Proposed Draft

Serial ATA International Organization

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Title : Long Term Frequency Accuracy and SSC Profile Tests for Transmitters

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Document History

Version	Date	Comments
0.9	April 2, 2007	Initial release.
0.91	May 30, 2007	Additions for other issues.
0.92	June 15, 2007	Removed SSC profile in terms of JTF
0.93	June 20, 2007	Clarify definition section 7.2.2.1.6, remove spectrum analyzer description from 7.4.6
0.94	June 20,2007	
1.0	June 20, 2007	Phy WG approval

1 Introduction

1.1 Problem Statement

Item 1:
The measurement of long term frequency cannot be done in the presence of SSC since the average of the SSC profile is not specified. When SSC is present, the long term frequency accuracy cannot be separated from SSC.

Item 2:
The specification refers to long term frequency “stability” in the requirements section, but describes “accuracy” in the measurement section.

Item 3:
The limits for tUI in the Physical Requirements Tables contradict the description of the SSC profile limits. The tUI limits are absolute numbers based on a tolerance of Fbaud whereas the SSC profile limits are relative to a measurement of the long term frequency.

Item 4:
The example in Figure 123 has been misinterpreted as a normative (requirements) part of the specification. It cannot be normative because it contradicts the tUI limits in the Physical Requirements Tables. It contains an undefined quantity fnom.

1.2 Solution

Item 1:
Upon submittal to a test house, the manufacturer indicates whether a product’s transmitter has SSC or not. This indicates whether the SSC profile test, or the long term frequency accuracy test is done.

The full limits for the SSC profile include the frequency accuracy of its source which is +-350ppm. The SSC profile limits are restated to indicate the observable SSC profile limits at the compliance point, not the characteristics of the parts within the design (SSC spread and accuracy).

Item 2:
Since the specification describes a frequency accuracy requirement and measurement, change occurances of stability to accuracy.

Item 3:
The limits for long term frequency accuracy and for SSC profile are made absolute by defining them relative to Fbaud, an absolute number.

Item 4:
Label Figure 123 and its associated paragraph as “informative”.

1.3 Background

Item 1:
This remedy sets forth two different requirements: one for non-SSC and one for SSC transmitters. The non-SSC transmitter is tested to the long term frequency accuracy limits; the SSC transmitter is tested for SSC profile. The true SSC profile excursion limits are the combination of the spread 0 to –5000ppm and the long term frequency accuracy +-350ppm.

Long term frequency accuracy is used to specify clock sources; it is measured by using a frequency counter and assumes no intentional frequency modulation. Clock sources are employed in SATA solutions but these signals are not present at the SATA interface, there is no normative (required) means to turn off SSC modulation. The long term frequency accuracy of a clock source used in a SATA implementation with SSC cannot be measured per the specification as the means is not provided.

The SSC profile is observable at the compliance point. The current specification intends a design with a clock source of +-350ppm accuracy and a 0 to –5000ppm downspread. Since these two numbers are not separable, the observable SSC profile limit are the combination of these two numbers or +350ppm to –5350ppm.

Item 2:
Since the requirement description of Long term stability explicitly excludes phase noise, it must be describing accuracy not stability.

Item 3:
The tUI limits given in the specification physical requirements tables are 335.1167pS and 333.2167pS. The UI limits for +-350ppm from a nominal of 333.3333 are

$$(1.000350)(333.33333) = 333.44999$$
$$(1 - 0.000350)(333.333333) = 333.21666$$

The following calculation shows the tUI limits in the physical requirements tables are relative to Fbaud.

$$(333.3333 - 333.2167) / 333.3333 = +350 \text{ ppm}$$
$$(333.3333 - 335.1167) / 333.3333 = -5350 \text{ ppm}$$

The premise is that the SSC profile limits are relative to a measured long term frequency. This leads to a contradiction between the SSC profile limits and tUI limits; the contradiction is not present if the SSC profile limits are relative to an absolute number and are thus absolute numbers themselves. Given a transmitter with a long term frequency -350ppm above Fbaud and a modulation amount (delta in Figure 123) of 5000ppm. The average period associated with long term frequency is 333.21666pS. The transmitter with SSC swings down to 335.1167pS, the allowable tUI limit. The SSC profile limit of –5000ppm is exceeded.

$$(333.21666 - 335.1167) / 333.21666 = -5702 \text{ ppm}$$

When the SSC profile limits are relative to a measured long term frequency it conflicts with the tUI limits in the specification physical requirements tables. Therefore, this cannot be true and the SSC profile limits must be relative to the Fbaud absolute number.

Item 4:
Since the assumption that SSC always downspreads from a measured fnom within +-350ppm contradicts the absolute tUI limits in the Physical Requirements Tables and the SATAIO policy that the tables take precedence over graphs and text, Figure 123 and its associated paragraph should be changed.

2 Technical Specification Changes

2.1 7.2.2.1.4 TX Frequency Long Term Stability

7.2.2.1.4 TX Frequency Long Term ~~Stability~~Accuracy

This specifies the allowed frequency variation from nominal; this does not include frequency variation due to jitter, Spread Spectrum Clocking, or phase noise of the clock source.

2.2 7.2.1 Physical Requirements Tables

Table 1 – General Specifications

Parameters	Units	Limit	Electrical Specification						Detail Cross-Ref Section	Meas. Cross-Ref Section
			Gen1i	Gen1m	Gen1x	Gen2i	Gen2m	Gen2x		
Channel Speed	Gbps	Nom	1.5			3.0			**Error! Reference source not found.**	-
Fbaud	GHz	Nom	1.5			3.0			-	-
FER, Frame Error Rate		Max	8.2e-8 at 95% confidence level			8.2e-8 at 95% confidence level			**Error! Reference source not found.**	**Error! Reference source not found.**
$T_{UI,}$ Unit Interval	ps	Min	666.4333			333.2167			**Error! Reference source not found.**	**Error! Reference source not found.**
		Nom	666.6667			333.3333				
		Max	670.2333			335.1167				
f_{tol}, TX Frequency Long Term ~~Stability~~ Accuracy	ppm of Fbaud	Min	-350			-350			0	**Error! Reference source not found.**
		Max	+350			+350				
f_{SSC}, Spread-Spectrum Modulation Frequency	kHz	Min	30			30			**Error! Reference source not found. 0**	**Error! Reference source not found.**
		Max	33			33				

Parameters	Units	Limit	Electrical Specification						Detail Cross-Ref Section	Meas. Cross-Ref Section
			Gen1i	Gen1m	Gen1x	Gen2i	Gen2m	Gen2x		
SSC_{tol}, Spread-Spectrum Modulation Deviation	ppm of Fbaud	Min	~~-5000~~ -5350			~~-5000~~ -5350			0 0	Error! Reference source not found.
		Max	~~+0~~ +350			~~+0~~ +350				
$V_{cm,dc}$, DC Coupled Common Mode Voltage	mV	Min	200		-	-			Error! Reference source not found.	Error! Reference source not found.
		Nom	250		-	-				
		Max	450		-	-				
$V_{cm,ac\ coupled}$, AC Coupled Common Mode Voltage	mV	Min	0		-	-			Error! Reference source not found.	Error! Reference source not found.
		Max	2000		-	-				
Z_{diff}, Nominal Differential Impedance	Ohm	Nom	100		-	-			Error! Reference source not found.	Error! Reference source not found.
$C_{ac\ coupling}$ AC Coupling Capacitance	nF	Max	12			12			Error! Reference source not found.	Error! Reference source not found.
$t_{settle,cm}$, Common Mode Transient Settle Time	ns	Max	10		-	-			Error! Reference source not found.	-
V_{trans}, Sequencing Transient Voltage	V	Min	-2.0			-2.0			Error! Reference source not found.	Error! Reference source not found.
		Max	2.0			2.0				

2.3 7.2.2.1.6 Spread Spectrum Modulation Deviation

7.2.2.1.6 Spread Spectrum Modulation Deviation

This is the allowed frequency variation from the nominal Fbaud value in Table 27 when Spread Spectrum Clocking (SSC) is used. ~~due to the SSC AC modulation expressed in terms of the unit~~

interval deviation from the unit interval value of the long term frequency value. This deviation includes the long term frequency variation of the transmitter clock source, and the SSC frequency modulation on the transmitter output. The frequency variation limits are measured using the SSC profile measurement described in section 7.4.11. See further details of Spread Spectrum in section 0.

2.4 7.4.6 Long Term Frequency Accuracy

7.4.6 Long Term Frequency Accuracy

There are several considerations for choosing instruments to measure long term frequency accuracy. The long term frequency accuracy of the instrument time base needs to be significantly better than the 350 ppm limit in this specification; many oscilloscopes do not have this frequency accuracy. In general, equivalent time oscilloscopes cannot be used for this purpose since they require a trigger synchronous with the data.

A method to measure the long term frequency accuracy is to use a frequency counter. Many spectrum analyzers have frequency counters built in. The test setup shown in Figure 1 below shows the connections. The transmitter under test sends a HFTP (D10.2) signal to the frequency counter spectrum analyzer. The signal may or may shall not have SSC modulation, a 30 kHz frequency modulation on it. The frequency counter should have a gating period set long enough to reduce the effects of noise; this may be done by setting the Set the spectrum analyzer for a center frequency of 750 MHz at Gen1 or 1.5 GHz at Gen2, a frequency span of 100 kHz (with SSC on, frequency span of 20 MHz, resolution BW to 300 kHz, the video BW to 300 kHz), a counter resolution to of 10 Hz or better (350 ppm at 1.5 GHz is 525 kHz), and place the marker on the peak signal (center of peaks with SSC on). The counter reads the long term frequency of the transmitter, the accuracy is a percentage.

When SSC is present, long term frequency accuracy specification is not applicable, instead the SSC profile is measured (see section 7.4.11). the measurement is a combination of the long term frequency accuracy and a frequency offset due to the SSC modulation. Measure the span of the modulation and profile. Since the counter provides an average measurement of frequency, the profile should be considered. If the profile of the SSC modulation is not symmetrical, this should be considered when determining the actual long term frequency.

There are other instruments that contain frequency counter with an stability accuracy significantly better than 350 ppm. For example some BERT equipment has a frequency counter on the clock input. There are also stand alone frequency counters.

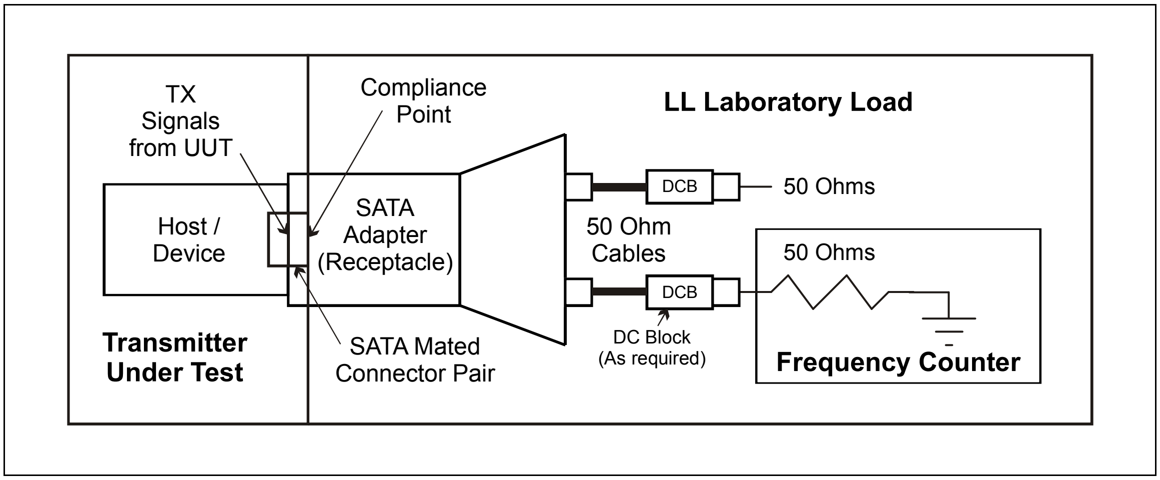

Figure 1 – TX Long Term Frequency Measurement

2.5 7.3.3 Spread Spectrum Clocking

7.3.3 Spread Spectrum Clocking

Serial ATA allows the use of spread spectrum clocking, or intentional low frequency modulation of the transmitter clock. The purpose of this modulation is to spread the spectral energy to mitigate the unintentional interference to radio services. The modulation frequency of SSC shall be in the range defined for f_{SSC} in Table 1.

The modulation frequency deviation shall be in the prescribed range for SSC_{tol} in Table 1. The instantaneous frequency (each period) of the Reference Clock shall fall within the prescribed T_{UI} range. If the rate of change of the instantaneous frequency is excessive jitter is increased.

The SSC modulation only moves the frequency below the nominal frequency. This technique is often called "down-spreading".

7.3.3.1 Example SSC Profile (Informative)

An example triangular frequency modulation profile is shown in Figure 2. The modulation profile in a modulation period is expressed as:

$$f = \begin{cases} (1-\delta) f_{nom} + 2 f_m \cdot \delta \cdot f_{nom} \cdot t & \text{when } \; 0 < t < \dfrac{1}{2 f_m}; \\ (1+\delta) f_{nom} - 2 f_m \cdot \delta \cdot f_{nom} \cdot t & \text{when } \; \dfrac{1}{2 f_m} < t < \dfrac{1}{f_m}, \end{cases}$$

where f_{nom} is the nominal frequency in the non-SSC mode, f_m is the modulation frequency, δ is the modulation amount, and t is time.

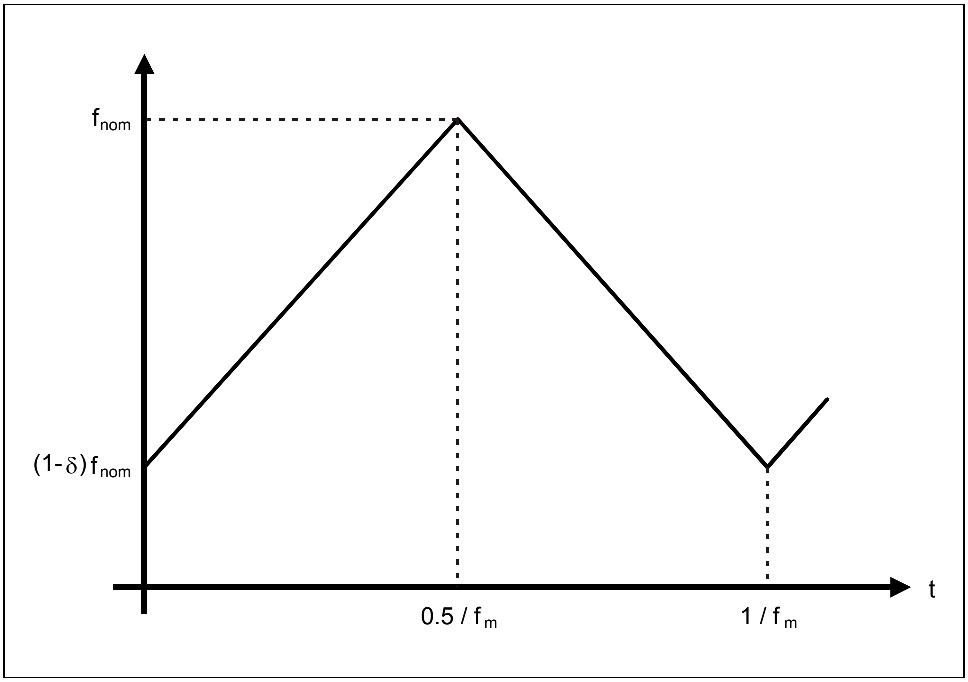

Figure 2 – SSC Profile Example: Triangular

As an example, for triangular modulation, the absolute spread amount at the fundamental frequency is shown in Figure 3, as the width of its spectral distribution.

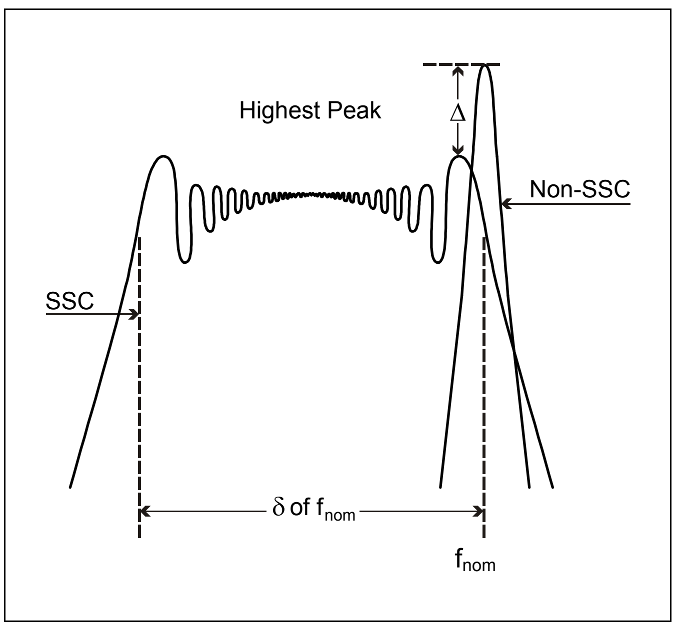

Figure 3 – Spectral Fundamental Frequency Comparison