure 6 shows the result of the Info Data Rate efficiency that results from the value (Mbps) of 4,138. On the other hand, the efficiency value in the bandwidth (MHz) 1.5 Mhz produced is efficiency is 2,896 [bits/baud]. With calculation calculations as follows: 4.13 Mbps link using APSK 3/4 (order 4 = 2^4), with 5% roll-off factor.

- Required bandwidth is: $\frac{1}{2} \times (1 + 0.05) \times \frac{6}{5} \div 4 = 0.500\ MHz$.
- Efficiency is 3.222 [bits/baud]

2. LINK AVAILABILITY

Figure 7 shows the results of the link availability calculations, using the ACM 16APSK LDPC$^{5/6}$ technique. The use of ACM with total links applied for 6 days and converted to minutes. At that time, 11520 minutes did not break the link. After passing the calculation, the network link level is obtained as long as the total link is connected to 11520 minutes, able to experience improvements reaching 100%. This has met the standards for the feasibility of using the transmission technology (4G) communication connectivity.

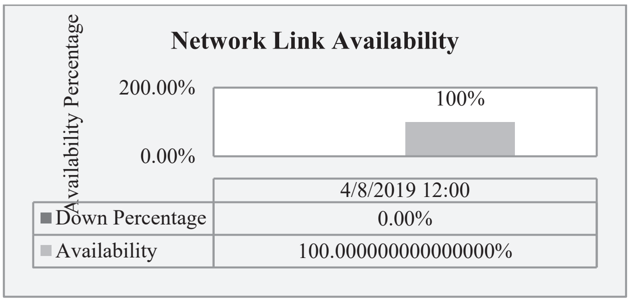

Figure 7. Network Link Availability (A-uplink and A-downlink)

Link Availability:

- Uplink (%)
- Downlink (%)
- End to End Link = 100-[(100-Au)+(100-Ad)]

End to End Link = 100%.

3. Network Traffic (Traffic Volume and Traffic Intensity)

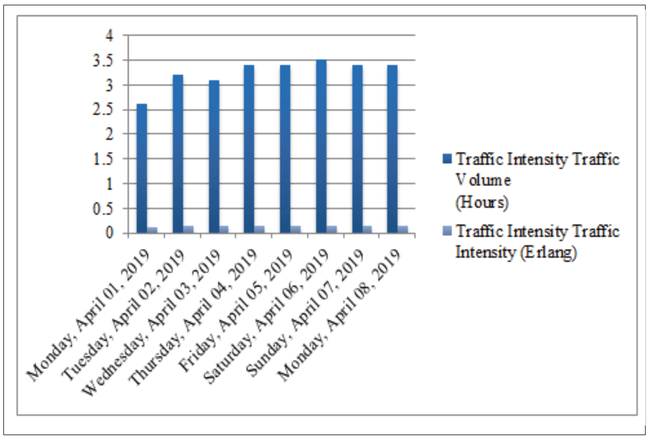

Figure 8. Network Link Availability (A-uplink and A-downlink)

Analysis of bandwidth usage is by monitoring for 1 week. Weekly data in Figure 8, obtained using MRTG is a sample of the average value of 1 hour of bandwidth usage in a week. Daily bandwidth usage analysis is carried out for 8 days, from Monday, April 01, 2019 until Monday, April 08, 2019. Therefore, the observation period of bandwidth usage for 8 days is 192 hours. In Figure 8, the daily bandwidth usage data is displayed in graphical form. These data are used to find the average volume value of the traffic generated, using equation 7. Table 2 shows the daily traffic intensity value used on remote Node-B, on the 2G GSM voice traffic that is applied. The highest traffic intensity occurs on 4/6/2019 with value Traffic Volume (Hours) = 3.5, Traffic Intensity (Erlang) 0.145833333. While the lowest traffic intensity occurred on 4/1/2019 with value Traffic Volume (Hours) = 2.6, traffic intensity=0.108333333 (Erlang). The value obtained on Traffic Volume and Traffic Intensity is 0.1%. the grade of service is very good because of the small possibility of access that fails.

V. CONCLUSION

This paper proposes the MODCOD scheme 5/6 on detailed design for satellite communication systems, on communication connectivity for GSM transmission technology (2G). To improve network reliability, link availability and system efficiency throughput. ACM is one of the various techniques used by the satellite industry to help reduce bandwidth costs for customers or users and improve network performance, especially in satellite communications that are implemented. It is a solution that can benefit the connectivity of GSM transmission technology (2G). The MODCOD scheme determines the efficiency that tells you how many MHz is needed to send one Mbps. From the efficiency value achieved by allocating, the bandwidth (MHz) generated by 1.0 Mhz is an efficiency of 3.222 [bit / baud]. And Info Data Rate is generated from the value (Mbps) of 3,175. Then the value of daily traffic intensity is used in the remote Node-B, in the 2G GSM voice traffic applied. The highest traffic intensity occurs on 4/6/2019 with the value of Traffic Volume (Hours) = 3.5, Traffic Intensity (Erlang) 0.145833333. While the lowest traffic intensity occurs on 4/1/2019 with the value of Traffic Volume (Hour) = 2.6, traffic intensity = 0.108333333 (Erlang). The value obtained on Traffic Volume and Traffic Intensity is 0.1%. the level of service is very good at grade of service, because of the small possibility of access failing. Calculation of link availability, using the 5/6 ACM 16APSK LDPC technique that can increase up to 100%. Calculated during the process of sending and receiving from remote eNodeB to earth station satellite backhaul. This is a solution that can benefit the connectivity of transmission technology (2G). The ACM implementation concept is characterized as a solution that enables mobile operators to expand their network coverage in underserved areas, while maintaining quality experience for end users and managing satellite bandwidth costs, in the case of OPEX and CAPEX used for ABIS GSM 2G backhaul.

Our future research will focus on how the LDPC-32 APSK modulation scheme is implemented with the current ABIS GSM architecture, and we will expand our performance comparison approach to run a series of analyzes on various architectural options for example in 2G management based on TDMA Satellite Technology. The Service Quality Results obtained are the efficiency of satellite bandwidth Throughput, Bandwidth Utilization, and need to be re-checked to assess each parameter using the ACM technique.

VI. REFERENCES

[1] Sebesta, J. (n.d.) (2012). Efficient Method for APSK Demodulation 2 APSK Modulation Schemes 4 Decision Method Based on Evaluation of Amplitude and Phase, 187–190.

[2] Kavya, K. (2017). Rural Tele-Communication Using VSAT Technology: A Review. ijpam.eu, 117(18), 155–162.

[3] H. V. Milner. The Digital Divide: The Role of Political Institutions in Technology Difusion. Comparative Political Studies, 39:176 – 199, March 2006.

[4] R. Abraham. Mobile Phones and Economic Development: Evidence from the Fishing Industry in India. In ICTD'06, Berkeley, CA, May 2006.

[5] S. Surana, R. Patra, S. Nedevschi, M. Ramos, L. Subramanian, Y. Ben-David, and E. Brewer. Beyond Pilots: Keeping Rural Wireless Networks Alive. In NSDI'08, San Francisco, CA, April 2008.

[6] Alawwad, F. M., Al-zahrani, Y. A., & Behairy, H. M. (2017). Maximizing System Capacity Using Adaptive Coding and Modulation Techniques for Slowly Fading Channels, 221–226.

[7] Chen, B., Lei, Y., Ber, P., & Ber, P. (2018). Rate-Adaptive Coded Modulation with Geometrically-shaped Constellations. 2018 Asia Communications and Photonics Conference (ACP), 1–3.

[8] Jordanova, L. (2014). Influence of BCH and LDPC Code Parameters on the BER Characteristic of Satellite DVB Channels, 4(1), 591–595.

[9] Ryu, J., Hong, S., & Oh, D. (2013). Forward Link ACM for Satellite Communication Public Test-bed via COMS, 368–369.

[10] Oh, J. R. D., & Hong, H. K. S. (2016). Proposal of an Algorithm for an Efficient Forward Link Adaptive Coding and Modulation System for Satellite Communication, 16(2).

[11] Tarchi, D., Corazza, G. E., & Vanelli-coralli, A. (n.d.) (2012). Adaptive Coding and Modulation Techniques for Mobile Satellite Communications: a State Estimation Approach.

[12] Jain, A., & Singhai, R. (2017). Broadcasting Standards. 2017 International Conference on Recent Innovations in Signal Processing and Embedded Systems (RISE), (Mc), 30‧ 32.

[13] Minoli, D. (n.d.) (2015 Innovations Satellite Communications Technology , ISBN-13: 978-1118984055.

[14] Sebesta, J. (n.d.) (2009). Efficient Method for APSK Demodulation 2 APSK Modulation Schemes 4 Decision Method Based on Evaluation of Amplitude and Phase, 187‧ 190.

[15] Dupak, D. (n.d). (2014). Optimization of 16-apsk by maximizing mutual information criteria in sc-fdma communication systems, 14(1), 3‧ 8.