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SERIES J: TRANSMISSION OF TELEVISION, SOUND PROGRAMME AND OTHER MULTIMEDIA SIGNALS

Measurement of the quality of service

Performance indicators for data services delivered over digital cable television systems

ITU-T Recommendation J.141

(Previously CCITT Recommendation)

ITU-T J-SERIES RECOMMENDATIONS

TRANSMISSION OF TELEVISION, SOUND PROGRAMME AND OTHER MULTIMEDIA SIGNALS

General Recommendations	J.1–J.9
General specifications for analogue sound-programme transmission	J.10–J.19
Performance characteristics of analogue sound-programme circuits	J.20–J.29
Equipment and lines used for analogue sound-programme circuits	J.30–J.39
Digital encoders for analogue sound-programme signals	J.40–J.49
Digital transmission of sound-programme signals	J.50–J.59
Circuits for analogue television transmission	J.60–J.69
Analogue television transmission over metallic lines and interconnection with radio-relay links	J.70–J.79
Digital transmission of television signals	J.80–J.89
Ancillary digital services for television transmission	J.90–J.99
Operational requirements and methods for television transmission	J.100–J.109
Interactive systems for digital television distribution	J.110–J.129
Transport of MPEG-2 signals on packetised networks	J.130–J.139
Measurement of the quality of service	**J.140–J.149**
Digital television distribution through local subscriber networks	J.150–J.159

For further details, please refer to ITU-T List of Recommendations.

ITU-T RECOMMENDATION J.141

PERFORMANCE INDICATORS FOR DATA SERVICES DELIVERED OVER DIGITAL CABLE TELEVISION SYSTEMS

Summary

This Recommendation describes some performance indicators to be used to evaluate the performance of digital modems in a hybrid fibre/coax cable television network in the presence of continuous or impulsive noise.

Source

ITU-T Recommendation J.141 was prepared by ITU-T Study Group 9 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on 16 September 1999.

FOREWORD

ITU (International Telecommunication Union) is the United Nations Specialized Agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the ITU. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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As of the date of approval of this Recommendation, the ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

CONTENTS

Page

1 Scope 1

2 References 1

3 Definitions 1

4 Abbreviations and acronyms 1

5 Performance Indicators 1

Appendix I – Example of the use of the recommended performance indicators.. 2

PERFORMANCE INDICATORS FOR DATA SERVICES DELIVERED OVER DIGITAL CABLE TELEVISION SYSTEMS

(Geneva, 1999)

1 Scope

Recommendation J.111 "Network independent protocols for interactive systems" specifies some characteristics for the modems to be used for the delivery of data services over digital television cable. This Recommendation recommends some performance indicators to be used to evaluate the performance of those modems in a hybrid fibre/coax (HFC) cable television network in the presence of continuous or impulsive noise.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

– ITU-T Recommendation J.111 (1998), *Network independent protocols for interactive systems*.

3 Definitions

This Recommendation defines the following terms:

3.1 frame loss ratio (FLR): The ratio of errored data frames with respect to total number of frames transmitted, when the data frames are transmitted over a noisy channel.

3.2 bandwidth efficiency (BWE): The amount of data that can be transmitted through a channel, expressed in terms of amount of data transmitted through the unit of bandwidth per unit of time (bits/s/Hz).

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations:

BWE Bandwidth Efficiency

CNR Carrier-to-Noise Ratio

FEC Forward Error Correction

FLR Frame Loss Ratio

5 Performance Indicators

Three important indicators have been in successful use and are listed below.

Carrier-to-Noise Ratio (CNR) – This is the widely used indicator of the noise level of a transmission channel. Depending on the characteristics of the noise in the channel, it can be expressed in terms of additive white Gaussian noise, or of impulsive noise bursts of specified duration and repetition rate. This is an indicator of the performance of the transmission network, and it can only be improved by changing the network or improving its maintenance.

Frame Loss Ratio (FLR) – The frame loss ratio is the ratio of errored data frames with respect to total number of frames transmitted, when the data frames are transmitted over a noisy channel. This indicator is often referred to Ethernet-type frames consisting of 64 bytes each, but it is also customary to refer to 53-byte frames as used in some regions, or to 1518-byte frames, which are also supported by Ethernet. The value of this indicator is dictated by the desired quality of service that the network should provide for a given service.

Bandwidth Efficiency (BWE) – The bandwidth efficiency indicates the data capacity that can be transmitted through the channel. It is expressed in terms of the amount of data transmitted through the unit of bandwidth per unit of time (bits/s/Hz). The value of this indicator is governed by the design of the modem. It should be noted that the usable data includes only the useful message data. It does not include any overhead needed for forward error correction (FEC) and control. Of course, the greater the percent overhead, the less the useful data that can be delivered. A modem without provision for FEC overhead will have a high bandwidth efficiency, but it will rapidly fail on a noisy transmission channel. A compromise FLR and bandwidth efficiency must be found case by case.

The three indicators above are related to each other and bounded by Shannon's law: when the value of CNR is known, the limit to the value of BWE at an arbitrarily small FLR can be computed by applying that law.

The values of the three indicators can be plotted on a three-dimensional graph. In practice, cross sections of the three-dimensional graph, perpendicular to the FLR axis, are often used instead, for the sake of convenience. The line that represents Shannon's law can also be plotted on those bidimensional cross-section graphs; that line describes the maximum theoretical performance possible for any combination of BWE and CNR at an arbitrarily low FLR approaching zero.

An example of the use of the described performance indicators is provided in Appendix I.

Appendix I

Example of the use of the recommended performance indicators

Different services have different error-performance requirements and different data rates. For example, a service, such as status monitoring or polling, may be able to tolerate more errors than a time-critical application, such as video telephony or "twitch" video games, where re-transmission of errored frames cannot be tolerated. A system designer engaged in the design of a digital transmission facility intended to provide a given service will try to optimize his choice of values for the three indicators above, through a trial-and-error process based on the steps described below.

1) Create tables or graphs, of the type described above, corresponding to the error performance needed for the service to be provided. This will determine a lower boundary plane, orthogonal to the FLR axis, on the three-dimensional graph described in clause 5.

2) Characterize the quality of the HFC cable television plant from a CNR and burst-noise distribution point of view. This will determine a lower boundary plane, orthogonal to the C/N axis, on the same graph.

3) Determine the minimum acceptable data rate for the service and the amount of bandwidth which can be dedicated to that particular service. There are several issues associated with this decision.

   - The bandwidth decision may be limited to a range between strong ingress sources.

   - The service to be provided may be a low revenue-generating service, to which only a modest bandwidth can be dedicated, or the service may be a high revenue-generating service, to which a full channel may be dedicated in the best part of the spectrum.

   - It may be necessary to fit the return channels of all the bidirectional services into a limited return band.

4) Calculate the required bandwidth efficiency by dividing the required bit rate by the available bandwidth. This will determine a lower boundary plane, orthogonal to the BWE axis, on the three-dimensional graph.

The system designer can then plot the performance indicators of the various available modem models on the bidimensional cross-section of the three-dimensional graph, applicable to the required FLR value. The designer can focus his choice on those modem models that fall in the area bounded by the lines that correspond to the measured CNR and to the minimum required BWE and thus simultaneously meet or exceed the minimum identified requirements for CNR, FLR and BWE. The designer's attention should particularly focus on those modems that, while meeting the condition above, appear to be closest to the upper boundary of theoretical performance represented by Shannon's law.

Figure I.1 provides an example of such a bidimensional cross-section graph and its use.

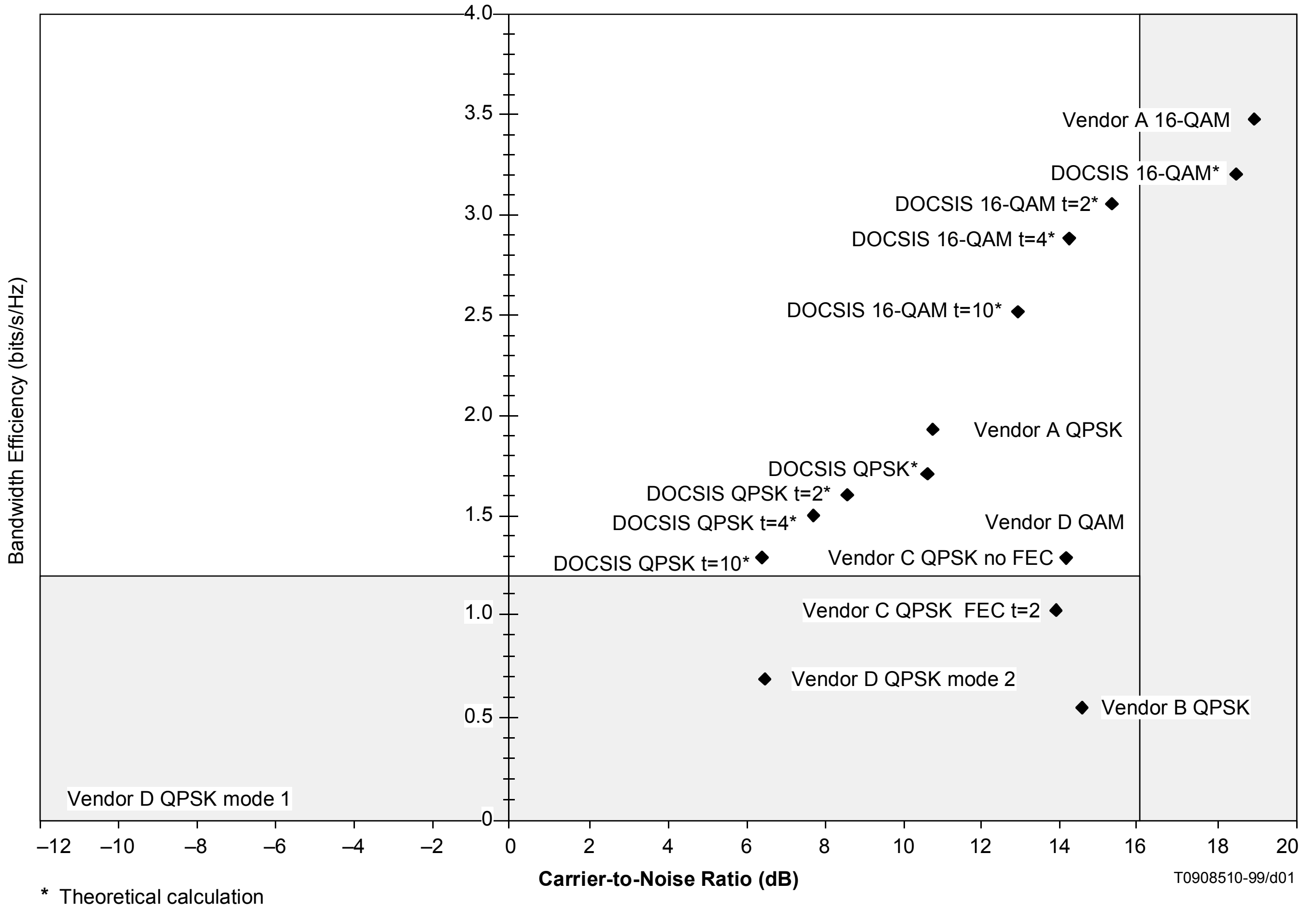

Figure I.1/J.141 – Bandwidth efficiency vs. CNR for 1% FLR

It should be noted that several available modems have a set bandwidth and a set FEC capability. Therefore, the system designer is limited to what is available. However, some modems have varying parameters that can be used to move to different points on the three-dimensional graph. For the modems with several modes, the system engineer could add points to create more of a continuous trace and could choose the operating point to be somewhere along the trace. While it would be convenient to choose any arbitrary bandwidth and power efficiency, all these modems operate with a discrete set of parameters. In an operational system, FEC options, data rates, or bandwidths, can be controlled dynamically to adjust for the changing channel conditions.

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