Atmospheric gas impact on fixed satellite communication link a study of its effects at Ku, Ka and V bands in Nigeria

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Abstract:
The total atmospheric absorption due to Oxygen and water vapour on the earth-space path at Ku (12/14 GHz), Ka (20/30 GHz), and V (40/50 GHz) bands was evaluated for communication with Nigeria communication satellite (Nigcomsat1) on both uplink and down link at 0.01 % unavailability of an average year. The basic input climatic data used include monthly and yearly mean meteorological parameters of surface and vertical profiles of pressure, temperature, and relative humidity obtained from recent measurement from space by the Atmospheric Infrared Sounder (AIRS) instrument on NASA's Aqua spacecraft for the period 2002 to 2006. The International Telecommunication Union Radio Propagation Recommendation (ITU-RP 676, 2009) procedure was used for the computation of gaseous attenuation for each of the 37-stations in Nigeria. Attenuation values were obtain for both uplink and downlink frequencies, at Ku, Ka and V bands, total atmospheric absorption was determined to be between (0.11 to 0.24) dB, (0.7 to 1.1) dB and (0.82 to 3.1) dB for Ku, Ka, and V bands respectively. Contour maps showing a consistent signal absorption due to Oxygen is generally higher in the South-West region and water-vapour attenuation higher in the South-South part of Nigeria are presented.

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I. Introduction

THE demands for new satellite services and global broadband communications services such as VSAT for internet access, multimedia applications has caused a greater demand of bandwidth pushing up the frequency for satellite communications beyond Ku (12/14 GHz) to Ka (20/30 GHz), and V (40/50 GHz) bands because larger bandwidth are available at higher frequency bands. In the absence of rain, cloud and atmospheric gases can play an important role in signal attenuation, hence their effects must be assessed in order to determine their impact on satellite communications [1]. The higher frequencies at Ka and V-band are more vulnerable to propagation effects such as Oxygen and water vapour absorption for both fixed and mobile satellite communications. Therefore an extensive data base of total atmospheric absorption and accurate propagation model to decide on the fade margin for satellite communication link design are needed[2], [3]. The principal atmospheric gases which absorb electromagnetic energy in the microwave frequencies are Oxygen and Water vapor. Atmospheric gases absorb energy from electromagnetic waves if the molecular structure of the gas is such that the individual molecules possess electric or magnetic dipole moments [4]. It is known from quantum theory that at specific wavelengths, energy from the wave is transferred to the molecule, causing it to rise to a higher energy level. If the gas is in thermodynamic equilibrium, it will then reradiate this energy isotropically as a random process, thus falling back to its prior energy state. Because the incident wave has a preferred direction and the emitted energy is isotropic, the net result is a loss of energy from the wave. The only atmospheric gases with strong absorption lines at millimeter wavelengths are water vapor and Oxygen. The magnetic dipole moment of Oxygen is approximately two orders of magnitude weaker than the electric dipole moment of water vapor. The net absorption due to oxygen is still very high, simply because it is so abundant. The fact that the distribution of Oxygen throughout the atmosphere is very stable makes it very easy to model [5].