

**Minutes of TC-10 Waveform Recorder Subcommittee Meeting of  
June 13, 2006 in Colorado Springs, Colorado**

**Attendance:**

Tom Linnenbrink	Hittite Microwave
Jerry Blair	Bechtel Nevada
Sol Max	LTX Corporation
Bill Boyer	Sandia (retired)
Bob Graham	Sandia
Fang Xu	Teradyne

**1. Agenda**

Bill Boyer distributed an agenda by email prior to the meeting. It is attached to the minutes.

**2. Status of Draft**

A new draft was put on the web page on June 6. This was used for most of the meeting. A partial draft – Clauses 7.7 through 10, with edits by Sol Max, was put on later. This was used while reviewing these particular clauses.

**3. Review of Assignments from previous meeting.**

The names in parentheses after each item are the responsible persons.

**Annex G – Presentation of sinewave data.** (Called Annex H in the agenda.)

- Some of the new material supplied by Sol Max was redundant with material of the Mod T plot. The redundant material should be removed. (Sol Max)
- Insert correct reference on the modulo time plot (Bill Boyer)
- Change terminology to agree with the Irons & Mummels paper (Jerry Blair)
- Redo the figures. (Jerry Blair with data from Sol Max)

**Annex A – Sinewave fitting.** Remove the added material on initial estimate of amplitude and phase. It is not needed for the algorithms that remain.

**Clause 7.4:** Finish updating plots. (Jerry Blair with data from Sol Max)

**Clause 7.7 –Harmonic Distortion.**

- Refer back to the DFT section for DFT. Explain that we are following the convention of using frequencies between 0 and the sampling frequency rather than the usual convention of frequencies between minus and plus the Nyquist frequency. (Bill Boyer)
- Change Equations 46 and 48 to have absolute values. (Bill Boyer)

- Point out that multiples of the Nyquist frequency cannot be used as test frequencies. (Bill Boyer)
- Extract the material on aliasing added by Sol Max in Clause 7.7, and place it in Clause 4.4. (Bill Boyer)
- Figure 20. Explain that horizontal axis is sorted to give a distribution. Give formula for vertical axis for this figure and figure 21. (Sol Max)

**Clause 8.** In first paragraph change "harmonics greater" to something clearer (greater frequency or greater order.) Clause on SSBWSNR was deleted – the term should be removed from the definitions. (Bill Boyer)

**Dynad reference.** Put in correct reference (Bill Boyer, Jerry Blair)

**References added by Francisco Alegria.** A reference should be included only if the text tells specifically what is in the reference. Simply saying "for more information see ..." is not adequate. (Francisco Alegria)

**Introduction.** No one had additional names for contributors. We will add names of organizations that made substantial contributions. (Bill Boyer)

**Annex F.** The formulas have been reviewed.

**Annex B – Phase noise.** Fix the text of the Mathematica programs so that they can be correctly included in a text box. (Jerry Blair)

**Plots.** Send out email requesting data for plots that need to be redone. (Jerry Blair)

**Clause 8.4 – Normalized signal-to-noise ratio.** This will be deleted unless someone has a strenuous objection.

**Clause 4.4.** Add some more explanation of the difference between the DFT presentation and that of a spectrum analyzer. Move material on aliasing from Clause 7.7 to Clause 4.4. (Sol Max)

**Clause 9.2.2.** In first sentence replace "nonlinear" with "a nonlinear function of the input signal." Remove the last 2 sentences of the clause. (Bill Boyer)

**Clause 10.2.2.** Change "%" to degrees in the expression for error in phase shift. (Bill Boyer)

**Standard 181.** We will not include the 181 material in 1057, we will continue to reference it.

**Grounding.** Sol Max will send extract the material on grounding that he did for the DAC standard, and we will attempt to incorporate it into 1057. (Sol Max, Bill Boyer)

**Clause 4.6.2.** The  $N_0$  notation is OK, does not need to be fixed. Sol will do a final tweaking on this section. (Sol Max)

**Clause 4.6.10.1.1.** Provide reference for equation (31). (Sol Max)

**All assignments must be completed by August 1, 2006.** we are planning to go to ballot in September. This will be before the next meeting.

**Agenda for Waveform Recorder Subcommittee Meeting  
June, 2006**

1. Introductions
2. Review of status of the draft – a new draft was created dated June 3, 2006. This draft includes modifications by Sol Max, Francisco Alegria, Fang Xu, Jerry Blair and Bill Boyer.
3. Review of status of old assignments and those per minutes of April 2006:
  - **Annex H, Presentation of Sinewave data** Fix figures (Jerry Blair, done by B. Boyer?)
  - **Annex A, Sinewave Fitting** review new material (Sol Max, Blair)
  - **Clause 7.4 INL. Modify new example figures** (Sol Max) **partially done**
  - **Clause 7.6 Hysteresis. Modify new figure.** (Sol Max) **done**
  - **Clause 7.7 Total Harmonic Distortion. Various corrections to submitted material** (Jerry Blair, Sol Max)
  - **Clause 8.1 to 8.3 Various changes** (Alegria, Blair review)
  - **Clause 8.5.1.1 ENOB test method** – add material (Blair)
  - **Clause 16.1 Test method for cycle time. Eliminate** (Boyer) **done**
  - **Clause .4.6.8 Sinewave Histogram** - Fix reference and equation numbers (Blair - done)
  - **Introduction** – add names of more people (Boyer) started
  - **References:** a few of them need to be verified and identified (everyone)
  - **Annex F** – review formulas (Alegria)
  - **Annex G.** The new material supplied by Sol Max has now been included. Blair will regenerate the figures with Kaleidagraph starting with the data files. (Sol Max, Jerry Blair, Bill Boyer)
  - **Annex A.** eliminate the non-matrix algorithms. (Jerry Blair, Bill Boyer – done (need to decide what to do with old method of estimating initial conditions.)
  - **Annex B.** (Phase Noise) The Mathematica programs need to be included, and the figures need to be improved. (Jerry Blair - done)
  - **Clause 7.4.** Figures need an x-axis label. (Sol Max, Jerry Blair)
  - **General.** For consistency of appearance Jerry Blair will redo all plots using Kaleidagraph and Francisco Alegria will do diagrams in Visio. (Jerry Blair, Francisco Alegria)
  - **Clause 7.7 Total Harmonic Distortion.**
    - The equations were all retyped, so they should be checked. (All)
    - THE – When introduced it should be mentioned that it is only a temporary variable and not of importance. It should be removed from the definitions. (Jerry Blair, Bill Boyer - done)
    - The mod notation is inconsistent. The uncapitalized form should be used throughout and the notation should be explained. Try to find references for the mathematics. (Jerry Blair, Boyer – added definition, set to lower case)
  - **Clause 8.** Changes need to be reviewed. (Jerry Blair)

- **Clause 8.4.** Change name to "signal-to-noise over a specified bandwidth." Get copy of VIMS (international vocabulary for measurement Systems) and check terminology against it. (Bill Boyer, Jerry Blair)
- **Clause 8.5.1.1.** This was put in the draft as 8.5.2. It was reviewed at the meeting. It needs pictures and more explanation. (Jerry Blair). Fix section numbers (Boyer – done)
- **Clause 16.1.** Needs change to say that no general test method is recommended. (Bill Boyer - done)
- **Clause 4.4.** Point out the differences between DFT and spectrum analyzer. (Sol Max)
- **TOC.** The table of contents needs to be updated to reflect the changes in the document. (Bill Boyer - done)
- **Clause 5.2.** Replace "precision terminating resistor" with "precision RF terminator" or "standard terminator" to make clear that it is not just the DC resistance that needs to be precise. (Bill Boyer – done but said “precision impedance”)
- **Clause 5.1.** Replace “appropriate output level” with an explanation of what is appropriate. Add "use precision impedance, low loss cable” (Bill Boyer - done, Fang Xu to review all of Clause 5.)
- **Review of entire draft.** The draft was divided into 4 approximately equal parts for review. Everyone should review as much of the draft as possible doing the assigned section first. Mark up the draft in "track changes" mode.
  - Beginning through Clause 4.4, Fang Xu.
  - Clauses 4.5 through 7.6, Francisco Alegria.
  - Clauses 7.7 through 10, Sol Max.
  - Clause 11 to end, Jerry Blair.
- **Standard 181.** I have a Word copy and will help extract parts. (Jerry Blair, Bill Boyer (I have one also and don't think anymore should be extracted.)
- **Clause 4.6.10.** Explain "synchronous with sampling clock." (Sol Max)
- **SFDR** – The current general agreement is to include harmonics in SFDR. IEC standard includes harmonics – done??
- **8.8 and 8.9 New sections on Spurious components and SFDR.** Change notation to  $X[n]$  from  $X[f]$ . (Bill Boyer - done)
- **Grounding.** Find a reference on grounding to place at the proper place in the standard (Tom Linnenbrink). Ask Steve Tilden if he will write something on grounding for this standard. Put a grounding section under test setup. (Bill Boyer – done including draft write up and a reference)
- **Look over all material in draft in red and propose what should be done** (All)
- **Look other issues identified in attachment** (All)

4. Other business

5. Review new action items

Some issues with June 03 1057 draft:

New proposed first cut definitions:

**quantization noise:** Equivalent noise produced during the quantization of a continuous range variable. A quantization process of step size  $Q$  produces an rms quantization noise of  $Q/12$  when the continuous variable range is much larger than  $Q$ .

Bill Boyer 3/18/06 9:24 AM  
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**(input) coupling:** type of nominal series impedance at the input of the recorder. Recorder input could be either ac (capacitive impedance) or dc coupled (nominal short circuit).

**mod number1, number2 or number1 mod number2:** a mathematical operator that divides *number1* by *number2* and returns only the remainder as the result, e.g.,  $13 \bmod 5 = 3$ .

**single-ended recorder/single-ended signaling:** A non-differential waveform recorder, i.e. one that does not subtract the signals at two input terminals.: Asymmetric signal and signal return. The return is usually referred as ground or shield. (need better definition)

should we only use “'” (prime) notation for derivatives

4.6.8.2 Need Reference for Dynad?? Are all these necessary: “For further information, see [B1, FA1, FA4, FA6, FA8, FA10, FA12 and FA14]”

#### Text issues

Fix notation in Fig 7 in 4.6.2

In 4.6.10.1.1 May need a reference for equation 31. {add reference?}:  
{ALEGRIA: There is no mention to the averaging in the text or in the previous section}

In 4.6.10.2 need to fix notation in Fig. 11, 12. (Also do we really need Figure 12? This about the only place where we diagram an algorithm.)

In 4.6.10.3 has ADC specific language i.e. sampling clock

4.6.10.4 unknown reference for uncertainties in values of the code transition levels

7.6.1 “{ALEGRIA: The values will never be equal. They should just be close enough...}”

In 7.7 THD, is  $A_{\text{rms}}$  really an rms quantity. The equation doesn't look like it.

7.7.1  $n_h = hn_i \bmod(M)$   $h = \pm[2,3,\dots,H]$  {ALEGRIA: Changed; fix mod function} (1) and (53)

In 7.9.1 on NPR, need a figure more appropriate for waveform recorders. This one shows a clock generator.

7.9.2 Are B10 and B15 appropriate references.

In 8.0 we say noise does not include sample rate errors but does include fixed error in sample time. Is this consistent?

8.4 Normalized SNR measures was rewritten and needs to be reviewed. SSBWSNR was deleted. { NOTE: "I am suggesting deleting the SSBWSNR stuff. You get essentially the same results by measuring the noise (with any size input signal) and expressing the result in dBFS. This is much clearer"}

9.4.1 Test method for overshoot. Last time I proposed putting algorithm in our text instead of simply referencing 181. Having actually looked at how much of 181 would be required, I think we should continue to just reference it as we have in the past.

$$12.2.2 \quad \sigma_t = \frac{\sqrt{\eta_2^2 - \eta_1^2}}{\sqrt{2\pi f_2 A}} \quad \{\text{ALEGRIA: Changed}\} \quad (2)$$

17.2 . NOTE: The figure does not illustrate the parameters discussed. It does show  $V_{\text{HYST}}$ .

Annex A –

A revised version of A-3 was submitted and should be reviewed by the whole committee

Annex F Triangle Wave considerations:

Rand M ??

What is correct equation reference in item (3).

Annex G Presentation of sinewave data:

Need cleaner plots.

Is reference [B15] correct