

SMPTE RECOMMENDED PRACTICE

Jitter Measurement Procedures In Bit-Serial Digital Interfaces



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Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in its Standards Operations Manual.

SMPTE RP 192 was prepared by Technology Committee 32NF.

Intellectual Property

At the time of publication no notice had been received by SMPTE claiming patent rights essential to the implementation of this Engineering Document. However, attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. SMPTE shall not be held responsible for identifying any or all such patent rights.

Introduction

This section is entirely informative and does not form an integral part of this Engineering Document.

Jitter is one of the most important parameters in the performance of serial digital transmission systems. It can cause errors in the transmission and recovery of digital data, and may degrade analog signal performance if the jitter is transferred through the digital-to-analog conversion process. Characterizing and measuring jitter are important for reliable and predictable serial digital system operation.

1 Scope

This Recommended Practice describes methods for measuring jitter performance in bit-serial digital interfaces. The techniques are specifically suited for jitter specifications that follow the form described in SMPTE RP 184.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword "reserved" indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword "forbidden" indicates "reserved" and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; followed by formal languages; then figures; and then any other language forms.

3 Normative References

The following document contains provisions which, through reference in this text, constitute provisions of this recommended practice. At the time of publication, the edition indicated was valid. All documents are subject to revision, and parties to agreements based on this recommended practice are encouraged to investigate the possibility of applying the most recent edition of the document indicated below.

SMPTE RP 184:2015, Specification of Jitter in Bit-Serial Digital Systems

4 Definitions

4.1 Alignment jitter

Variation in position of a signal's transitions relative to those of a clock extracted from that signal. The bandwidth of the clock extraction process determines the low-frequency limit for alignment jitter.

4.2 BER

Acronym for Bit Error Ratio. BER indicates the ratio of errors to total bits received. This is a measure of the integrity of the transmission link.

4.3 Clock extractor

A device which is able to extract the serial data clock from a serial data stream, and outputs a clock-related trigger. It may also provide the serial digital data reclocked with the extracted clock.

4.4 DSO

Acronym for digital storage oscilloscope.

4.5 DUT

Acronym for device under test.

4.6 Error rate tester

A device that quantifies the error rate of a serial digital signal. Two examples are the classic bit error ratio (BER) tester and the field rate CRC method (EDH) described in SMPTE RP 165.

4.7 Independent Samples

For band-limited systems, samples are only independent if they are not over-sampled. By the Nyquist criteria this means that for a given bandwidth in Hz, the maximum number of independent samples per second is approximately twice the bandwidth. Any higher rate of samples will be just giving more information about the same signal components.

4.8 Input jitter tolerance

Peak-to-peak amplitude of sinusoidal jitter that, when applied to an equipment input, causes a specified degradation of error performance.

4.9 Intrinsic jitter

Jitter at an equipment output in the absence of input jitter.

4.10 Jitter

Variation of a digital signal's transitions from their ideal positions in time.

4.11 Jitter generator

A device that produces a serial digital signal containing sinusoidal jitter of adjustable amplitude and frequency.

4.12 Jitter receiver

Demodulates and allows measurement of the jitter present on a serial signal. It commonly provides an output proportional to the demodulated jitter.

4.13 Jitter transfer

Jitter on the output of equipment resulting from applied input jitter.

4.14 Jitter transfer function

Ratio of the output jitter to the applied input jitter as a function of frequency.

4.15 Output jitter

Jitter at the output of equipment that is embedded in a system network. It consists of intrinsic jitter and the jitter transfer of jitter at the equipment input.

4.16 Phase demodulator

A device that provides as its output a signal proportional to the phase difference of two input signals.

4.17 Probabilistic Peak-to-Peak Jitter (p-p-p, Stated as Jitter at 1 in 10^x)

This is an estimate of the most likely p-p jitter in unit intervals when measured over 10^x independent jitter samples. See SMPTE RP 184 for derivation.

4.18 SDI

Acronym for Serial Digital Interface.

4.19 Timing jitter

Variation in position of a signal's transitions occurring at a rate greater than a specified frequency, typically 10 Hz or less. Variations occurring below this specified frequency are termed wander and are not addressed by this practice.

4.20 Unit interval (UI)

Abbreviated "UI", it is the period of one clock cycle. It corresponds to the nominal minimum time between transitions of the serial signal.

5 Common Guidelines for Indicating Device Specifications

For all the measurement types and methods in this Recommended Practice, the following guidelines should be observed for optimal results:

- 1) All high-speed signals, especially SDI signals, shall be terminated in the appropriate impedance. For SDI signals this means to terminate in 75 ohms with return loss that meets the relevant SMPTE specification.
- 2) All SDI measurement inputs shall have sufficient bandwidth to prevent a significant degradation in the signal. For the time domain methods, the measuring device shall cause no more than a 20% increase in the risetime relative to a measurement with unlimited bandwidth. For frequency domain methods the measuring device shall be able to display signals up to the serial rate plus the jitter frequency limit f_4 in order to observe the jitter sidebands.

- 3) For the time-domain methods, the horizontal and/or trigger bandwidth of the indicating device shall not attenuate the observed jitter. The trigger bandwidth shall be at least f_3 .
- 4) For the time-domain methods, the indicating device shall not create inter-symbol interference at the zero-crossing point. This requires a vertical system step response that transitions and settles in less than 1 UI.
- 5) The indicating device shall acquire sufficient samples so that peak-to-peak jitter can be determined. This requires sampling until the shape of the jitter distribution is known. If the jitter specification includes a measurement time, this shall be the minimum acquisition time. The maximum acquisition time will depend on the device sample rate and the type of jitter distribution. For example, a sinusoidal distribution will typically be determined with fewer samples than will a Gaussian-like distribution. If the jitter specification includes a sample size or probability at which the jitter must be satisfied then the indicating device shall collect samples to meet those specifications. If a probability is specified then the indicating device shall indicate if the jitter measurement at that probability is directly measured or extrapolated from a smaller sample set.
- 6) The minimum measurement time " t_m " shall be as specified in SMPTE RP 184. Depending on the type of indicating device, the actual measurement time may be significantly longer than the minimum in order to collect required number of samples or p-p-p threshold.
- 7) If the indicating device is an oscilloscope, the jitter measurement is usually made at the eye crossing. A digital storage oscilloscope with infinite persistence is recommended.

6 Intrinsic and Output Jitter Measurement

Seven methods are described and each of these methods has advantages and disadvantages. The particular characteristics of each method are discussed in the individual sections. The implementer can choose the method which is most appropriate for a particular application. The method described in Section 6.2 is considered the preferred reference method.

The first of the seven methods uses an available reference clock to trigger an oscilloscope; the second and third use a clock extractor with defined characteristics to trigger the oscilloscope; the fourth uses a spectrum analyzer; the fifth and sixth are based on a phase demodulator method jitter receiver; the seventh method uses a clock extractor and a Bit Error Ratio Tester (BERT).

6.1 Oscilloscope Measurement by Means of Triggering on a Reference Signal

If a reference signal is available, a basic jitter measurement can be done (see Figure 1). The oscilloscope is directly triggered by the reference signal. This reference signal could also be a serial digital signal with high stability. The digital data signal is connected to the suitably terminated vertical channel of the oscilloscope and an eye measurement is done. The jitter is typically measured at the eye crossing.

– Presentation of measurement results: The test signal, the jitter amplitude, the parameters of the oscilloscope (bandwidth, etc.), and the measurement time should be indicated.

– Background information: This measurement procedure provides a coarse survey of jitter in an SDI signal. The measurement result depends on the stability of the reference signal (its jitter sets the measurement floor), the type of oscilloscope, and the measurement time (e.g., when a DSO is used in persistence mode). All of these parameters influence the measurement result and contribute to variability in the result as conditions vary. This method does not allow bandwidth restriction as generally required in jitter specification. This method is not recommended if other jitter measurement methods are available. The frequency of the reference should not be closely related to the word rate. This will avoid masking word rate jitter. For example, the reference frequency should not be the serial rate divided by 10 or 20.