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Effect of Elevation Angle on Power Budget Down Link Weather Satellite in Case of Clear Sky Conditions

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Abstract

The quality of the link between a transmitter and a receiver can be characterized by the ratio of the carrier power to the noise power spectral density C/N0. The propagation conditions in the atmosphere affect the uplink and downlink differently. In this paper, Effect of elevation angle on power budget down link weather satellite(Clear sky conditions).

Keywords: Satellite, weather, attenuation, power budget, Temperature, Elevation angle, FSL, C/N0.

1. Introduction

A satellite link consists of an uplink and a downlink, Signal quality over the uplink depends on how strong the signal is when it leaves the source earth station and how the satellite receives it. Also, on the downlink side, the signal quality depends on how strongly the satellite can retransmit the signal and how the receiving earth station receives the signal.

In telecommunication, a power budget (or system budget) is the allocation, within a system, of available transmitter power output to achieve the desired effective radiated power, among the various functions that need to be performed.

2. Free-space loss (FSL)

Loss in free space is a function of frequency squared plus distance squared plus a constant. using kilometers (km) for distance and megahertz (MHz) for frequency,[1,2].

$$=32.45+20\log D \quad +20\log \tag{1}$$

3. Effective isotropic radiated power (EIRP)

The effective isotropic radiated power (EIRP) can be calculated as follows:

$$=P_o + \quad + G \tag{2}$$

where P_o is the RF power output of the transmitter at the waveguide flange, *Lt* is the transmission line losses, and is the gain of the transmit antenna,[1].

4. Gain-to-Noise Temperature Ratio

Can be called the ''figure of merit'' of a radio receiving system. It is most commonly used in space communications. can be expressed by the following identity:

$$– =G_{dB} \text{ - 10 log T} \tag{3}$$

where *G* is the receiving system antenna gain and *T* (better expressed is T_{sys}) is the receiving system noise temperature.

$$= T_{ant} + T_r \tag{4}$$

The antenna noise temperature T_{ant} , coming inward in the system, includes all noise contributors, including sky noise, up to the reference plane. Receiver noise *Tr* includes all noise contributors from the reference plane to the baseband output of the demodulator,[1,2].

4.1 Noise temperature of an earth station antenna

The noise captured by the antenna consists of noise from the sky and noise due to radiation from the earth Figure(1),[2].

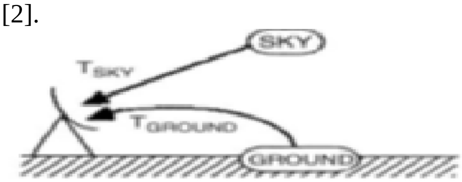

Fig.1.Contributions to the noise temperature of an earth station: clear sky conditions [2].

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4.2 Clear Sky Conditions

At frequencies greater than 2 GHz, the greatest contribution is that of the non-ionized region of the atmosphere which, being an absorbent medium, is a noise source. In the absence of meteorological formations, the antenna noise temperature contains contributions due to the sky and the surrounding ground (Figure 1). The antenna noise temperature is thus given by [2,15,16] :

$T_A = T_{sky} + T_{GROUND}$ (K°) (5)

Where

- T_{GROUND}=290 k° for lateral lobes whose elevation angle E is less than -10°.
- T_{GROUND} = 150 k° for -10° < E < 0°.
- T_{GROUND} = 50 k° for 0° < E < 10°.
- T_{GROUND} = 10 k° for 10° < E < 90°.

T_{sky} sky noise temperature.

4.3 Calculation of sky noise temperature as a function of attenuation.

The effective sky noise due to the troposphere is primarily dependent on the attenuation at the frequency of observation

$$T_{sky} = T_m (1- 10^{\frac{-A}{10}}) \quad K° \qquad (6)$$

where T_{sky} is the sky noise and T_m is the mean absorption temperature of the attenuating medium (e.g., gaseous, clouds, rainfall) and A is the specific attenuation,[1].

5. Calculation of C/N0 Using the Link Budget Technique

The link budget is a tabular method of calculating space communication system parameters. the starting point of a link budget is the platform EIRP. The platform can be a terminal or a satellite. In an equation, it would be expressed as follows:

$$\frac{C}{N_o} \text{ (dB)} = EIRP_{dBW} - FSL_{dB} - \text{(other losses) (dB)} + \frac{G}{T} \text{ (dB/K°)} - k \qquad (7)$$

Where k is Boltzmann's constant expressed in dBW,[1,2]. Referring to ref [1,5], the other losses are Polarization loss, Pointing losses (terminal and satellite), Off-contour loss and Excess attenuation due to atmospheric gases were investigated.

6. Results and Discussions

To compute the link analysis or link budget a Matlab program has been written and obtained results as given below:

6.1 Computed factors

The computed result of the Matlab program are follows:
θ: the elevation angle to the satellite, in degrees =30°
RH: the relative humidity = 0.5
e_s : the saturated partial pressure of water vapor =2300 N / m²
To: the surface temperature = 20°C
p_o: The surface water vapor density = 8.5139 (g/m³)
total zenith attenuation = 0.24db
bp : The coefficient b_p is frequency dependent = 0.05
ΔA_{c1} is the additive correction to the zenith clear air attenuation that accounts for the difference between the actual surface water vapor density and 7.5 g/m³ = 0.0507 db
cT: the frequency-dependent values for c_T is given in figure 4 = 0.0015
ΔA_{c2} is an additive correction to the zenith clear air attenuation = 0.0015 db
clear air zenith attenuation A'_c = 0.2922 db
The total attenuation for an elevation angle θ = 0.5844db.
Tm: absorption temperature of the attenuating medium = 275 db
T_{sky} : the sky noise = 34.6226K°
T_{GROUND} = 10 K°
T_{ant} : the antenna noise temperature = 44.6226K°
T_r: effective input noise temperature of receiver (K°) = 295.5 K°
T_{sys}: total effect system noise temperature (K°)= 340.1226K°
G_{dB} : receiving system antenna gain (dB) = 42.1dB
$\frac{G}{T}$: figure of merit (dB/k°) = 16.7836dB/k°
EIRP: effective isotropic radiated power = 30 dBw
FSL: Loss in free space = 196.78 dB
satellite pointing loss (dB) = 0.5 dB
off contour loss (dB) = 0.5 dB
polarization loss (dB) = 0.5 dB
terminal pointing loss (dB) = 0.5 dB
excess attenuation (dB) due to oxygen= 1.09dB
$\frac{C}{N_o}$ (dB) : carrier to noise ratio (dB) = 74.9293 dB

6.2 Discussion

It is clear that when the elevation angle increase the attenuation ,sky noise temperature and Antenna noise temperature decrease as represented Fig(2) and(3).

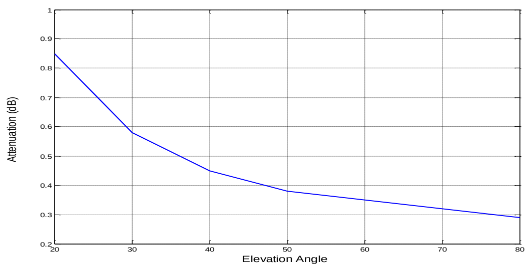

Fig.2 Elevation Angle and Attenuation

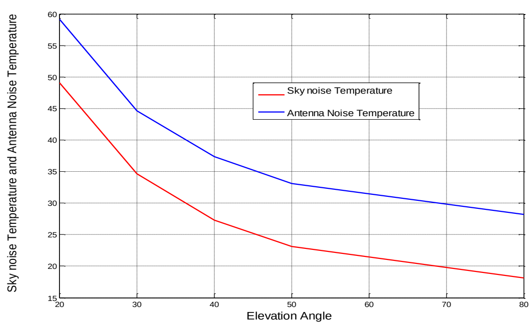

Fig.3 Elevation Angle , Sky noise Temperature and Antenna Noise Temperature

When the elevation angle increase the carrier to noise ratio increase as shown in Fig(4). But the decrease of attenuation due to decrease of carrier to noise ratio as represented in Fig(5).

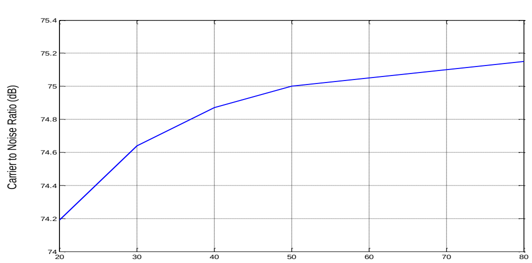

Fig.4 Elevation Angle and Carrier to Noise Ratio (dB)

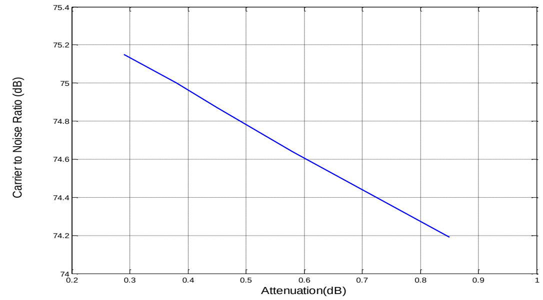

Fig.5 Attenuation and Carrier to Noise Ratio (dB)

7. Conclusion

Referring to the main goal of this paper it conclude that

- When the increase in elevation angle in clear air attenuation have a direct impact on improving carrier to noise ratio.
- In general ,increase in elevation angle in clear sky cases it observes that decrease in attenuation ,but carrier to noise ratio and figure of merit will increase.
- Finally observes that the elevation angle is a main factor effecting carrier to noise ratio in clear air attenuation.

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