Investigation of the Effect of Cloud Covers in Satellite Communication

Nweke F. U. PhD

Industrial Physics Department, Ebonyi State University, Abakaliki, Ebonyi State

Abstract: ***The effect of cloud cover in satellite communication was investigated from the data collected at Nigeria Telecommunication Limited, standard "A", earth station, Enugu. Data were collected during moderate and heavy rainy season and moderate and heavy dry season from the signal received by the earth station from China, satellite link BER for Burst 12, and South Africa, satellite link BER for Burst 28. The result showed that cloud cover affects satellite communication and is much prominent during rainy seasons as lots of bad signals and unusable signal were recorded by the earth station. This is attributed to so much water content, moist, fog, dew and dust that is in the cloud by that period of the year and this does not allow signals to be transmitted very well and as such bad, interference and unusable signal results.***

Keyword: Bit error rate (BER), satellite, communication and modulation.

1. Introduction

A communication satellite is a spacecraft that causes broad communication equipment, enabling a communication links to be established between distant points [1]. Satellite that orbits the earth does so as a result of the balance between centrifugal forces and gravitational forces. In 1571 – 1630, Johnonnes Kepler discovered the laws that govern satellite motion. These laws are applied to the artificial satellite launched for communication purposes today [1].

The history of satellite communication was traced to January 28, 1960, where an American Navy publicly demonstrated the first regular satellite telecommunication. The signals were reflected using the moon [2,3,4]. On August 12, 1960, Echo I was launched into the orbit at a height of 1000m. Echo I satellite was the first artificial satellite whose primary purpose was to provide real time of messages and could reflect radio signals. Later, on July 10th, 1962, the Telstar and relay satellite equipped with transponder was launched by American telephone and Telegraph Company [2,3]. These satellites are made to provide full scale communication experiments and test including relaying of telephone and television signals. The satellite receive, amplify and frequency convert the waves radiated from earth station and then return them to the earth. On July, 1963, National Aeronautics and Space Administration, NASA, launched the first successful Syncon into a synchronous orbit. These proved that the synchronous equatorial orbit was achievable and that a satellite in this orbit was suitable for relaying telecommunication signals for uninterrupted service [3]. Then, in August 1964, an international consortium was formed to exploit commercial utilization of communication satellite for international communication. On April 6th, 1965, Early Bird or the Intelsat was launched from Cape Kennedy. The Intelsat satellite was designed to handle all types of communication traffic, including television between Northern America and Europe [2,3]. After this, three successors of early Bird were launched in 1967 to expand the commercial satellite system. In January, 1967, the Intelsat 2 was launched followed by launching of Intelsat 3 in December, 1968, Intelsat 4, 5 in 1971 with a designed capacity of 12,000 voice channels plus television launch in 1979 [2,3,5]. Also April, 1965, Soviet Union developed and launched communication satellite for its domestic system, serving their domestic system. The united State and Canada also have separate domestic system, serving their own domestic system. Then many other countries lease satellite capacity from Intelsat to interconnect their earth station. Recently, about 300 communication satellite, most of them are geostationary in operation connecting the world. The Intelsat VIII series since 1997 can provide three television broadcast and a maximum of 112,250 telephone circuit [3]. The benefit of satellite communication cannot be over emphasized and notwithstanding communication have a lot of hinderers which was investigated in this research.

2. Broadcasting by Satellite

Broadcasting satellites are located in geostationary orbit at an altitude of 3786 km above sea level where signals are transmitted from one earth station to another. Communication satellite acts as relay station in space, and people use them to bounce messages (i.e. telephone calls, TV pictures, internet connections) from one part of the world to another [2,6,7]. Satellite use remote sensing and weather studies to observe planet which often travel in low earth orbit and it can capture very detailed images of the earth's surface.

The satellite must be spin stabilized about an axis at right angle to the equatorial planet, and the aerial must be attached to a de-spin part of the satellite. The de-spinning rate must be such that the aerial is pointing to the earth. The frequencies employed are about 4GHz for the satellite to the earth satellite [2,7]. The ground station consists of tracking dish aerials of 10meter or more in diameter according to the number of channels required. The channel requires two ways such that each ground station will have separate transmit aerial and receive aerial. The modulating method required is frequency modulation (FM) and multi-channel method for television and FDM for telephony and telegraph. A broadcasting satellite has a highly directional aerial that pick up radio signal from the earth and return them by simple reflection [2,7].

3. Satellite Station and Earth Station

Once satellite is launched, there may be no probability of intervention on board in the event of failure. Hence, the satellite components must be very reliable because the transmitter and the vehicle in which they are flown must function for 7 years or more or even without failure [2,6,7]. The satellite condition is monitored on the ground at all times through sensors placed at several strategic points on the spacecraft with telemetry. Then for tracking, transmitter is provided on the spacecraft to monitor launch operations, angular momentum are taken by conventional terrestrial method using ground antenna. Satellite communication require antenna on the transponder and the earth station.

The earth station is the collection of equipment on the surface of the earth used for communication. Earth stations are used to transmit or receive messages from various parts of the world through the satellite [2,6,7].

This paper investigated the effect of cloud cover in satellite communication and the periods of the year were this more pronounced.

4. Data Collection:

Data were collected at Nigeria Telecommunication Limited, Enugu (NITEL) earth station from a signal received on 23rd February, 2005 from China for Burst 121, 18th October, 2005 from South Africa for Burst 28, 4th November, 2005 from South Africa for Burst 28 and 17th May, 2006 from South Africa for burst 28 to satellite standard A earth station NITEL, Enugu for the period covering both moderate dry season and server dry season and moderate rainy season and server rainy season respectively [8].

5. Results and Theory

The satellite bit error rate (BER) for burst 121(China), sub burst 1 for 23rd February, 2005 is shown in Table 1.

The cloud cover effect based on bit error rate received for 18th October, 2005 for satellite link BER for Burst 28, South Africa is shown in Table 2. The cloud cover effect based on bite error rate (BER) for 4th November, 2005 received from satellite link BER for Burst 28 in South Africa is shown in Table 3. The cloud cover effect based on BER for 17th May, 2006 received from satellite link BER for Burst 28 in South Africa is shown in table 4.

The bit error which is the quality measure of good signal is calculated as the total number of error transmitted divided by the total number of bit received [8].
From theory, the BER is graduated thus [8].
Unusable signal is between 1.0×10^{-1} and $1.0 \times 10^{-3.39}$
Poor signal is between $1.0 \times 10^{-3.4}$ and $1.0 \times 10^{-5.9}$
Good signal is between 1.0×10^{-6} and $1.0 \times 10^{-6.9}$
Very good signal is between $1.0 \times 10^{-7.0}$ and $1.0 \times 10^{-8.9}$
Excellent signal is between 1.0×10^{-9} and 1.0×10^{-10}.

6. Discussion of Results

From Table 1 and 2, it was observed that the satellite base station in Nigeria Telecommunication Limited, Enugu received good signals throughout the month of October and better signals throughout the month of February. The month of October in Nigeria marks the beginning of the dry season and month of February is the pick of dry season and hence during such periods the cloud cover which constitute high water content, moist, fog and dust is extremely very low. Therefore, good signals recorded by the earth station were as a result of cloud that is clearer during dry season.

Also from Table 3 and 4, it was observed that the earth station received lots of bad signals and unusable signals during the month of November and May, which marks the end of rainy season and pick of rainy season respectively. During these periods the cloud cover is heavy with a lot of water content, moist, dew, fog and dust in the atmosphere. These could have contributed to the lots of bad signal and unusable signals received by the earth station.

Therefore from the data and its analysis, it is deduced that cloud cover affects satellite communication which is more pronounced during the rainy season than the dry season.

7. Conclusion and Recommendations

The effect of cloud cover on satellite communication was investigated. The results showed that cloud cover actually affect satellite communication and is very much experienced during rainy season as lots of bad signals and unusable signals were recorded by the earth station during such period. The rainy season period constitute a lot of water content and this makes the cloud heavy and not clear for transmission. The signal does not penetrate very well in the cloud and hence results to bad signals, unusable signals and interference.

The satellite should be designed to transmit signals which will withstand cloud cover for efficient transmission and communication throughout the periods of the year.

Table 1: Cloud cover report based on BER for 18th February, 2005

S/N	*Time*	*Bite error rate (BER)*	*Nature of signal*
1	06: 00	$1.0 \times 10^{-6.9}$	Good signal
2	07:00	$1.0 \times 10^{-7.0}$	Very good signal
3	07:30	$1.0 \times 10^{-7.1}$	Very good signal
4	08:00	$1.0 \times 10^{-7.0}$	Excellent signal
5	08:30	$1.0 \times 10^{-6.7}$	Good signal
6	09:00	$1.0 \times 10^{-6.5}$	Good signal
7	09:30	$1.0 \times 10^{-6.6}$	Good signal
8	10:00	$1.0 \times 10^{-6.2}$	Good signal
9	10:30	$1.0 \times 10^{-7.8}$	Very good signal
10	11:00	1.0×10^{-10}	Excellent signal
11	11:30	$1.0 \times 10^{-8.6}$	Very good signal
12	12:00	$1.0 \times 10^{-6.7}$	Good signal
13	12:30	$1.0 \times 10^{-6.8}$	Good signal

Table 2: Cloud cover report based on BER for 18th October, 2005

S/N	*Time*	*Bite error rate (BER)*	*Nature of signal*
1	07:00	$1.0 \times 10^{-8.0}$	Very good signal
2	08:00	$1.0 \times 10^{-7.9}$	Very good signal
3	09:00	$1.0 \times 10^{-7.5}$	Very good signal
4	10:00	1.0×10^{-10}	Excellent signal
5	11:00	$1.0 \times 10^{-7.8}$	Very good signal
6	12:00	$1.0 \times 10^{-7.8}$	Very good signal
7	13:00	$1.0 \times 10^{-8.2}$	Very good signal
8	14:00	$1.0 \times 10^{-7.8}$	Very good signal
9	15:00	$1.0 \times 10^{-8.0}$	Very good signal
10	16:00	$1.0 \times 10^{-8.0}$	Very good signal
11	17:00	1.0×10^{-10}	Excellent signal
12	18:00	$1.0 \times 10^{-9.5}$	Excellent signal
13	19:00	$1.0 \times 10^{-8.1}$	Very good signal

Table 3: Cloud Cover Report based on BER for 4th November, 2005

S/N	*Time*	*Bite error rate (BER)*	*Nature of signal*
1	13: 30	$1.0 \times 10^{-6.2}$	Good signal
2	14:00	$1.0 \times 10^{-5.8}$	Poor signal
3	14:30	$1.0 \times 10^{-6.2}$	Good signal
4	15:00	$1.0 \times 10^{-6.3}$	Good signal
5	15:30	$1.0 \times 10^{-6.5}$	Good signal
6	16:00	$1.0 \times 10^{-6.7}$	Good signal
7	16:30	$1.0 \times 10^{-6.5}$	Good signal
8	17:00	$1.0 \times 10^{-7.7}$	Very good signal
9	17:30	$1.0 \times 10^{-3.5}$	Poor signal
10	18:00	$1.0 \times 10^{-3.4}$	Unusable signal
11	18:30	$1.0 \times 10^{-3.6}$	Poor signal
12	19:00	$1.0 \times 10^{-3.5}$	Poor signal
13	19:30	$1.0 \times 10^{-3.5}$	Poor signal
14	20:00	$1.0 \times 10^{-2.5}$	Unusable
15	21:00	$1.0 \times 10^{-2.6}$	Unusable
16	21:00	$1.0 \times 10^{-2.5}$	Unusable
17	22:00	$1.0 \times 10^{-2.5}$	Unusable
18	22:30	$1.0 \times 10^{-2.5}$	Unusable
19	23:00	$1.0 \times 10^{-2.6}$	Unusable
20	23:30	$1.0 \times 10^{-2.6}$	Unusable

Table 4: Cloud cover report based on BER for17th May, 2006

S/N	Time	Bite error rate (BER)	Nature of signal
1	19:00	$1.0 \times 10^{-6.2}$	Good signal
2	19:30	$1.0 \times 10^{-6.5}$	Good signal
3	20:00	$1.0 \times 10^{-6.6}$	Good signal
4	20:30	$1.0 \times 10^{-3.8}$	Poor signal
5	21:00	$1.0 \times 10^{-3.5}$	Poor signal
6	21:30	$1.0 \times 10^{-3.5}$	Poor signal
7	22:00	$1.0 \times 10^{-3.6}$	Poor signal
8	22:30	$1.0 \times 10^{-3.5}$	Poor signal
9	23:00	$1.0 \times 10^{-3.6}$	Poor signal
10	23:30	$1.0 \times 10^{-3.4}$	Poor signal
11	00:00	$1.0 \times 10^{-3.3}$	Unusable signal
12	00:30	$1.0 \times 10^{-3.4}$	Unusable signal
13	01:00	$1.0 \times 10^{-6.8}$	Good signal

References

[1] Dennis Roddy and John Coolen (2003). Electronic Communication. 4th edition, Pearson Education Pte. Limited, India. Pp 711-743.
[2] Michael U. Onuu (2004). Satellite Communication. 1st edition., Index Educational Foundation. Pp 1-21
[3] Greg N. Onoh (2005).Communication Systems. De-Adroit Innovation, Enugu. Pp 25-41.
[4] Concise Encyclopedia of science and technology (1996). 3rd edition, Mcgraw-Hill. Pp 1605-1608
[5] Rupae H. O. (1972). Advances in Space and Science and technology, Astronautics, An Outline of Unity, Academic Press, New York.
[6] Kwaha, B. J. and Akande, S. F. (1998). Satellite Communication System. A paper presented in the 21st annual conference of the Nigerian institute of physics held at Ogun state University, 23rd -29th September.
[7] Matsumae T., Shimoda H. and Etana M. (1987). Technological Requirements of Satellite monitoring System: a paper presented at Tokai University Research and Information center, Japan.
[8] Receive Bit Error Statistics (Version 317A). NITEL standard "A" earth station