



Recommendation ITU-R S.2131-1
(01/2022)

**Method for the determination of
performance objectives for satellite
hypothetical reference digital paths using
adaptive coding and modulation**

S Series
Fixed-satellite service



International
Telecommunication
Union
Documents
Document Sharing Hub

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

Policy on Intellectual Property Right (IPR)

ITU-R policy on IPR is described in the Common Patent Policy for ITU-T/ITU-R/ISO/IEC referenced in Resolution ITU-R 1. Forms to be used for the submission of patent statements and licensing declarations by patent holders are available from <http://www.itu.int/ITU-R/go/patents/en> where the Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC and the ITU-R patent information database can also be found.

Series of ITU-R Recommendations

(Also available online at <http://www.itu.int/publ/R-REC/en>)

Series	Title
BO	Satellite delivery
BR	Recording for production, archival and play-out; film for television
BS	Broadcasting service (sound)
BT	Broadcasting service (television)
F	Fixed service
M	Mobile, radiodetermination, amateur and related satellite services
P	Radiowave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management
SNG	Satellite news gathering
TF	Time signals and frequency standards emissions
V	Vocabulary and related subjects

Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

Electronic Publication
Geneva, 2022

© ITU 2022

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without written permission of ITU.

RECOMMENDATION ITU-R S.2131-1

Method for the determination of performance objectives for satellite hypothetical reference digital paths using adaptive coding and modulation¹

(Questions ITU-R 275 and ITU-R 277-1/4)

(2019-2022)

Scope

The use of adaptive coding and modulation (ACM) allows maintaining a satellite connection in spite of degradation due to propagation but at lower throughput rates. This Recommendation provides a method for determining the performance objectives for satellite communication systems using ACM.

Keywords

Adaptive coding and modulation, performance objectives, satellite communications

Abbreviations/Glossary

ACM	Adaptive coding and modulation
BBER	Background block error rate
BEP	Bit error probability
BER	Bit error ratio
DVB	Digital video broadcasting
DVB-S2	Second generation digital video broadcasting via satellite
DVB-S2X	Extension of second-generation digital video broadcasting via satellite
EB	Errored block
ES	Errored second
ETSI	European Telecommunications Standards Institute
FER	Frame error rate
HRDP	Hypothetical reference digital path
HRX	Hypothetical reference connection
MODCOD	Modulation and coding
MPEG	Moving Picture Experts Group
PER	Packet error ratio
QEF	Quasi error free
SES	Severely errored second
TDM	Time division multiplex
TDMA	Time division multiple access

¹ Additional performance assessment methodologies and metrics require qualitative and quantitative analysis to determine the efficacy of these methodologies and metrics.

C/N	Carrier to noise ratio γ
E_s/N_0	Symbol energy to noise spectral density ratio
η	Spectral efficiency in bit/s/Hz
ϕ_{total}	Percent degraded throughput

Related ITU-R Recommendations and Reports

Recommendation ITU-R S.614-4	Allowable error performance for a satellite hypothetical reference digital path in the fixed-satellite service operating below 15 GHz when forming part of an international connection in an integrated services digital network
Recommendation ITU-R S.1061-1	Utilization of fade countermeasure strategies and techniques in the fixed-satellite service
Recommendation ITU-R S.1062-4	Allowable error performance for a satellite hypothetical reference digital path operating below 15 GHz
Recommendation ITU-R S.1878-0	Multi-carrier based transmission techniques for satellite systems
Recommendation ITU-R S.2099-0	Allowable short-term error performance for a satellite hypothetical reference digital path
Report ITU-R S.2173-1	Multi-carrier based transmission techniques for satellite systems
Recommendation ITU-T G.826	End-to-end error performance parameters and objectives for international, constant bit-rate digital paths and connections

The ITU Radiocommunication Assembly,

considering

- a) that adoption of ACM and power amplifier linearization has led to improved satellite efficiency and transmission performance;
- b) that satellite systems utilizing ACM techniques will adapt to degraded conditions by reducing overall throughput and are, therefore, no longer provide constant bit rate services;
- c) that satellite link performance must be sufficient to allow compliance with overall end-to-end performance objectives and end-user requirements;
- d) that in defining error performance criteria, it is necessary to take into account all foreseeable error-inducing mechanisms, especially time-varying propagation conditions and interference,

noting

- a) that long-term error performance objectives have been provided in Recommendations ITU-R S.614 and ITU-R S.1062;
- b) that the definition of the short-term in satellite communications and information on the short-term performance objectives have been provided in Recommendation ITU-R S.2099;
- c) that information on adaptive transmission and power control techniques which can be used to counteract time-varying attenuation has been provided in Recommendation ITU-R S.1061, Recommendation ITU-R S.1878, and Report ITU-R S.2173;
- d) that the satellite link impairments are caused by degraded propagation, which can be characterized using the models given in Recommendations ITU-R P.618-13 and ITU-R P.1623-1, and these propagation Recommendations are applicable up to 51.4 GHz,

recommends

- 1 that satellite systems using ACM should be designed to meet the performance objectives given by either the packet error ratio (PER) or the spectral efficiency (bit/s/Hz) as a function of C/N ;
- 2 that the following Notes should be regarded as part of this Recommendation.

NOTE 1 – In the case of using PER, the values given in Table 3 of § 2.2 of the Annex should be used.

NOTE 2 – In the case of using performance objectives given in terms of spectral efficiency, the spectral efficiency, measured at the operating γ value in dB, is assumed to be no less than $\eta(\gamma - 1.0)$, where γ is the carrier-to-noise ratio (C/N) in dB, and $\eta(\gamma)$ is the spectral efficiency in bit/s/Hz as a function of γ defined in § 2.3 of the Annex.

NOTE 3 – It was assumed that the system is able to accommodate a 1 dB reduction in C/N , during a 1-second interval when changing modulation and coding (MODCOD) state. This corresponds to about a 10% reduction in spectral efficiency (throughput or capacity) over a nonlinear satellite link. This decrease in C/N may be due to any source of external noise and rain fading.

NOTE 4 – It should be noted that the time-average of the throughput, over any year, does not give sufficient information on the performance of a link for a particular percentage of time of any year. Additional requirements for overall performance may be stated in terms of throughput/spectral efficiency as a function of percentage of a year. Such a potential metric needs to be considered in the overall assessment of the performance of the link using ACM and the above-mentioned percentages may require further studies.

Annex

Example method for the determination of performance objectives for satellite hypothetical reference digital paths using adaptive coding and modulation

1 Background

Existing error performance and availability Recommendations were created while recognizing the satellite link impairments caused by degraded propagation, which can be characterized using the models given in Recommendations ITU-R P.618-13 and ITU-R P.1623-1. The studies conducted by Study Group 3 have indicated that these propagation Recommendations are applicable up to 51.4 GHz, but there are no Recommendations for slant paths using frequencies above 52 GHz. In light of this information, the existing error performance and availability Recommendations, apply on Hypothetical Reference Digital Paths (HRDPs) up to 52 GHz.

The development and adoption of adaptive coding and modulation (ACM) and power amplifier linearization techniques by satellite equipment manufacturers and operators has led to improved satellite efficiency and transmission performance. The use of ACM allows maintaining a satellite HRDP in spite of degraded propagation but at lower throughput rates. The application of ACM techniques to satellite transmission systems is covered in Report ITU-R S.2173 and § 2 of Annex 1 to Recommendation ITU-R S.2099.

1.1 Performance objectives for constant bit rate HRDPs

Recommendation ITU-R S.1062 gives performance objectives for satellite HRDPs providing constant bit rate services. These connections typified satellite traffic in the early 1990s, before the