Proposed Draft

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The Serial ATA International Organization, Serial ATA Ratifed ECN ("Final Specification") is available for download at http://www.sata-io.org.

For more information about Serial ATA, refer to the Serial ATA International Organization website at http://www.sata-io.org.

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Document History

Version	Date	Comments
0	May 22, 2012	Initial release.
1	May 30, 2012	Phy meeting May 30, 2012 changes.
2	June 7, 2012	Changes to formula in 7.2.7.1
3	June 13, 2012	Phy meeting June 13, 2012 prior to vote.

1 Introduction

1.1 Problem Statement

When integrating TP034 SATA Universal Storage Module there was a typo in Table 2 that placed the letter H representing host in the Gen2i and SATA USM cell. The original TP034 shows this cell should be the letter D representing device. The rest of SATA USM applies Gen2i to the device requirements.

The compliance interconnect channel definition was missing.

Once the CIC acronym is established, the full phrase compliance interconnect channel was continued to be used.

In section 7.4.4.2 Minimum Differential Voltage Amplitude (Gen3i, Gen3u) figure 163 – Transmit Amplitude Test with Laboratory Load is cross referenced when describing the use of the CIC. The reference should have been to Figure 164 – Transmit Amplitude Test with Compliance Interconnect Channel.

In section 7.2.7 there is a reference to Table 37 input swing (VdiffTx). Table 37 only specifies Vdiff Txdevice, TX Differential Device Output Voltage and VdiffTXhost, TX Differential Device Output Voltage.

A concern was raised with the opening sentence in section 7.4.4.2 Minimum Differential Voltage Amplitude (Gen3i, Gen3u), potentially conflicting with other sections of the specification since Gen3u is not measured with the CIC. There have been two proposals to add Gen3i to this sentence as shown below.

Proposal 1:
The Gen3i minimum TX differential amplitude shall be measured through the Gen3i CIC as ~~specified~~defined in ~~section~~ [Editor's note 7.2.7] terminated into the Lab-Load.

Proposal 2:
For Gen3i t~~T~~he minimum TX differential amplitude shall be measured through the Gen3i CIC as ~~specified~~defined in ~~section~~ [Editor's note 7.2.7] terminated into the Lab-Load.

1.2 Solution Summary

Change the letter H in the Gen2i and SATA USM cell to the letter D.

Added the Compliance Interconnect Channel definition and acronym.

The use of CIC to represent the compliance interconnect channel was cleaned up in section 7.2.7. Removed "input swing" since no input swing is defined in Table 37.

Changed the figure reference to Figure 164 – Transmit Amplitude Test with Compliance Interconnect Channel when talking about measurement using the CIC in section 7.4.4.2.

The Gen3i minimum TX differential amplitude shall be measured ~~through~~with and without the Gen3i CIC as ~~specified~~defined in ~~section~~ [Editor's note 7.2.7] terminated into the Lab-Load.

The Gen3u case is covered in the very next paragraph.

1.3 Background (optional)

When discussion of adding a direct attach usage model began a review of the existing SATA USM usage model highlighted the issues being resolved.

Review of SATA USM confirmed the following.

The Gen1u, Gen2u, and Gen3u electrical specifications only apply to the host. Using Table 2 as the primary reference. Reviewed text for consistency. The device always uses Gen1i, Gen2i and Gen3i.

Gen3u Tx measurements (i.e., host) do not use the CIC.
Gen3i Tx measurements (i.e., device) Laboratory Load with and without CIC added for amplitude and total jitter.

2 Technical Specification Changes

2.1 <Title of section being changed>

[**Editor's Note:** The changes marked in ~~red~~ (and strikethrough) will be deleted. The changes marked in blue (and underlined) will be incorporated]

2.1.1.1 [Editor's note 4.1.1.19] command packet

A data structure transmitted to the device during the ~~execution~~processing of a PACKET command that includes the command and command parameters.

2.1.1.2 [Editor's note 4.1.1.19+1] CIC (Compliance Interconnect Channel)

A Compliance Interconnect Channel (CIC) is defined as a set of calibrated physical test circuits applied to the Transmitter mated connector (see [Editor's note 7.2.7]).

2.1.2 [Editor's note 4.1.1+1] Symbols and abbreviations

CIC Compliance Interconnect Channel (see [Editor's note 4.1.1.19+1])

Table 1 – Usage Model Descriptions

Characteristic	Internal 1 meter Cabled Host to Device	Short Backplane to Device	Internal 4-lane Cabled Disk Arrays	System to System Inter connects – Data Center Applications xSATA	System to System Inter connects – External Desktop Applications eSATA	Proprietary Serial ATA Disk Arrays	Serial ATA and SAS	LIF-SATA	mSATA	SATA USM
Usage model section number	5.2.1	5.2.2	5.2.4	5.2.5	5.2.6	5.2.7	5.2.8	5.2.10.2	5.2.10.1	5.2.11
Cable and/or backplane type	Int SL	BP	Int ML	Ext ML	Ext SL	BP and cable	BP	P	BP	P
Cable length	<= 1 m		<= 1 m	<= 2 m	<= 2 m			P		P
Cable Electrical	Table 20	P	Table 20	Table 22	Table 21	Table 20	P	Table 20	P	P
Attenuation at 4.5GHz	-6dB	P	-6dB	-8dB	-8dB	-6dB	P	-6dB	P	P
Host-side connector	6.1.5	P	6.1.11 or 6.1.12	6.7.3 (key 7)	6.7.1	6.1.5 or P	SAS	6.4.3	6.5.2	6.6.1
Device-side connector	6.1.3.1	6.1.3.1	6.1.3.1	6.7.3 (key 7)	6.7.1	6.1.3.1	6.1.3.1	6.4.2	6.5.3.1	6.1.3.1
Gen1i 1.5 Gbps	R	D (host to provide received signal)	R	NS	NS	R	D	R	R	D
Gen1m 1.5 Gbps	NS	H	NS	R (key 7)	R	NS	NS	NS	NS	NS
Gen1u 1.5 Gbps	NS	NS	NS	NS	NS	NS	NS	NS	NS	H
Gen2i 3.0 Gbps	FS	D (host to provide received signal)	FS	NS	NS	FS	D	FS	FS	~~H~~D

Characteristic	Internal 1 meter Cabled Host to Device	Short Backplane to Device	Internal 4-lane Cabled Disk Arrays	System to System Inter connects – Data Center Applications xSATA	System to System Inter connects – External Desktop Applications eSATA	Proprietary Serial ATA Disk Arrays	Serial ATA and SAS	LIF-SATA	mSATA	SATA USM
Gen2m 3.0 Gbps	NS	H	NS	FS (key 7)	FS	NS	NS	NS	NS	NS
Gen2u 3.0 Gbps	NS	NS	NS	NS	NS	NS	NS	NS	NS	H
Gen3i 6.0 Gbps	FS	NS	FS	NS	NS	FS	D	FS	NS	D
Gen3u 6.0 Gbps	NS	NS	NS	NS	NS	NS	NS	NS	NS	H
Hot plug support	NS	R	NS	R	R	R	R	NS	NS	R

Key:

- R – Required : configuration requires appropriate capabilities
- FS – Feature specific : configuration is supported by specification but may be tied to an optional capability
  - NOTE: Feature specific is intended to indicate that Gen1 is required but higher data rates are optional.
- NS – Not supported : configuration is not supported by definition in specification
- P – Proprietary : implementation is vendor specific and not defined in specification
- H – Host
- D – Device
- SL – single lane
- ML – multi-lane
- Int – Internal
- Ext – External
- BP – Backplane

NOTE : Many of the references in the table are section numbers or notations of clarification which do not require Key values

2.1.3 [Editor's note 7.2.7] Compliance Interconnect Channels (Gen3i, Gen3u)

2.1.3.1 [Editor's note 7.2.7.1] Compliance Interconnect Channels overview

For Gen3i, a Compliance Interconnect Channel~~s~~ (CIC) is~~are~~ defined as a set of calibrated physical test circuits applied to the Transmitter mated connector, intended to be representative of the highest-loss interconnect~~s~~. For Gen3u, the Gen3i CIC~~Compliance Interconnect Channel~~ is used to set up the Lab-Sourced Signal and then removed prior to applying the signal to the UHost receiver under test (see [Editor's note Table 41]). A CIC~~Compliance Interconnect Channel~~ is not used in testing the UHost transmitter.

The ~~Compliance Interconnect Channel (~~CIC~~)~~ is used to verify that the signal electrical characteristics at the Transmitter mated connector are sufficient to ensure compliance to the input electrical specifications for Gen3i receivers as delivered through worst-case media. The magnitude of this worst-case loss as a function of frequency is defined mathematically as a Transmitter Compliance Transfer Function (TCTF). Any linear, passive, differential two-port (e.g., a SATA cable) with loss greater than the TCTF at all frequencies and which meets the ISI loss constraint (defined below) is defined to be a CIC~~.~~ (See ~~also section~~ [Editor's note 7.2.7.1]~~.~~).

A combination of a zero-length test load (i.e., the Laboratory Load) plus the applicable CIC (Gen3i) is used for the specification of the host-controller or device transmitter characteristics.

A Gen3i transmitter signal is specified by meeting:

~~1.~~ a) ~~Meeting~~ all parameters in [Editor's note Table 37][1] for Gen3i when transmitting into a Laboratory Load; and~~.~~

~~2.~~ b) ~~Meeting~~ [Editor's note Table 37] ~~input swing (~~VdiffTx~~)~~ and total jitter (TJ after CIC) requirements for Gen3i when transmitting through the appropriate Gen3i CIC into a Laboratory Load while using the same transmitter settings (emphasis, amplitude, etc.) as in the first test.

NOTE 1 - Note that the Transmitter Compliance Specifications are defined and measured into a Laboratory Load. Received signal attenuation or amplification due to actual receiver terminator tolerance as well as additional received signal ISI due to the actual receiver return loss may further degrade the actual receiver's input signal. Transmitter Compliance Specifications are expected to be only slightly tighter than Receiver Specifications.

The transmission magnitude response, $|S_{21}|$, of the Gen3i TCTF satisfies the following two inequalities[2]~~:~~

$$|S_{21}| \le -20 \times \log_{10}(e) \times ((3.0 \times 10^{-6} (f^{0.5})) + (1.1 \times 10^{-10} (f))) \text{ dB}$$

for 50 MHz < f < 9.0 GHz, (f expressed in Hz),

$$|S_{21}| \text{ at 600 MHz} - |S_{21}| \text{ at 3 000 MHz} > 2.7 \text{ dB}$$

~~[1] Note that the Transmitter Compliance Specifications are defined and measured into a Laboratory Load. Received signal attenuation or amplification due to actual receiver terminator tolerance as well as additional received signal ISI due to the actual receiver return loss may further degrade the actual receiver's input signal. Transmitter Compliance Specifications are expected to be only slightly tighter than Receiver Specifications.~~

~~[2] Note that "e" in the first expression is the base of the natural logarithms, approximately 2.71828. Hence, the first factor, 20 log10(e), evaluates to approximately 8.6859. This value is the conversion factor from nepers (defined as the natural logarithm of a power ratio) to decibels.~~

Note : The "e" in the first expression is the base of the natural logarithms, approximately 2.71828. Hence, the first factor, $20 \log_{10}(e)$, evaluates to approximately 8.6859. This value is the conversion factor from nepers (defined as the natural logarithm of a power ratio) to decibels.

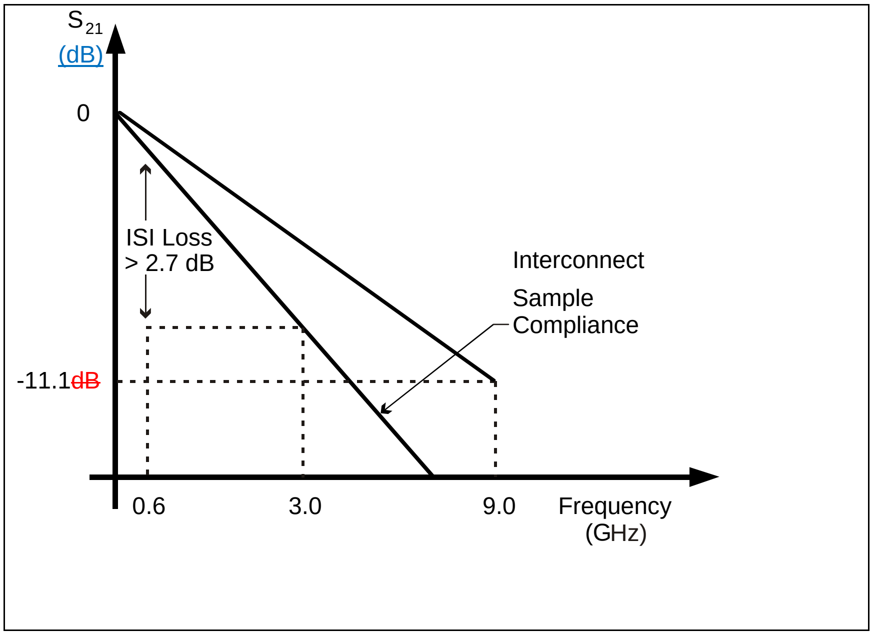


Figure 148 – Compliance Channel Loss for Gen3i

The second constraint, termed ISI loss, may be motivated as follows,: $|S_{21}|$ at one tenth the data rate is the attenuation of the fundamental component of a repeating five-ones-five-zeroes pattern, the longest possible run lengths in 8b/10b encoded data. Similarly, $|S_{21}|$ at one half the data rate is the attenuation of the fundamental component of a repeating …010101b… pattern, the shortest possible run lengths in 8b/10b encoded data.

Hence, for an output waveform of this TCTF, ISI loss approximates the ratio between:

a) the peak-peak voltage (established by the long run lengths); and

b) the inside vertical eye opening (established by the high frequency pattern).

Anny TCTF with a flatter loss characteristic (i.e., with more broadband attenuation) would generates less inter-symbol interference (ISI) and therefore less output jitter. This constraint prohibits such a TCTF.

2.1.4 [Editor's note 7.4.4]Measurement of Differential Voltage Amplitudes (Gen3i, Gen3u)

2.1.4.1 7.4.4.1 Measurement of Differential Voltage Amplitudes overview

The amplitude measurement of differential signals for Gen3i uses different methods for the maximum amplitude and the minimum amplitude compliance tests. The maximum amplitude is a peak-to-peak value measured at the TX compliance point into a Lab-Load. This limits the magnitude of signals present in the interface. The minimum amplitude is a measurement of the minimum eye opening, using the specified method, after the Gen3i CIC, into a Lab-Load. This provides a minimum signal level for the receiver, measured in a manner that is representative of how a typical receiver would processes the signal.

Achieving both the maximum and minimum differential amplitude compliance limits as ~~listed~~given in [Editor's note Table 37] shall be required, using the same transmitter settings for both tests.

The same methods and patterns are used for setting up the Lab-Sourced Signal for Receiver Tolerance Testing, with the compliance limits specified in [Editor's note Table 40].

The Gen3u transmitted signal maximum amplitude is a peak-to-peak value measured at the TX compliance point into the Lab-Load. The minimum amplitude is a measurement of the minimum eye opening, using the specified method, into a Lab-Load. The Gen3i CIC is not used for the Gen3u transmitted signal minimum amplitude. The measured values shall comply with the limits specified in [Editor's note Table 38].

The same methods and patterns are used for setting up the Lab-Sourced Signal for Gen3u receiver tolerance testing, with the compliance limits specified in [Editor's note Table 41]. The Gen3i CIC is used to calibrate the Lab-Sourced Signal for Gen3u receiver tolerance testing; however, the Gen3i CIC losses are removed from the Lab-Sourced Signal prior to testing the Gen3u receiver under test for compliance.

2.1.4.2 [Editor's note 7.4.4.1+1]Maximum Differential Voltage Amplitude (Gen3i, Gen3u)

The maximum differential amplitude shall be measured at the TX Compliance point into a Lab-Load. [Editor's note Figure 163] shows a drawing of this test connection. A Gen3 MFTP shall be used for this compliance measurement, although it is possible that with other patterns and signal path characteristics, additional peak-to-peak maximum amplitude values maybe present in the actual system. The MFTP ~~will~~should contain emphasis due to its run length, if the transmitter supports this signal conditioning, and allows for simple edge triggering for the signal capture.

The maximum amplitude is defined as the peak to peak value of the average of 500 waveforms measured over a time span of 4 Gen3 UI, using the HBWS.

2.1.4.3 [Editor's note 7.4.4.2+1] Minimum Differential Voltage Amplitude (Gen3i, Gen3u)

2.1.4.3.1 7.4.4.2+1.1 Minimum Differential Voltage Amplitude overview

The Gen3i minimum TX differential amplitude shall be measured ~~through~~with and without the Gen3i CIC as ~~specified~~defined in ~~section~~ [Editor's note 7.2.7] terminated into the Lab-Load. [Editor's note Figure 163 was incorrectly referenced and is here by changed to Figure 163 and Figure 164] shows ~~a~~ drawings of ~~this~~these test connections. A Gen3 LBP shall be used for this compliance measurement, although it is possible that with other patterns and signal path characteristics, lower amplitudes may be present in the actual system.

The Gen3u transmitted minimum TX differential amplitude shall be measured terminated into the Lab-Load. [Editor's note Figure 154] shows a drawing of this test connection. The Gen3i CIC is not used for this measurement. The measured value shall comply with the limits specified in [Editor's note Table 38].

The minimum amplitude is defined as the vertical eye height on a population of at least 5 ~~*~~× 10^6 unit intervals of data measured at the minimum voltage measurement interval of the UI using the Gen3i Reference Clock JTF as defined in ~~section~~ [Editor's note 7.3.2]. When calibrating a receiver stressed signal, an explicit clock shall be used instead of the JTF.

All test equipment (e.g., HBWS), requires a minimum signal amplitude to be able to measure the eye height to a population of 5 ~~*~~× 10^6 unit intervals. This level varies with instrumentation type, hardware and software. This minimum required instrumentation amplitude introduces errors in the reported minimum amplitude measurement value. This error results in the minimum amplitude reported by the test equipment to be smaller than the actual signal minimum amplitude. This instrumentation error shall be corrected for, to determine the actual minimum amplitude value using recommended methods provided by the test equipment manufacturer. If no such recommended correction procedure is available for one piece of test equipment, alternate test equipment ~~could~~may be selected. Instrumentation performing this measurement shall be traceable to industry standards setting origination in the area of performing amplitude measurements (e.g., National Institute of Standards and Technology (NIST)) within the USA. HBWS Instruments shall be calibrated and be traceable to ISO/IEC 17025:2005 specifications.

2.1.5 [Editor's note 7.4.6] Transmitter Amplitude

2.1.5.1 7.4.6.1 Transmitter Amplitude overview

The transmitter amplitude values specified in [Editor's note Table 37 and Table 38] refer to the output signal from the unit under test (UUT) at the mated connector into a Laboratory Load (LL) (for Gen1i, Gen1m, Gen1u, Gen2i, Gen2m, Gen2u, Gen3i, and Gen3u), or from the unit under test through a ~~Compliance Interconnect Channel (~~CIC~~)~~ into a Laboratory Load (for Gen3i only). The signals are not specified ~~when~~while attached to a system cable or backplane.

2.1.5.2 [Editor's note 7.4.6.1+1]Transmitter Amplitude (Gen1 and Gen2)

Transmitter minimum amplitude is measured with each of three waveforms:

a) HFTP;~~,~~
b) MFTP;~~,~~ and
c) the Lone Bit Pattern (LBP).

Amplitude specifications shall be met according to the measurement method ~~outlined~~as defined in ~~section~~ [Editor's note 7.4.3].

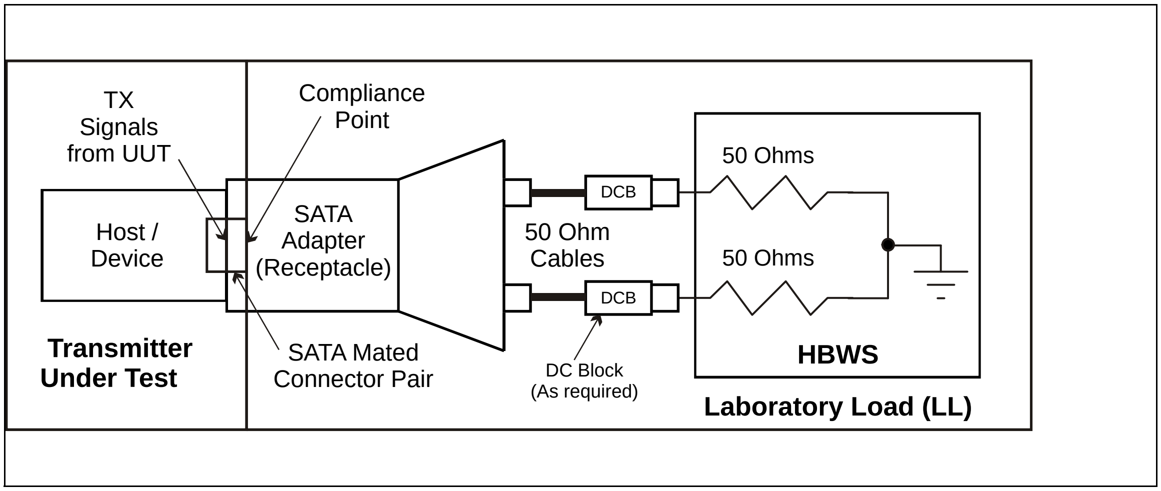
The minimum amplitude value is measured during the TX minimum voltage measurement interval defined in [Editor's note Table 37 and Table 38. The Reference Clock (~~defined in section~~ see [Editor's note 7.3.2]) defines the ideal (zero jitter) zero crossing times. The maximum amplitude is measured ~~according to~~with the measurement method ~~outlined in section~~ according to [Editor's note 7.4.3.2] using waveforms LFTP and MFTP.

The transmit DC offset voltage (for Gen1i only) should be measured with the setup in [Editor's note Figure 163]. The HBWS is measuring a DC voltage and the DC blocks shall not be present.

[Editor's note Figure 163] shows the test setup for measuring transmitter amplitude. The HBWS is the standard for measuring amplitude. The losses in the test connections may be significant so it is prudent to minimize and estimate these.

Several methods may be used to estimate the cabling losses:~~.~~

a) ~~T~~the first is to use two cables of different lengths and compare the losses of each;~~.~~
b) ~~T~~the second is to rely on published data for the cables; or~~.~~
c) ~~T~~the third is to obtain a separate means for measuring the cable loss ~~such as~~(e.g., characterization with a network analyzer or power meter).



[Editor's note Figure 163] – Transmit Amplitude Test with Laboratory Load

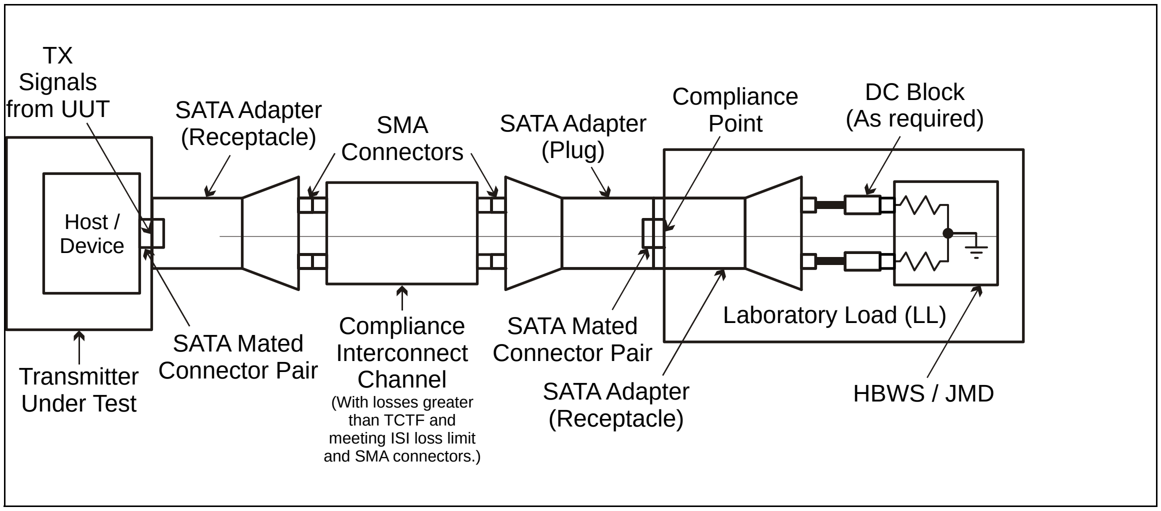
This specification describes transmitter levels in terms of voltage ~~when~~while driving a test load of 100 Ohms differential (the Laboratory Load, LL) and 50 Ohms single ended to ground. To relate the specified maximum levels to the maximum values seen in a system requires a calculation. For ~~A~~an example of this calculation ~~is in section~~ see [Editor's note 7.4.7].

2.1.5.3 [Editor's note 7.4.6.2+1]Transmitter Amplitude (Gen3i, Gen3u)

Transmitter minimum amplitude is measured with the Lone Bit Pattern (LBP). Amplitude specifications shall be met according to the measurement method ~~outlined in section~~ as defined in [Editor's note 7.4.4].

The minimum amplitude value is measured during the TX minimum voltage measurement interval defined in [Editor's note Table 37 and Table 38]. The Reference Clock (~~defined in section~~ see [Editor's note 7.3.2]) defines the ideal (zero jitter) zero crossing times. The maximum amplitude is measured ~~according to~~with the measurement method ~~outlined in section~~ according to [Editor's note 7.4.4] using the MFTP waveform.

[Editor's note Figure 163 and Figure 164] show test setups for measuring transmitter amplitude. See ~~section~~ [Editor's note 7.4.6.1] for suggestions on compensating for losses in the test connections.



[Editor's note Figure 164] – Transmit Amplitude Test with ~~Compliance Interconnect Channel~~CIC