High Resolution Audio Codec Test

P. Fexa, J. Svatoš, J. Vedral

Czech Technical University, Technická 2, 166 27 Prague 6, Czech Republic
Email: fexap1@fel.cvut.cz, svatoj1@fel.cvut.cz, vedral@fel.cvut.cz

Abstract. *This paper is to show the methods of dynamic parameters testing of high quality audio codec with 24 bits nominal resolution. In the paper are briefly the best Sine Wave Fit Test, Spectral Purity Test and Noise Histogram Test presented. The above mentioned testing methods are then used for testing of these ADCs and obtained data are discussed..*

Keywords: Audio Codec Test, Sine Wave Fit Test, Spectral Purity Test, Noise Histogram Test

1. Introduction

High resolution audio analog-to-digital converters are one of the most important parts in different electronic applications in this time. The typical example is spectral analyzing in measurement applications and processing from sensors of physical (non-electric) quantities (magnetometery, resistive bridges, and thermometry). The degradation of signal rising on the beginning of measuring chain is very difficult to correct. Therefore the knowledge of parameters of ADC used in such systems is necessary.

2. Used Methods of Testing

Main parameters of tested ADC from the point of view of dynamical testing audio converters are the ratio of *Signal Noise and Distortion SINAD, Effective Number of Bits ENOB, Total Harmonic Distortion THD, Spurious Free Dynamic Range SFDR* and *Effective Resolution ER*. The principles of these methods are well described in the IEEE standards [1], [2]. The dynamic testing methods are in principle divided into two main parts.

In the *Time Domain* is the S*ine Wave Fit Test* witch uses pure harmonic signal as an input signal. The principle of method is fitting of sin wave into measured record of data by the least minimum squares algorithm. Basic algorithms are possible to use *four parameter* least squares fit to sine wave data. The parameter *ENOB* is possible to re-count from this result as

$$ENOB = n - \log_2 \frac{\varepsilon}{RMS_q} \tag{1}$$

where n is number of *nominal bits*, ε is *minimum square error* of Fit Test and $RMS_q = 2^{-n}/\sqrt{12}$ is quantized noise of ideal AD converter.

In the *Spectral Purity Test method is* data recorded not absolutely coherent with used sampling frequency in ideal case. In this case is not necessary to use any window function because the required periodicity of sampled time interval is conformed a priori. Often used window is *Blackman - Harris's Window*. The parameter *SINAD* is calculated as the ratio of the RMS_{Sin} value of basic harmonic component to the RMS_{Tn} value of the total noise including harmonic distortion, spurious components and various types of noise

$$SINAD = 20\log_{10} \frac{RMS_{Sin}}{RMS_{Tn}} (dB) \tag{2}$$

Parameters *SINAD* and *ENOB* are mutually re-countable by means of well-known formula

$$SINAD = 6.02ENOB + 1.76(dB) \tag{3}$$

It should be stated the method of determination of this parameter if any dynamic parameter of ADC is stated.

Total Harmonic Distortion THD represents the nonlinearity of the A/D converter transfer characteristic. For a pure input sine wave is the ration of the root sum of squares of all the harmonic distortion components, including their aliases in the spectral output of the converter.

$$THD = 20\log_{10}\frac{\sqrt{\sum_{i=2}^{m} U_i^2}}{U_i}(dB) \tag{4}$$

Spurious Free Dynamic Range SFDR is defined for a pure sin wave input as the ration of the root sum of squares of all the lowest harmonic distortion components, including their aliases to the *RMS* value of the main harmonic amplitude

$$SFDR = 20\log_{10}\frac{U_{max}}{U_1}(dB) \tag{5}$$

Effective Resolution is defined for grounded inputs of converter

$$ER = \log_2\frac{FS}{RMS_n}(bit) \tag{6}$$

where *FS* is nominal range of converter and RMS_n is effective value of noise signal.

3. Test Conditions

Both above described converters have been tested by means of the boards supplemented by Creative Sound Blaster Live. The audio codec under test is 24 bit codec Terratec Phase 26 USB with maximal sample rate 96 kSa/sec. The part contains a *sigma-delta modulator* 8 order, a *finite impulse response FIR digital filter*. The digital filter frequency response can be programmed to be either low pass or band pass. The on-chip filtering combined with an *oversampling ratio* 256 reduces the external antialiasing requirements to first order in most cases. The board is connected to the PC by USB2 interface. Measured data are processed by soft in MATLAB.

The ultra-low distortion function audio generator DS360 from Stanford Research has been used as a source of reference harmonic signal. The manufacturer guarantees the total harmonic distortion $THD \leq 120$ dB in the frequency range from 20 Hz to 50 kHz. The frequency of generated signal should not be an integer multiple of line frequency. With such arranged measuring conditions all next measurements have been performed.

4. Results

In Fig.1 and Fig.2 is presented *FFT spectral plot* and *Noise Histogram Test* grounded input of audio codec. The *Effective Resolution* of codec is 15,6 bits. In FFT spectral plot are evident parasitic spectral components with USB supply frequency 200 kHz. For FFT test is 64 kbyte samples and Blackmann-Harris Windows 4 order used.

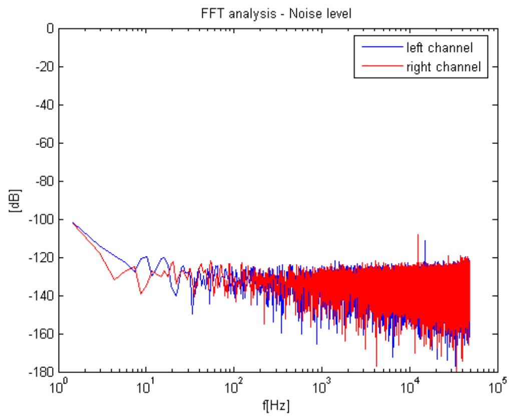

Fig. 1 FFT spectral plot of Noise Histogram Test

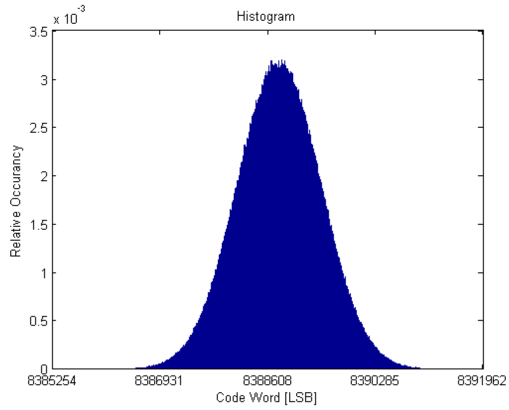

Fig. 2 Noise Histogram Test

In Fig.3 and Fig.4 is presented FFT plot of reconstructed sinus signal 1 kHz with USB and battery supply. In spectral plots of Fig. 3 is evident parasitic spectral components in amplitude under - 100 dB versus major spectral component 1 kHz.

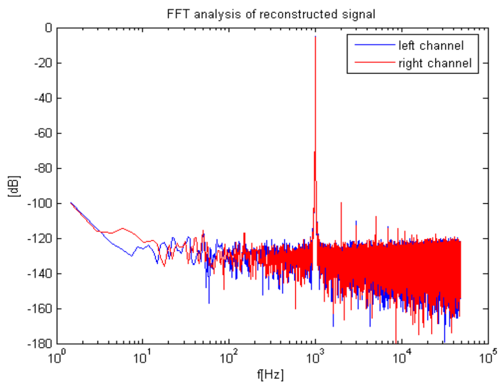

Fig. 3 FFT spectral plot 1 kHz with USB supply

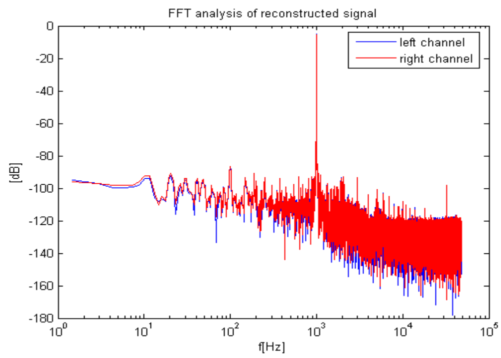

Fig. 4 FFT spectral plot 1 kHz with battery supply

In Fig.5 and Fig.6 is presented plot of *Effective Number of Bits* and *Total Harmonic Distortion* in frequency range 20 Hz to 20 kHz.

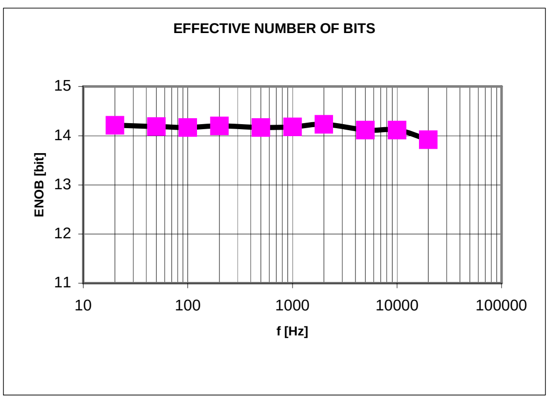

Fig. 5 Effective number of bits frequency plot

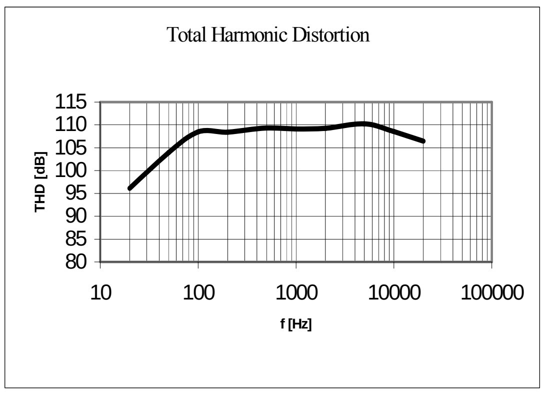

Fig. 6 Total harmonic Distortion frequency plot

5. Discussion

From tested audio codec in frequency range 20 Hz to 20 kHz *ENOB* = 14,5 bits and *THD* up to 110 dB in frequency range 100 Hz to 10 kHz. Frequency range corresponding to drop-off of transfer function – 3 dB is 20 Hz to 40 kHz. In this frequency range is stereo crosstalk 48 dB, and in the frequency range 1 kHz to 10 kHz is this stereo crosstalk up to 85 dB. Characteristic noise of tested sound card reaches to level of 120 dB. Disruptive spectral elements in both channels in frequency area close to 10 kHz reduce this distance to 110 dB. The official parameters of audio codec Terratec Phase 26B is certified: *THD* = 105 dB and *SINAD* = 98 dB from input signal frequency 1 kHz [9].

6. Conclusions

Under testing it's very important to separate alternating supply source from inner analog to digital converters in tested sound card. External accumulator was used as power source and decrease of disruptive signals more than 20 dB was achieved. We can say, that tested audio sound card match common 16 bit digital converters except the distortion done by high frequency signals and signal to noise ratio. Those parameters are close to nominal resolution 24 bits.

Acknowledgements

This project is supported by the Czech ministry of Education: MSM 6840770015.

References

[1] IEEE Standard 1057-1994, *IEEE Standard for Digitizing Waveform Recorders.*

[2] IEEE Standard 1241 - 2000, *IEEE Standard and Teminology and Test Methods for Analog-to-Digital Converters.*

[3] Jeng., Y.C., Crosby, P.B.: Sinewave parameter estimation algorithm with application to waveform digitizer effective bits measurement. IEEE *Trans. Instrum. Meas.,* vol. IM-37, pp. 529-532, Dec. 1988.

[4] Jeng., Y.C.: Measuring harmonic distortion and noise floor of A/D converter using spectral average, *IEEE Trans. Instrum. Meas*., vol. IM-37, pp. 525-528, Dec. 1988.

[5] Harris, F.J.: On the use od windows for the harmonic analysis with the DFT. *Proc. IEEE*, vol.66, pp. 51-83, Jan. 1978.

[6] Vedral, J.: Holub, J.: Measurements od ADCs effective number of bits. ADDA 2005, *International conference on advanced A/D and D/A Conversion Techniques and their Applications.* Limerick, 26005, pp. 255-257, ISBN 0-86341-542-3.

[7] Podlipny, J.: High resolution ADC Testing. Diploma work, CTU FEE, Prague, 2008.

[8] Vedral, J.: Aspects of ADC Verification . In *Testmethoden und Zuverlässigkeit von Schaltungen und Systemen*. Erlangen: Universität Erlangen-Nürnberg, 2007, p. 23-25.

[9] http//www.teratec.com.