American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-04, Issue-02, pp-79-86
www.ajer.org
Research Paper Open Access

Modelling of Transmitter & Receiver for VSAT Communication System

Sanjida Sharmin Mohona[1] , Laboni Islam[2], Professor Dr. Md. Osman Goni[2]
[1]Dept. of Electronics & Communication Engineering , Khulna University of Engineering & Technology
Khulna-9203, Bangladesh
[2]Dept. of Electronics & Communication Engineering Khulna University of Engineering & Technology
Khulna-9203, Bangladesh

ABSTRACT— *The Satellite communication is an essential part of telecommunication systems which carrying large amount of data (internet, e-mail) and telephone traffic in addition to TV signals. Very small aperture terminal (VSAT) is widely used for these purposes. This paper aims to provide the framework of VSAT technology in the evolving context of satellite communications in terms of network configuration, services, economics and operational aspects. This paper presents the modelling and simulation aspects of communication blocks of VSAT which can be used in different types of network topology and also includes the numerical results simulated by MATLAB.*

KEYWORDS— *VSAT, HPA, LNA, Satellite Transponder, Star, Mesh.*

I. INTRODUCTION

VSAT, now a well established acronym for Very Small Aperture Terminal, was initially a trademark for a small earth station marketed in the 1980s by Telecom General in the USA. VSAT refers to receive or transmit terminals installed at dispersed sites connecting to a central hub via satellite using small diameter antenna dishes (0.6 to 3.8 meter). The majority of VSAT antennas range from 75 cm to 1.2 m. VSATs provide the vital communication link required to set up a satellite based communication network. VSAT systems can be configured for bi-directional or receive-only operation. VSATs can support any communication requirement be it voice, data, or video conferencing. Data rates typically range from 56 kbit/s up to 4 Mbit/s. VSATs access satellite(s) in geosynchronous orbit to relay data from small remote earth stations (terminals) to other terminals (in mesh topology) or master earth station "hubs" (in star topology).

The organization of this paper is as follows- Section II conducts VSAT Satellite Communication System. Section III describes VSAT topology. Section IV shows VSAT frequency band. Section V describes VSAT transmitter & receiver part. Section VI illustrate the simulation results. Section VII resembles link budget Calculation. Finally, Section VIII provides some concluding remarks.

II. VSAT SATELLITE COMMUNICATION SYSTEM

Fig.1shows the block diagram of basic VSAT satellite communication system. Satellite communication system consists of many earth stations on the ground and these are linked with a satellite in space [2]. The user is connected to the Earth station through a terrestrial network and this terrestrial network may be a telephone switch or dedicated link to earth station. The user generates a baseband signal that is processed through a terrestrial network and transmitted to a satellite at the earth station. The satellite transponder consists of a large number of repeaters in space which receives the modulated RF carrier in its uplink frequency spectrum from all the earth station in the network, amplifies these carriers and retransmits them back to the earth stations in the downlink frequency spectrum [8]. To avoid the interference, downlink spectrum should be different from uplink frequency spectrum. The signal at the receiving earth station is processed to get back the baseband signal, It is sent to the end user through a terrestrial network.

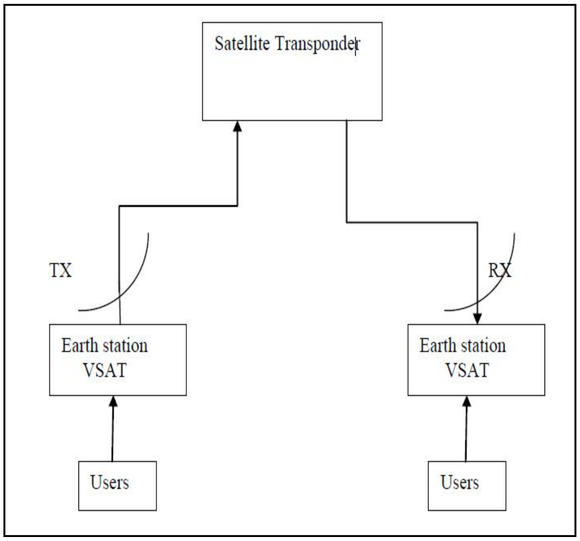

Fig. 1 Basic Satellite communication System

The basic block diagram of a VSAT earth-station Transmitter is as shown in fig. 2. The baseband signal from the terrestrial network is processed through modulator and then it is converted to uplink frequency [2],[3]. Finally it is amplified by high power amplifier and directed towards the appropriate part of antenna. The block diagram of a VSAT earth station receiver is as shown in fig. 3. The signal received from the satellite is processed through LNA (Low Noise Amplifier). Then it is down-converted and demodulated. Thus the original baseband signal is obtained.

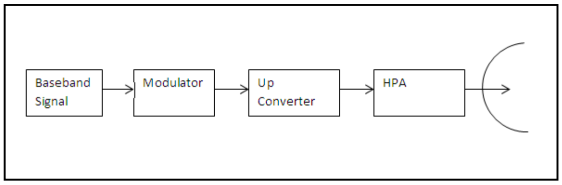

Fig. 2 Block diagram of VSAT Earth Station Transmitter

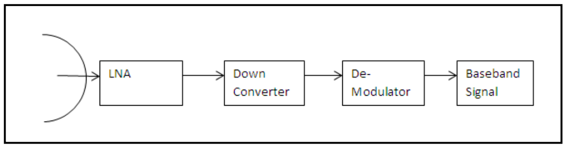

Fig. 3 Block diagram of VSAT Earth Station Receiver

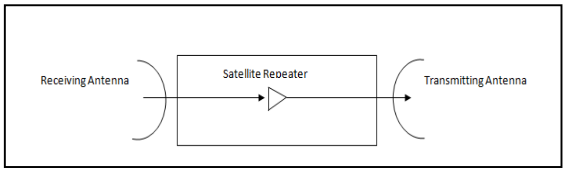

Fig. 4 Block Diagram of Satellite transponder

III. VSAT TOPOLOGY

STAR

The hub station controls and monitors can communicate with a large number of dispersed VSATs. Generally, the Data Terminal Equipment and 3 hub antenna is in the range of 6-11m in diameter [1]. Since all VSATs communicate with the central hub station only, this network is more suitable for centralized data applications.

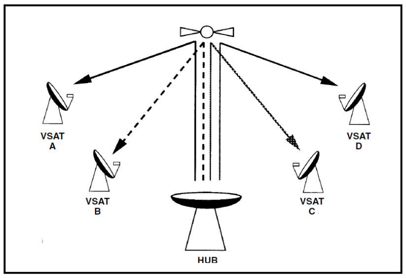

Fig. 5 Star Topology

Mesh

A group of VSATs communicate directly with any other VSAT in the network without going through a central hub. A hub station in a mesh network performs only the monitoring and control functions. These networks are more suitable for telephony applications[6].

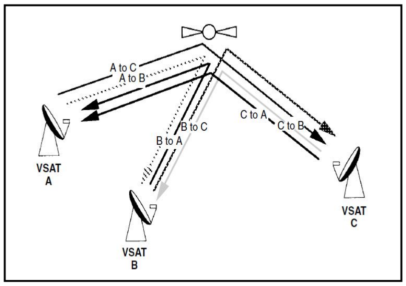

Fig. 6 Mesh Topology

Hybrid Network

In practice usually using hybrid networks, where a part of the network operates on a star topology while some sites operate on a mesh topology, thereby accruing benefits of both topologies.

IV. VSAT FREQUENCY BAND

TABLE I. VSAT FREQUENCY BAND

SI No.	Band	Uplink Range(GHZ)	Downlink range(GHZ)
1	C Band	5.925-6.425	3.700-4.200
2	Ex C Band	6.725-7.025	4.500-4.800
3	Ku Band	14.00-14.50	10.95-11.70
4	Ka Band	30.00	20.00

TABLE II. ADVANTAGE & DISADVANTAGE OF DIFFERENT BAND

Band	Advantage	Disadvantage
C Band	Broad footprint, Little rain fade	Interference , Large antenna & amplifier.
Ex-C Band	Broad footprint, Little rain fade, Less Interference.	Weak signals, Large antenna size, Large amplifier.
Ku Band	Focused Footprint, Less Terrestrial interference, Smaller antenna, Smaller Amplifiers.	Interference due to rain.
Ka Band	Focused Footprint, Less Terrestrial interference, Smaller antenna, Smaller Amplifiers.	Interference due to rain.

V. VSAT TRANSMITTER & RECEIVER PART

A. Transmitter Part

Modulator

Modulators are responsible for converting the digital data into IF Signals. We have used a QPSK modulator [5]. The mathematical analysis shows that QPSK can be used either to double the data rate compared with a BPSK system while maintaining the *same* bandwidth of the signal, or to maintain the data-rate of BPSK but halving the bandwidth needed. In this latter case, the BER of QPSK is exactly the same as the BER of BPSK - and deciding differently is a common confusion when considering or describing QPSK. The transmitted carrier can undergo numbers of phase changes.

Up Converter

An up-converter amplifies & converts the frequency (IF to RF), that is received from the modulator. This is then passed on to the power amplifier for further amplification and transmission. A block up converter (BUC) is used in the transmission (uplink) of satellite signals. Modern BUCs convert from the L band to Ku band, C band and Ka band. Older BUCs convert from a 70 MHz intermediate frequency (IF) to Ku band or C band.

HPA

The Power Amplifier is used for amplifying the Up converter RF signal before being fed into the Antenna system. The Amplifier can be either Mounted on the Antenna system or could be placed in the Indoor Rack. The amplification is required to send the up stream signals to the Satellite. There are four basic types of electronic amplifier: the voltage amplifier, the current amplifier, the trans-conductance amplifier, and the trans-resistance amplifier.

B. Receiver Part

LNA

The signal that travels from the satellite would have become weak due to various atmospheric issues, the signal strength is reduced to a few watts hence the signal needs to pass through an equipment that will increase the signal strength from a few watts to several Kilowatts [10]. Usually LNA require less operating voltage in the range of 2-10 V. LNA require supply current in the range of mA, the supply current require for LNA is dependent on the design and the application for which it has to be used. The Frequency Range of LNA operation is very wide. They can operate from 500 kHz to 50 GHz [14]. The temperature range where a LNA operates best is usually -30 to +50 C. Noise figure is also one of the important factors which determines the efficiency of a particular LNA. Low noise figure results in better reception of signal. With the low noise figure LNA must have high gain for the processing of signal into post circuit. If the LNA doesn't have high gain then the signal will be affected in by noise in LNA circuit itself and may be attenuated, so high gain of LNA is the important parameter of LNA.

Down Converter

A down converter amplifies and converts the frequency (RF to IF), which is received from the low noise amplifier. This is then passed on to the demodulator [9]. A low-noise block down-converter (or LNB) is the receiving device mounted on satellite dishes used for satellite TV reception, which collects the radio waves from the dish. Also called a low noise block, LNC (for low-noise converter), or even LND (for low-noise down-converter), the device is sometimes wrongly called an LNA (low-noise amplifier) [15].

Demodulator

Demodulator is responsible for converting the IF signals into digital format. This is understood by the networking components like Routers, Switches, Telephone systems, etc. and the same is then fed into the computer.

VI. SIMULATION RESULT

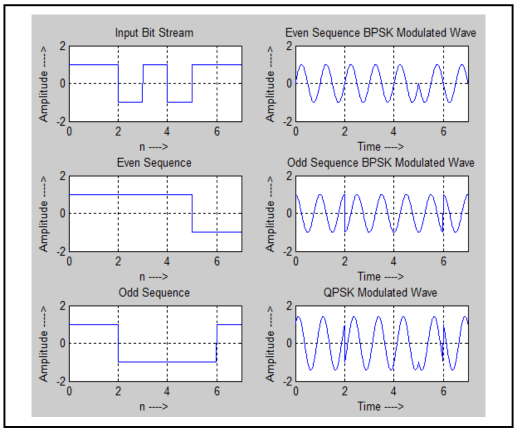

Fig. 7 QPSK modulated Output

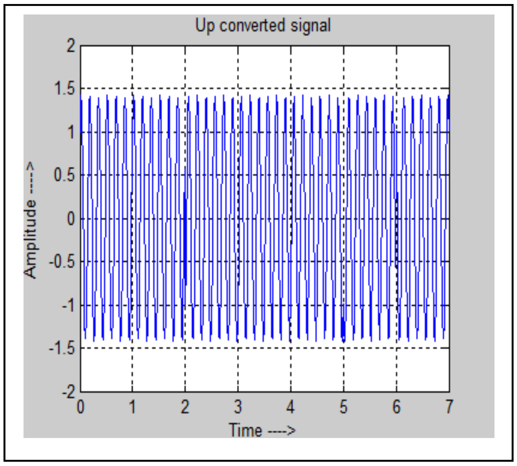

Fig. 8 Up Converted Signal

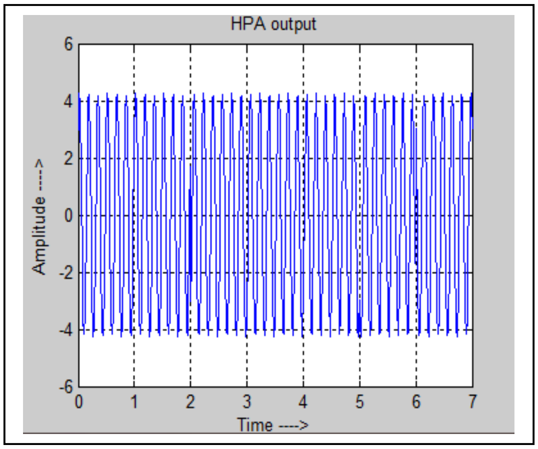

Fig. 9 HPA output

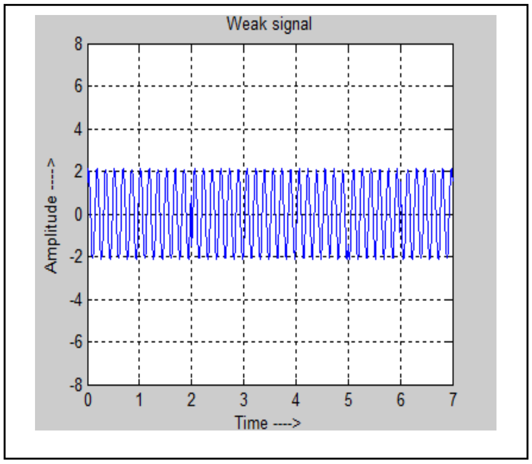

Fig. 10 Weak Signal

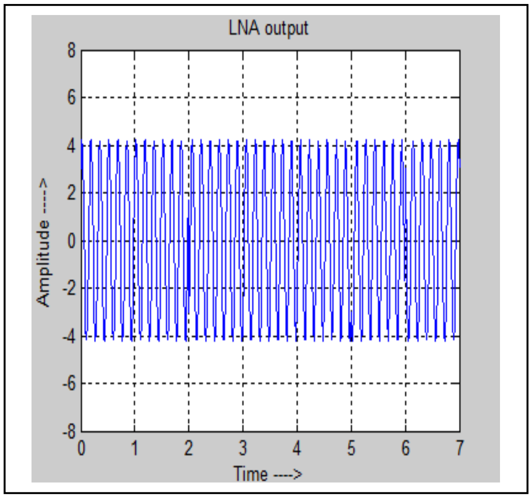

Fig. 11 LNA output

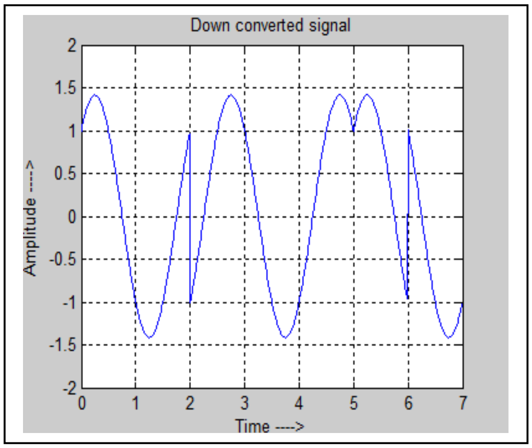

Fig. 12 Down converted Signal

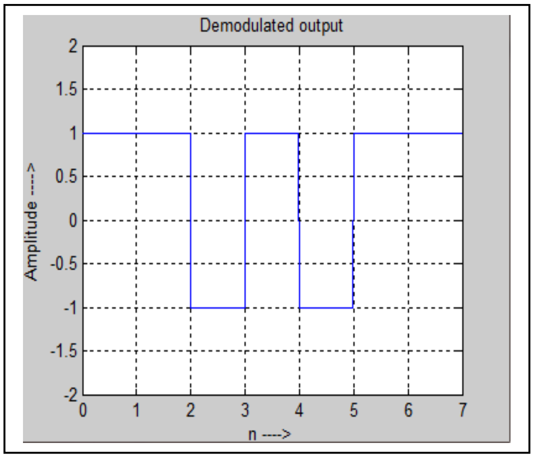

Fig 13 Demodulated Output

VII. LINK BUDGET CALCULATIONS

The link between the satellite and Earth station is governed by the basic microwave radio link equation [11],[12]:

$$Pr = \frac{PtGtGrC^2}{4\,\pi^2 R^2 f^2}$$

Where P_r is power received by the receiving antenna, Pt is the power applied to the transmitting antenna, Gt is the gain of the transmitting antenna, Gr is gain of the receiving antenna, C is the speed of light (c = 3 x 10^8 m/s), R is the range (path length) in meters and f is the frequency in hertz. Almost all link calculations are performed after converting from products and ratios to decibels. This uses the popular unit of decibels, thus converting the equation (1) into decibels. It has the form of a power balance as $P_r = P_t + G_t + G_r$ –Path-loss [13] . All link budgets require knowledge of the free space path loss between the earth station and the satellite and the noise powers in the operating bandwidth[16]. Free space Path loss:

$$L_p = 20 \log (4\pi R / \lambda).$$

Gain of the antenna is given by –

$$G = \frac{4\pi\eta A}{\lambda^2} = \eta\left(\frac{\pi D}{\lambda^2}\right)$$

Where η is the antenna efficiency, A is the effective area, and λ is the wavelength.

VIII. CONCLUSION

A comparison of costs between a VSAT network and a leased line network reveals that a VSAT network offers significant savings over a two to three years timeframe. This does not take into account the cost of downtime, inclusion of which would result in the VSAT network being much more cost - effective. Pay-by-mile concept in case of leased line sends the costs spiraling upwards. More so if the locations to be linked are dispersed all over the country. Compare this to VSATs where the distance has nothing to do with the cost. Additionally, in case of VSATs, the service charges depend on the bandwidth which is allocated to your network in line with your requirements. Whereas with a leased line you get a dedicated circuit in multiples of 64Kbps whether you need that amount of bandwidth or not.

REFERENCES

[1] M. H. Hadjitheodosiou, Frances P. Coakley and Barry G. Evans, *Next Generation Multi service VSAT Networks*, July 2, 1997 .

[2] T. Pratt, C. Bostian , J.Allnutt, *Satellite Communication*, John Wiley and Sons, 2nd Edition.

[3] Theodore S. Rappaport, *Wireless Communications*, Principles and Practice, Prentice – Hall of India Private Limited, 2nd Edition.

[4] Sanjay Sharma *Wireless and Cellular Communications*, S. K. Kataria and Sons 2nd edition, Jan 2007.

[5] R . E. Ziemer and W. H. Tranter *Principle of communications Systems, Modulation and Noise*, Published by Jaico Publishing House.

[6] G´erard Maral *VSAT Networks*,Published by John Wiley & Sons Ltd

[7] Robert M. Gagliardi Satellite Communication CBS publishers & Distributors.

[8] Tri T. Ha *Satellite Digital Communication,* McGraw-Hill publishing Company

[9] Gerben W. de Jong, Domine M. W. Leenaerts, *Fellow, IEEE*, and Edwin van der Heijden *A Fully Integrated Ka-Band VSAT Down-Converter* ,IEEE Journal Of Solid-State Circuits, Vol. 48, No. 7, July 2013 Kosei Nishimura and Futoshi Kuroki *Connection between Microstrip Circuits in Transmitter and Receiver of VSAT Systems*, Proceedings of Asia-Pacific Microwave Conference 2010.

[10] F. Michael Naderi ,William W. Wu *Advanced Satellite Concepts for Future Generation VSAT Networks*, 0 163-6804/88/00 13-000 1 $0 1 .OO ' 1988 IEEE.

[11] Paolo Amadesi The Role Of VSATs & Other Small Satellite Terminals *In The Evolving Telecommunications Environent,* EUTELSAT Tour Maine Montpamasse 33, Ave du Maine 75755 Paris Cedex 15 France

[12] Aderemi A. Atayero, Matthew K. Luka and Adeyemi A. Alatishe, *Satellite Link Design: A Tutorial‖*,International Journal of Electrical and Computer Sciences IJECS-IJENS Vol: 11 No:04, August 2011.

[13] Howard Hausman, *Fundamentals of Satellite Communications, Part-2‖*, Hauppauge, NY 11788,January 22, 2009.

[14] Charan Langton, Intuitive Guide to Principles of Communications‖, copyright 1998 and 2002

[15] Basari, Development of Simple Antenna System for Land Mobile Satellite Communications, Doctoral Dissertation, February, 2011.