

CO-CHANNEL INTERFERENCE ANALYSIS FOR DIGITAL MODULATION SYSTEMS IN CO-LOCATED SATELLITES

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ABSTRACT

Satellites in GEO orbits are being co-located using orthogonal polarization to place more number of satellites to meet the demand. But while co-locating satellites operating in the same frequency band, careful system analysis and optimization is required to deal with co-channel interference. This paper studies the co-channel interference that may arise between co-located satellites employing frequency re-use and its effects on the system performance. The various sources of the interference are identified and modeled. The vulnerability of the system to the interference is assessed.

INTRODUCTION

Assessment of co-channel interference is very important for co-located satellites accessing overlapping frequency bands. Factors like insufficient cross-polarization isolation, poor antenna side lobe radiations, power amplifier nonlinearities and improper filtering etc. may cause interference to the neighboring satellites. In addition to this the input power flux densities for the co-located satellites may take different values due to different application requirements. For example, one satellite supporting high power Direct-To-Home services may be co-located with another satellite supporting the DVB-RCS link employing low power signals for return channel. In such cases the co-channel interference effects are prominent even when other system parameters like cross-polarization isolation etc. are complying the specifications for the system link budget. The effect of co-channel interference can be reduced by using frequency staggering, carrier power enhancement, base band pulse shaping, antenna beam shaping etc. Here analysis for frequency staggering and carrier power enhancement case is presented.

CO-CHANNEL INTERFERENCE ANALYSIS

Uplink Interference Computation

The interference in the desired satellite link is introduced due to the unwanted emissions from the uplink earth station (ES) of the other co-located satellite.

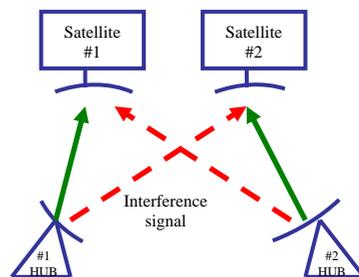


Fig. 1 Co-Channel Interference Scenario for Co-located Satellites

To compute the aggregate interference from a population of ES spread across the Earth's surface, the field of view of the satellites is divided into a number of concentric rings.

$$(C/I)_{uplink} = C - 10 \log \left\{ \sum_{i=1}^N 10^{(EIRP_{unwanted} + 10 \log(n_i) - L_i + G_i)/10} \right\} \quad (1)$$

where, $(C/I)_{uplink}$ is carrier-to-interference ratio in dB, C is the desired carrier power in dBW, N is the number of concentric rings in satellite field of view, $EIRP_{unwanted}$ is the unwanted EIRP from each interfering ES in dBW, n_i is the number of ES in ring i , L_i is the free space propagation loss from the inner edge of ring i in dB, G_i is the satellite receiving antenna gain at the corresponding off-axis angle in dBi.

Effect of Interference on the System Performance

The degradation in the system performance depends on the interfering signal power and its phase distribution. This effect can either be seen as percentage increase in the system noise temperature or as degradation in carrier-to-noise ratio (C/N)/bit error rate (BER).

The interference effects on satellite communication system are analyzed by Link Budget analysis and through BER performance curve simulation [1].

Link Budget Analysis

The interference effects on the satellite communication system performance with link budget analysis are characterized as degradation in carrier to noise of the link. The degradation in the carrier-to-noise ratio $\Delta(C/N)_{link}$ due to uplink interference, from the uplink ES through satellite to receive ES is computed as following:

$$\Delta(C/N)_{link} = \left\{ \left(\frac{C}{N} \right)_{uplink}^{-1} + \left(\frac{C}{N} \right)_{downlink}^{-1} \right\}^{-1} - \left\{ \left(\frac{C}{N} \right)_{uplink}^{-1} + \left(\frac{C}{N} \right)_{downlink}^{-1} + \left(\frac{C}{I} \right)_{uplink}^{-1} \right\}^{-1}$$

A typical satellite link is analyzed using satellite parameters given in Table 1. The results are shown in Fig. 2.

The results presented in Fig. 3 show that degradation in C/N increases with better BER and also degradation is more for higher order modulation.

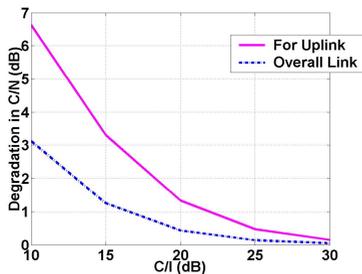


Fig. 2 Degradation in C/N due to uplink Interference

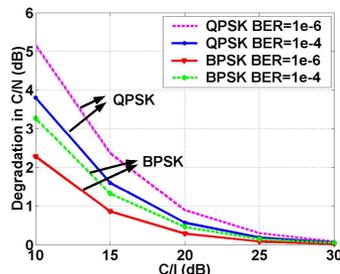


Fig. 3 Degradation in C/N for BPSK and QPSK signal

Table-1 Satellite link parameters considered for Uplink Interference analysis

System Parameter	Specifications	System Parameter	Specifications
Uplink Frequency	14.25 GHz	Downlink Frequency	11.20 GHz
Ground EIRP	66.62 dBW	Satellite EIRP	49.30 dBW
Uplink C/N (C/N) _{uplink}	15.56 dB	Downlink C/N (C/N) _{downlink}	11.73 dB

BER Performance Curve Simulation

The interference affects both the amplitude and phase of the received symbols. This effect on the system can only be seen through simulation. System model of Fig. 4 is used to estimate the interference effect on the BER performance curve on MATLAB.

For the system performance analysis three types of interference signals are being considered: (a) CW interference, (b) Digital modulated interference (c) Gaussian interference. The effect of various interfering sources on BER is shown in Fig. 5, Fig. 6 and Fig. 7 respectively. The results show that Gaussian interference has most severe impact on the system performance. The link budget analysis assumes the interference to be of Gaussian kind and hence, gives the worst case estimate of the interference effects.

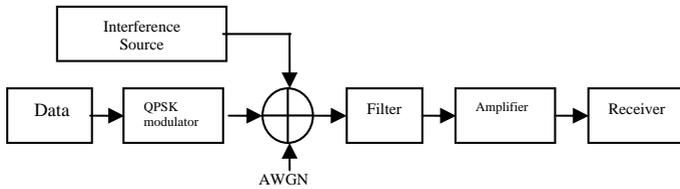


Fig. 4 System model for BER performance simulation

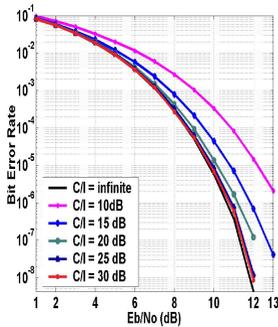


Fig. 5 Effect of CW interference

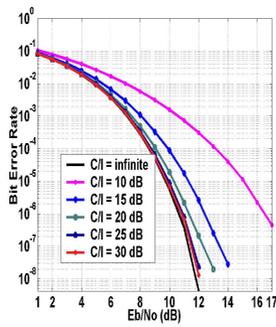


Fig. 6 Effect of Digital modulated interference

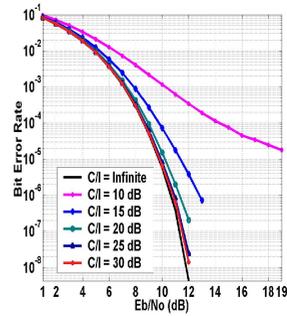


Fig. 7 Effect of Gaussian interference

Compensating Interference Effects

Desired system performance can be ensured in the presence of interference by two ways

- (a) Interference suppression
- (b) carrier power enhancement

Interference Suppression

Interference suppression achieved by staggered frequency band allocation is shown in Fig. 8. The frequency bands are staggered by 50% of the channel bandwidth.

Carrier Power Enhancement

Increase in the uplink carrier power provides two-fold advantage in the link. The amount of carrier power enhancement needed is more than the degradation in overall link C/N and is given in Table 2.

CONCLUSIONS

For the co-located satellites with different input power flux densities substantial interference suppression can be attained through modification in the system parameters such as frequency staggering and adjustment in the uplink carrier power or combination of both. Final implementation shall be studied case by case and suitable method can be implemented.

REFERENCES

- [1] Feher Kamilo, "Digital Communication: Satellite/Earth Station Engineering", Prentice-Hall Inc., 1983.

Table 2 Comparison of additional power requirement

Over all link C/N (dB)	BER	Up link C/I (dB)	Degr adation in C/N (dB)	Additional uplink power required (dB)	
				Uplink C/N limited link	Downlink C/N limited link
8.6	8e-5	10	3.4	6.1	11.8
		15	1.5	3.2	6.8
		20	0.8	1.4	3.5
		25	0.4	0.6	1.5

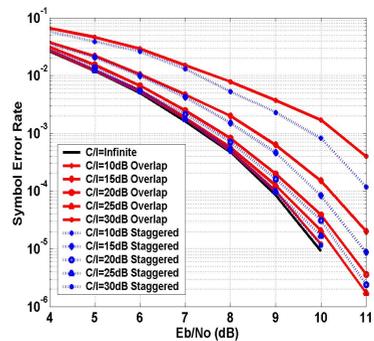


Fig. 8 Comparisons of Overlap and Staggered Frequency Band Interference Effect