Minutes of P1658 Standards Committee Meeting in Ottawa, Ontario Canada - May 19, 2005

Solomon Max – 2005-May-31

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

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

Steve Tilden	Texas Instruments (on phone line from Asia)
Sol Max	LTX Corporation, Westwood, MA USA
Pasquale Daponte	University of Sannio, Italy
Eulalia Balestrieri	University of Sannio, Italy
Sergio Rapuano	University of Sannio, Italy
David Bergman	NIST at Gaithersberg, MD
Don Hummels	University of Maine, USA
Henrik Lundin	Stockholm Royal Institute of Technology
Fang Xu	Teradyne, Boston, MA USA
Vladimir Haasz	Technical University in Prague, Czech Republic
Tom Linnenbrink	Qdot, Colorado Springs, CO

The meeting opened with a phone call from Steve Tilden. He noted that it was necessary to get more people involved as active participants in the writing of the standards. He suggested that possible sources of active participants might be:

1) The academic world, such as the University of Maine
2) Users such as Sandia, Lincoln Labs
3) DAC manufacturers such as TI, ADI, Maxim, Linear Technology, National Semiconductor, and Cirrus.

One of the main issues is the necessity of a financial commitment by the participants.

The 1057 PAR is extended. Boyle wants to finish the writing within the next year.

Tom Linnenbrink suggested that the current draft of P1658 be reviewed be started. The following items were mentioned

1) Sections 1 – 3 seem OK
2) Sol Max suggested that Section 4 has too many items.
3) Sol Max agreed to write the text for 4.1.2 “Taking a record of data”
4) Sol Max agreed to write the text for 4.1.6 “Determining the transfer curve”
5) Section 4.1.4 “Fitting sinewaves” is still unassigned.

6) Section 4.1.5 - “Discrete fourier transforms and windowing” is still unassigned

7) Section 4.2.2 - “Digital input” – It was recommended that the contents of Section 1.2 should be moved here, and that the text in 1.2 should be changed to point to section 4.2

8) Section 4.2.3 – “Input leakage current ”It was recommended that the title be changed to “Static input parameters” and that the section be broadened to include all physical static input parameters – including but not limited to:

    a. Input leakage current

    b. Input impedance

    c. Logic levels

9) Section 4.2.4 – “Setup and hold time”. It was recommended that the section title be changed to “Timing parameters”, and that the subject matter be broadened to include:

    a. Setup and hold time

    b. Input rise-time and overshoot

10) It was recommended that the section numbered 4.3 “Analog output (single-ended and differential)” be changed to 4.4 and that a new section be added as 4.3 titled “Analog inputs”. The section should include discussions on the following items:

    a. Reference inputs

    b. Analog ground

    c. Digital ground

11) Section 4.3 – “Analog output (single-ended and differential)” should be modified to include current outputs. Perhaps the title should be “Analog outputs (voltage, current, single-ended, and differential”. The section probably needs paragraphs on timing, and expected delays between a digital input change and an analog output change. The section should also include a discussion on glitch

12) Section 4.3.2 - “Short circuit current” needs an author

13) Section 4.3.3 - “Compliance” needs an author

14) Section 4.3.4 - “Load current” needs an author

15) Section 4.3.5 - “Dynamic range” needs an author

16) It was suggested that settling time, and glitch energy might be more appropriate if placed in the section connected with frequency response – Section 4.9. It was also suggested that the transfer response from unwanted signals (PSRR and Common mode rejection)

17) Section 4.4.1 – “Gain and Offset (static and dynamic)” has been rewritten by Solomon Max. The section is now on the web site. It will be reviewed by the group at the University of Sannio. It was recommended that particular reference be made to the unipolar and the bipolar cases. Solomon Max will make those

changes and post them on the web site.

18) Section 4.4.3 - "Dynamic gain and offset" needs an author. It was recommended that the section be replaced by a note in the transfer function section (4.1.6) which is being written by Solomon Max

It was noted that the section numbering for 4.4.1 "Adjustment range", was incorrect and is not in the appropriate sequence. Eulalia Balestrieri agreed to add this topic to the DAC topologies section. (Section 1.3.2 – "Coding"

19) Section 4.5 "Linearity (static and dynamic)" needs text.

20) The authors and reviewers of each section should be included in the draft. The names will be removed before the standard is sent out for balloting

21) Equation (12) is in error. It should read:

$$INL[k] = 100\% \cdot \frac{\epsilon[k]}{2^N \cdot Q \cdot G} = 100\% \cdot \frac{\epsilon[k]}{V_{FSR} \cdot G}$$

22) Section 4.5.1 "Integral nonlinearity" needs some corrections:

   a. Equation (12) should be corrected as mentioned above

   b. The term $\epsilon[k]$ should be explained as

      is the difference between GT[k] + V_{OS} and the ideal value of T[k]

23) Section 4.6 "Signal-to-noise and distortion ratio (SINAD)" should read "Signal-to-noise-and-distortion ratio (SINAD). The section needs text. The text is currently placed just before 4.6.6.1.

   "Noise" is an ambiguous term. When the word "noise" is used without qualification (e.g., "random noise", "quantization noise") in this Standard, it shall be assumed to refer to total noise. Total noise is 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, fixed pattern errors, nonlinearities, and aperture uncertainty. Notable examples of such effects and deviations here defined as noise include harmonic and intermodulation distortion, spurious distortion. This definition of total noise should be compared to the definition of Random Noise in clause XXX (specify the Clause number). SINAD is the same as the term SNR in IEEE Standard 1057[1]. The term SNR is not used here because in the context of DAC testing, it is used different ways by different concerned parties, and is thus too ambiguous. For instance, as of this writing, in the DAC industry, SNR often is equivalent to SNHR, the ratio of the signal to the portion of the noise that is not harmonic distortion.

   David Bergman has agreed to modify the text in all of Section 4.6. It should be specifically mentioned in 4.6.1 that many points are needed in the data record to accurately measure SINAD, and that the number of points in the record must be carefully chosen so that harmonics do not overlap, and so that many DAC codes are used.

24) Each section should consist of

   a. Introduction

b. Test method

c. Discussion or comment – although it was pointed out by Pasquale that the new standards allow comments to be placed elsewhere if appropriate.

25) Fang Xu has agreed to write a section on input pattern selection for dynamic testing as a part of Section 4.6.

26) There are two definitions for jitter give in Section 3.1.37. It is recommended that the ITU definition for random jitter. The pk-pk jitter should be referenced to BER. Fang Xu will com,e up with a definition. Sol Max and David Bergman will be reviewers.

The next meeting will take place in Las Vegas at the end of October or the beginning of November. Sol Max and Fang Xu indicated there preference for the beginning of November.

Professor Haasz will find someone (a colleague) for multi-channel testing and parameters

A long discussion of ENOB in DACs & ADCs took place. There was disagreement as to whether whether the term applies to DACs. The consensus was that ENOB is useful even if it has theoretical problems. Don Hummels will modify wording of ENOB section, and David will review. Henrik will also review it. 4.6.1 to 4.6.6

It was recommended that we add reference to Mil Std 810F (Environmental Engineering Considerations)

The standard file name for the draft will be P1658 yyddmm.doc

Professor Haasz will review Sections 4.6.1 to 4.6.6.

David Bergman will write a section on frequency response. Sol Max will review the section.

Section 4.6.11 “Idle noise” will be deleted.

David Bergman will do glitch energy and related material. Sol Max will review it.

Don Hummels will find someone to do Annex A material.

Section 4.11 “Power supply parameters” will be written by Eulalia Balestrieri. This will include considerations of transient currents, PSRR, and ground currents.

Professor Haasz will do the section on intermodulation distortion

Solomon Max offered to periodically remind reviewers and authors of their assignments.

Summary of Assignments – Including Unassigned Sections

Section	Title	Writer	Reviewer
1.3.1	Adjustment range to be added	Eulalia Balestreiri	***Solomon Max

Section	Title	Writer	Reviewer
3.1.37	Jitter definition	Fang Xu	David Bergman Solomon Max
4.1.2	Taking a record of data	Solomon Max	***David Bergman
4.1.4	Fitting sinewaves – input patterns	Fang Xu	Solomon Max
4.1.5	Discrete Fourier transforms and windowing	Fang Xu	Solomon Max
4.1.6	Determining the transfer curve	Solomon Max	***David Bergman
4.3.2	Short circuit current		
4.3.3	Compliance		
4.3.4	Load current		
4.3.5	Dynamic range		
4.4.1	Gain and offset (static and dynamic)	Solomon Max	Univ of Sannio
4.6.1	Signal-to-noise-and-distortion-ratio	David Bergman	Vladimir Haasz
4.6.2	Signal to non-harmonic noise ratio (SNHR)	David Bergman	Vladimir Haasz
4.6.3	Effective number of bits (ENOB)	Don Hummels	Vladimir Haasz David Bergman Henrik Lundin
4.6.4	Noise Power Ratio	David Bergman	Vladimir Haasz
4.6.5	Harmonic and spurious distortion	David Bergman	Vladimir Haasz
4.6.6	Total harmonic distortion	David Bergman	Vladimir Haasz
4.6.7	Intermodulation distortion	Vladimir Haasz	***Fang Xu
4.11	Power supply parameters	Eulalia Balestreiri	***Solomon Max
Annex A	DAC architectures	Don Hummels	***University of Sannio

***No reviewer was assigned. The secretary has tentatively assigned the people shown in the reviewer section. Unless they indicate that they cannot fulfill the assignment, they will be considered reviewers.