Minutes of P1658 Standards Committee Meeting in Gaithersburg, Maryland USA – February 19, 2007

Minutes Prepared by: Solomon Max – 2007 - February 27 (revised 2007-March-10)

Draft Standard for Terminology and Test Methods for Digital to Analog Converters

Attendance: (Some arrived at different times during the day)

Sol Max	LTX Corporation, Norwood, MA USA (Secretary) sol_max@ltx.com
Fang Xu	Teradyne, Boston, MA USA fang.xu@TERADYNE.COM
Eulalia Balestrieri	University of Sannio, Benevento Italy balestrieri@unisannio.it
Pasquale Daponte	University of Sannio, Benevento Italy (Editor) daponte@unisannio.it
Robert Graham	Sandia National Laboratories, Albuquerque, NM USA rmgraha@sandia.gov
Rich Liggiero	LTX Corporation, Norwood, MA (USA) Richard_Liggiero@ltx.com
Francisco Alegria	Instituto Superior Tecnico, Lisbon, Portugal falegria@LX.IT.PT

Agenda: Monday February 19, 2007 – No Agenda was published, but the following items were implemented

9:00 AM

1. Introductions – All
2. Review the minutes of the last meeting.
3. Detailed review of assignments, the standard, action items to assign, etc.

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4. Break for Lunch – All
5. Continue draft review and new assignments.
6. New Business, suggestions and ideas for improvement.
7. Adjourn, Set next meeting.

Meeting Called to Order at 9AM

The minutes were accepted with no changes.

We attempted to make certain that the revision of the document was working from the latest draft. The revision was updated from 2.0 to 3.0 by Robert Graham who did the typing of the changes to the draft.

The IEC standard 60784-4 was added to the draft on page ii. Pasquale will come up with the exact title of the standard. Steve Tilden pointed out that IEC 60794-4-3 was just published last year titled "Semiconductors devices - Integrated circuits - Part 4-3: Interface integrated circuits - Dynamic criteria for Analogue-Digital Converters (ADC)".

Section 1.1.1 was assigned to Solomon Max. The section is titled “Analog-to-digital and digital-to-analog converters differences and similarities”.

Section 1.2 changes were reviewed and accepted. The changes were minor. The original text read:

binary words as a continuous analog signal, an underlying model implicit in many of the tests in this standard assumes that the relationship between the input signal and the output values approximates a straight line as depicted in Figures 2a, and 2b. Applying this model to a code-input DAC, the full-scale

The revised text reads:

binary words as a continuous analog signal, an underlying model implicit in many of the tests in this standard assumes that the relationship between the input code and the output value (transfer function) approximates a straight line as depicted in Figures 2a, and 2b. Applying this model to a code-input DAC,

Section 1.3.2.1 (Adjustment range) was modified slightly. The old suggested text read:

Many converter types require no adjustment as purchased to meet specified accuracy. However, there are cases where (1) adjustments are called for in the specifications, (2) cost-savings can be effected by trimming inexpensive pre-trimmed devices, with modest specs, for use over narrow ranges for better than specified accuracy, or (3) long-term corrections are necessary during years of operation.

The new text reads:

Many converter types require no adjustment as purchased to meet specified accuracy. However, there are cases where:

1) adjustments are called for in the specifications
2) cost-savings can be effected by trimming inexpensive pre-trimmed devices, with modest specs, for use over narrow ranges for better than specified accuracy
3) long-term corrections are necessary during years of operation.

The new text was accepted, as well as the whole section 1.3.2.1

There was much discussion on Section 1.1.3 (bandwidth). It was decided that Solomon Max would be assigned the task of rewriting the definition to highlight the difficulties in the definition. Tom Linnenbrink was unhappy with a definition that included the sample rate. As of this time, Solomon Max is inclined to rewrite the definition to include only the transient response limitations of the DAC (This was the original David Bergman recommendation). Fang Xu indicated that he might be happier if the definition was not included.

It was decided to eliminate the term CNR that was defined in section 3.1.4. The original text read:

3.1.4 carrier to noise ratio (CNR): SNR measured relative to modulated carrier; may be defined in a specific frequency band depending on the transmission standard

The text was eliminated.

Section 3.1.15 had contained the definition of DNL that is listed below:

3.1.15 differential nonlinearity (DNL): The difference between the output at a specified input code and the output at the preceding code, divided by the measured average LSB size of the DAC under test.

It was agreed that this definition is wrong. It was replaced by:

3.1.14 differential nonlinearity (DNL): The difference between the output at a specified input code and the output at the preceding code divided by the ideal minimum output increment divided by the gain of the DAC under test minus 1.

The issue of jitter was discussed. Fang Xu was assigned the task of writing a section that will describe jitter that is appropriate for DAC testing. The assumption will be that the DAC Under Test will assume to receive a jitter-free clock. The jitter of the device will be detected by measuring artifacts that are produced by imperfections in the DAC Under Test.

Currently there are many DAC jitter definitions in the text. These include the following in the draft that was released before the meeting:

jitter: Short term non-cumulative signal edge placement variation relative to its' ideal position. Unless otherwise specified, for single-ended signal, edge placement is defined as 50 % of signal peak-to-peak level; for differential signal, edge placement is defined as the instance of signal polarity changes. Only variation within the interval during which our each single observation will last is considered as jitter. Cumulative edge placement variation corresponds to a frequency offset, so it is excluded from jitter. In the context of DAC, jitter could be either clock jitter or DAC output relative to clock jitter.

When DAC is used for data communication, information could be coded with different level or transition. Overall jitter or peak-to-peak jitter is defined as expected maximum deviation from ideal signal transition at median of all possible signal level

The following changes were proposed:

3.1.33 jitter: Short term non-cumulative signal edge placement variation relative to its ideal position. Unless otherwise specified, for a single-ended signal, edge placement is defined as 50 % of signal peak-to-peak level; for a differential signal, edge placement is defined as the instance of signal polarity changes. Only variation within the interval during which each single observation will last is considered as jitter. Cumulative edge placement variation corresponds to a frequency offset, so it is excluded from jitter. In the context of DAC, jitter could be either clock jitter or DAC output relative to clock jitter.

It was recommended that a separate section on data dependent jitter be added

to handle the situation where a DAC is used as the source of a serial bit stream, and the transmission medium in the device introduces data dependent jitter (Is this wise? SM)
The definition of output skew had been given as:

3.1.48 output skew: Output skew of the multiple DACs is calculated as absolute time difference at the 50% point of the transition. It is recommended to capture the data of all the DACs simultaneously to get best possible accuracy. (not understood by CTU Prague)(Also Albuquerque)

This section was changed to:

3.1.50 output skew: Output skew is the time difference between multiple DAC outputs with the same input data.

The change was accepted.

The section on phase noise had been written as shown below:

3.1.50 phase noise: The fundamental component of an oscillatory regime could be expressed by a sinusoid equation. The phaser of this equation is a function of time. The order zero term is a phase offset while the first order in the phaser corresponding to a pure sinewave. Anything except the first two order in the phaser is phase noise. The phase noise is often expressed in frequency domain rather than time domain, typically expressed as a noise spectral density at a specific offset frequency from the fundamental. Time jitter is energy conversion of phase noise following the Parsval equality. As signal is real valued, the phase noise only has a bandwidth up-to the half of the frequency of the sinewave. Also, our observation has a limited duration, the integration of Parseval equality should start from inverse of the observation duration to half of the sinewave frequency.

This was changed to:

3.1.52 phase noise: The deviation of the phase of a sine wave synthesized by a DAC from the phase of a pure sine wave at the same frequency and the same average phase offset.

The change was accepted.

There was much discussion on the term hold jitter, which had been used to replace aperture jitter per the previous minutes. The term hold jitter was used in the current draft as a description of a property of the measurement system that was used to measure the performance of the DAC Under Test. The current draft does not use the term. It had been used in the following ways:

σ_t = hold jitter

4.7 Noise (total)[1] (Bergman)

[1] This definition of noise differs from the definition in the previous version of this standard (IEEE Std 1057-1994). It also differs from the definition in IEEE Std 1241-2000.

Noise has historically been an ambiguous term. In this standard, noise is any deviation between the input signal (converted to output units) and the output signal except deviations caused by linear, time-invariant system response (gain and phase shift), a DC level shift, total harmonic distortion, or an error in the sample rate. For example, noise includes the effects of random errors, nonlinearities producing harmonics greater than those used in measuring Total Harmonic Distortion, spurious signals, and time base errors (fixed error in sample time and hold jitter).

3.1.41 **noise (total):** Any deviation between the output signal (converted to input units) and the input signal except deviations caused by linear time-invariant system response (gain and phase shift), or a dc level shift. For example, noise includes the effects of random errors (random noise), fixed pattern errors, nonlinearities (e.g., harmonic or intermodulation distortion), and hold jitter.

These have now been changed to:

σ_t = timing jitter

4.7 Noise (total)[2] (Bergman)

Noise has historically been an ambiguous term. In this standard, noise is any deviation between the input signal (converted to output units) and the output signal except deviations caused by linear, time-invariant system response (gain and phase shift), a DC level shift, total harmonic distortion, or an error in the sample rate. For example, noise includes the effects of random errors, nonlinearities producing harmonics greater than those used in measuring Total Harmonic Distortion, spurious signals, and time base errors (fixed error in sample time and timing jitter).

3.1.43 noise (total): Any deviation between the output signal (converted to input units) and the input signal except deviations caused by linear time-invariant system response (gain and phase shift), or a dc level shift. For example, noise includes the effects of random errors (random noise), fixed pattern errors, nonlinearities (e.g., harmonic or intermodulation distortion), and timing jitter.

The term cdf (cumulative distribution function) was discussed and was left alone.

The term BW_m (Measurement Bandwidth) was discussed. It is not clearly defined. It was requested that this be discussed in connection with bandwidth that is being generated by Solomon Max.

Equivalent Time Sampling was discussed in connection with DACs. Pasquale agreed to delete the section since it is not applicable to DACs other than as a measurement technique. It may be discussed in the section where the measurement of DAC bandwidth is described.

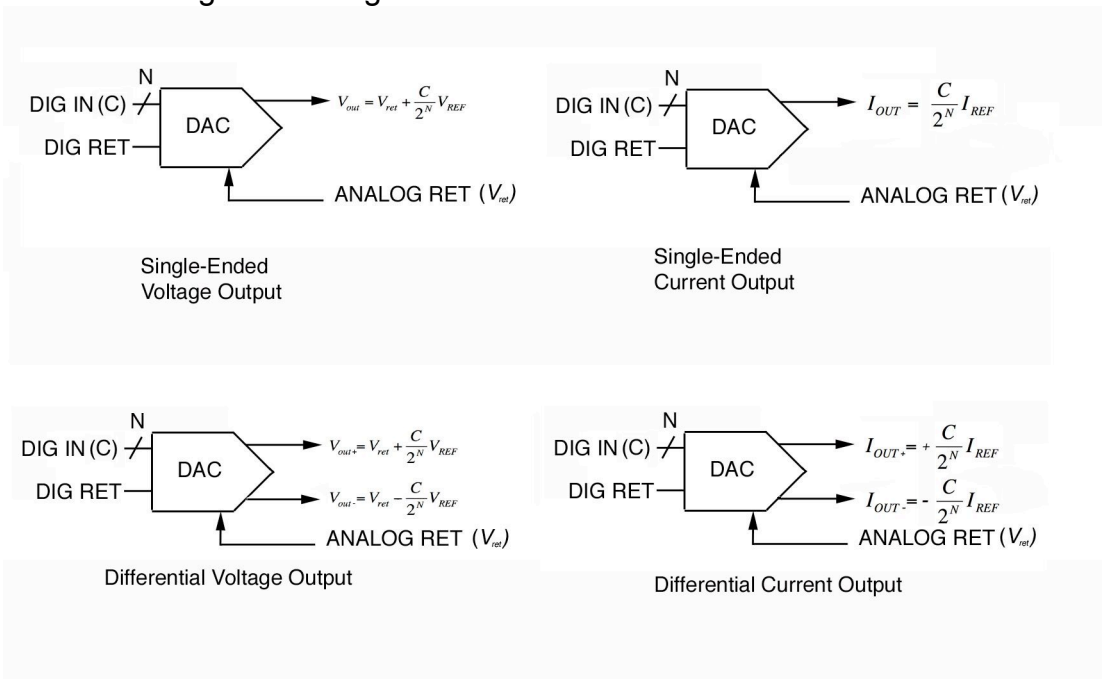
Richard Liggiero will write the section 4.2 (Digital input) that had previously been assigned to him.

[2] This definition of noise differs from the definition in the previous version of this standard (IEEE Std 1057-1994). It also differs from the definition in IEEE Std 1241-2000.

Robert Graham will write section 4.3 (Analog inputs)

In section 4.4.1 (Output impedance) the word ohms was replaced with Ω.
The term Dynamic range was discussed. It was felt that it needs a definition. It will be written in section 4.4.5 by Solomon Max.

The block diagrams of Figure 13 are shown below:



Pasquale agreed to modify them so that the term “Analog Ground Reference” will replace the term “Analog Return”.

The assignments are summarized in the table below.

Assignee	Reviewer	Sections	Description
Solomon Max	Richard Liggiero David Bergman Jerry Blair	1.1.1 1.1.3 4.4.5	Analog to Digital Converter and Digital to Analog Converter similarities and differences Bandwidth (Definition and caveats) Dynamic Range
Fang Xu	Solomon Max	4.13.1	Data Dependent Jitter
Robert Graham	Solomon Max	4.3	Analog inputs
Richard Liggiero	Tom Linnenbrink	4.2	Digital inputs
Pasquale Daponte	Robert Graham David Bergman Solomon Max	Introduction 4.1.3 Figure 13	Find full title of IEC 607844-4 Equivalent Time sampling Change Figure