# SOFTWARE FOR METROLOGICAL CHARACTERISATION OF PC SOUND CARDS

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**Abstract –** *The paper demonstrates virtual instrument software that performs simple and fast testing of any PC sound card with correctly preinstalled Windows driver in waveform recorder applications related to IEEE Std 1057, drafts IEEE Std. 1241 and DYNAD. In addition to the visualisation of recorded signal patterns in time and spectral domain, the software directly determines various basic parameters of input analog channels e.g. effective number of bits, THD, THD+noise, SINAD, etc. The parameter determination is performed both in spectral and time domains to compare the achieved results. A modified 4 parameters sine fit method was implemented with respect to soundblaster test nature. The software was developed in LabWindows/CVI (C language) with implementation of low-level Win32 API multimedia functions. The authors' intention is to apply the software for computer component vendors and in educational demonstration of ADC testing principles.*
*The paper contains also some example of achieved results from testing some soundblasters.*

**Keywords -** VI software, PC sound card, waveform recorder testing, ADC dynamic testing, 4 parameter sine wave fitting method.

## 1. INTRODUCTION

The sound cards for PC often named sound blasters are very common and often used accessories of many computers. They are relatively very cheap in comparison with multifunction and industrial data acquisition plug-in boards – in common more than 10 –100 times. On the other hand, the parameters of analog inputs and outputs declared by vendors (at least 16 bits AD and DA converters) indicate the possibility to apply such a card in simple, low cost, and low frequency data acquisition systems acquiring signals from chemical, pressure, vibration, and other sensors. The restriction on the lower input frequency could be simply overcome by applying a simple chopper or a modulation amplifier on input DC signal with consecutive digital demodulation in PC. These ideas and an industry challenge led the authors to perform some simple tests according to the IEEE Std. 1057 and IEEE Std. 1241 as well as DYNAD drafts with focusing on analog signal recording channels of some sound cards and with the goal to verify a possibility of their applications indicated hereinbefore. New proprietary virtual instrument software had to be developed to performe the needed experiments and tests.

## 2. DYNAMIC TEST METHODS FOR WAVEFORM RECORDERS BASED ON PLUG-IN BOARDS - STATE OF ART

The standard test methods for waveform recorders are generally well known and they were brought out in comprehensive form in IEEE Std. 1057 [1]. Nowadays the new, about to be accepted standards IEEE Std. 1241 [2] and DYNAD [3] are coming with some new ideas on such testing. More over, many researchers have contributed by a lots of ideas and approaches to the solving AD and DA converters test problems. Probably the widest survey of those ideas was made in [4].

Testing waveform recorders in the form of PC plug-in boards have some specifics. The interior of PC is generally illicit for precise digitalisation of input signal. The test methods developed and suggested as well as some achieved test results for multifunction industrial plug-in boards in various circumstances have been published in [5], [6], [7]. The authors preferred the dynamic test methods based on FFT spectrum or sinusoidal curve fit with determining effective number of bits (ENOB) versus test frequency as the main quality characterisation parameter of the tested board. An alternative dynamic test method based on spectral correction method that enable to use a low cost waveform generator for precise testing was suggested in [6].

In software area, two universal versions of VI software have been developed and published – one in LabVIEW [9] and second in Matlab [8]. Both versions of software have very general assignation – they process data from any measurement recorded in a file and they don't contain any data acquisition part.

## 3. SOUND CARD AS A WAVEFORM RECORDER

Sound cards are generally dedicated to recording and playing sound signal. It results in restriction of input and output frequencies span usually on band from 20Hz to 20kHz. This prevents from applying the static test methods and leads to

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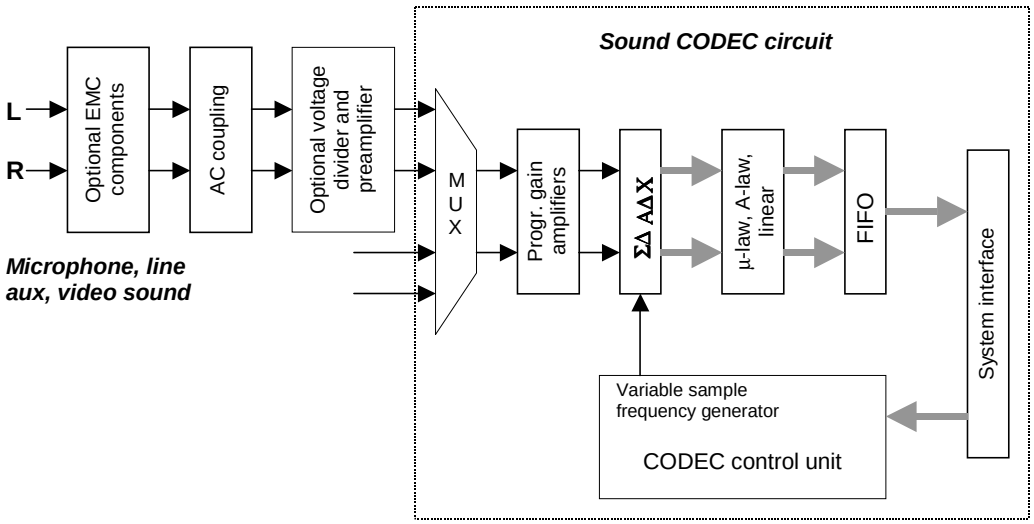


Fig. 1 - Typical function block diagram of analogue and digital circuits for signal recorder part in sound cards

the application of dynamic test method using the sinusoidal input test signal. The typical function block diagram of soundblaster input recording channels is shown in Fig. 1 ([10], [11] and others).

The analogue to digital conversion usually employs sigma-delta converters, which can work at least in two precision modes – 8 and 16 bits. Data can be coded into a few non-linear and linear formats. The linear PCM format, which is the most convenient format for performance test, was chosen in our testing procedures. The variety of optional sampling frequencies depending on sound card model – at least 8, 11, 22.05 and 44.1 kHz are commonly offered. The stability and eventually a frequency shift of these frequencies are not usually explicitly indicated in sound card manuals. Digitizing input may be switched by an analogue multiplexer – a microphone input and a less sensitive line-in (aux) input are built-in for linking external analogue signal sources.

Sound cards are probably the most often used in PC with operational system Windows 9x/NT/2000/ME. The application can use any of three levels of Win32 API multimedia class of functions for controlling and data transferring to/from any Windows compatible sound card:

- the highest MCIWnd window class,
- the middle MCI device-independent interface,
- the low-level audio interface, which is used by applications that need the finest possible control over audio devices.

## 4. TEST SOFTWARE AND SETUP CHARACTERISTICS

The general setup needed for soundblaster recording part performance test is very simple, consisting of a precise test signal generator and common PC with tested sound card in a PC chassis. This hardware must be integrated with convenient software, which must control the tested soundblaster, collect and process recorded data as well as present and archive results. The current general purpose software ([8], [9]) does not contain any part of data collecting and they enable only data processing. It led to the decision to develop new special VI software focussed on sound card testing. The software was created with intention of maximal comprehensiveness at sound card testing – it can be installed as an executable file in any PC with Windows OS and any correctly installed sound card. The sound card has to have installed only its Windows compatible driver. To avoid a possible additional distortion in recorded data, which can be cause by using a third-party software, unknown in details, the software was fully integrated with own low-level recording routines. Software development environment LabWindows/CVI (National Instruments) with support of Software Development Kit (SDK - Microsoft) was used as the main developing tools. The user panel is shown in Fig. 2.

The software enables:

- Recording data from any sound card in standard 8/16bits and mono/stereo modes at an optional standard sampling frequency in linear PCM format. The user can follow the recording process and simply identify any problem from text messages showed in message window.
- Visualisation of recorded data, including zooming for visual assessment as well as saving and reading recorded data to/from a file.
- Analysing recorded data in time domain:
  - Performing optionally 4 and 3 parameter fitting with enumeration of noise power, effective numbers of bits (ENOB) and others derived parameters
  - Estimation of real sampling frequency
  - Estimation of DC value, amplitude and phase of test signal
- Analysing and visualisation of recorded data in spectral domain:
  - Computing of power density spectrum and power spectrum distribution function
  - Estimation of basic harmonic, THD, THD+noise, ENOB and other parameters from the power density spectrum

Iteration algorithm for 4 parameter sine wave fitting was changed in contrary to IEEE standards because of generally known problems with its convergence. The applied algorithm starts with computing sinewave fit and corresponding noise

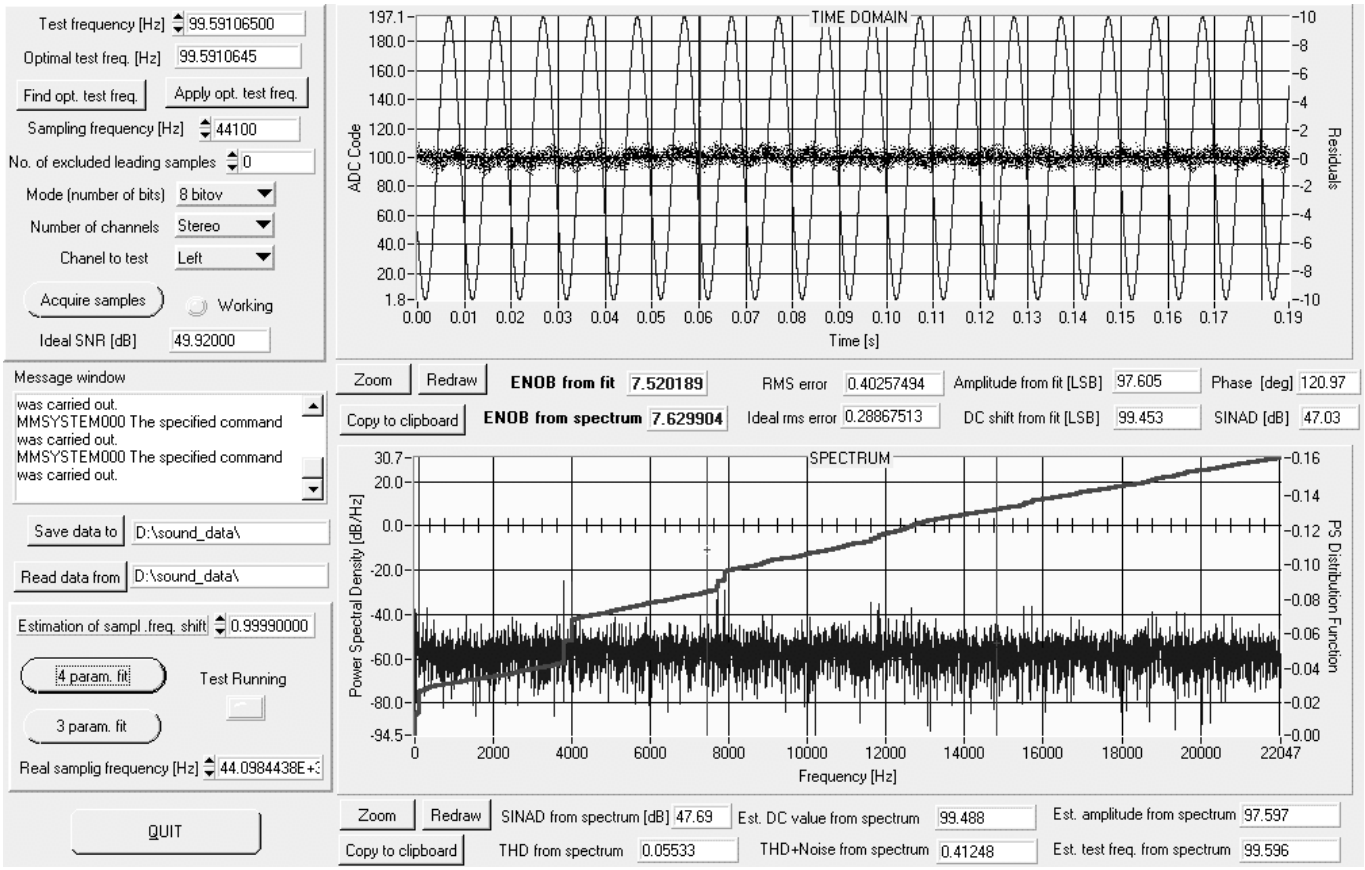


Fig. 2 - User panel of the developed test VI software.

power $P_{N0}$ with normalized frequency $f_{n0} = f_{signal}/(f_{sampling}\ s_f)$ higher than its estimation from given $f_{signal}$ and $f_{sampling}$ by sampling frequency shift $s_f < 1$. Then next two fits and corresponding noise powers $P_{N1}$, $P_{N2}$ are computed at frequencies $f_{nk} = f_{signal}/(f_{sampling}.s_f + k.f_{step})$ ($k$=0,1,2), where $f_{step0}$ is a beginning sampling frequency step for minimal $P_N$ searching procedure. Comparing $P_{Nk}$ values, either the $f_{n0}$ or $.f_{step}$ is decreased for the next iteration. The iteration process is stopped if the difference between $P_{Nk}$ is lower than armed limit. The iteration process converges certainly if the estimations of $f_{signal}$ and $f_{sampling}$ are relatively close to their exact values and $s_f$ is chosen properly.

## 5. EXAMPLES OF ACHIEVED TEST RESULTS

By now, 5 models of sound cards were tested. They can be divided into two groups

- Sound blasters implemented on PC mainboards
- "Stand-alone" plug-in sound cards

The first tested models were sound blasters integrated on relatively new ATX mainboards m805lr and m807r by PC CHIPS [12], [13] in 2000. The mainboards support Socket-462 (Socket-A) processor front-side bus speeds of 200MHz or 266MHz. It uses the VIA VT8363 chipset, which provides a 4X AGP slot for highly graphics display, CPU Plug & Play through firmware. The mainboards have built-in the same AC97 Codec, provide an AMR (Audio Modem Riser) slot to support Audio and Modem application. The m805lr has a built-in 10BaseT/100BaseTX. The vendor specifies following features of implemented AC97 Codec: "Supports 18-bit ADC and DAC as well as 18-bit stereo full-duplex codec" ([12], [13]). Two samples the PCCHPIS m805lr and one m807r were tested. Some results obtained at sampling frequency 44.1kHz are presented in Tab. I and II as well as in Fig. 3 and 4.

Table I - Results from ENOB testing of sound CODECs implemented on mainboard PC CHIPS m805lr

| Test freq. [Hz] | 8 bits mode | | 16 bits mode | |
|---|---|---|---|---|
| | mono | stereo | mono | stereo |
| 21 | 7.92 | 7.94 / 7.90 | 9.65 | 9.90 / 9.71 |
| 41 | 7.84 | 7.86 / 7.84 | 9.69 | 9.89 / 9.69 |
| 81 | 7.65 | 7.65 / 7.65 | 9.66 | 9.85 / 9.66 |
| 211 | 7.50 | 7.51 / 7.49 | 9.55 | 9.77 / 9.55 |
| 411 | 7.47 | 7.47 / 7.45 | 9.31 | 8.65 / 8.50 |
| 811 | 7.43 | 7.38 / 7.35 | 8.75 | 7.77 / 7.64 |
| 2.1k | 7.26 | 6.97 / 6.88 | 7.49 | 6.44 / 6.30 |
| 4.1k | 6.45 | 6.21 / 6.11 | 6.49 | 5.59 / 5.46 |
| 8.1k | 4.89 | 4.92 / 4.79 | 5.01 | 4.71 / 4.58 |
| 12.1k | 3.69 | 3.76 / 0.93 | 3.84 | 3.84 / 0.92 |
| 13.1k | 0.86 | 0.84 / 0.47 | 0.83 | 0.81 /0.44 |
| 16.1k | 0.08 | 0 / 0 | 0.06 | 0 / 0 |

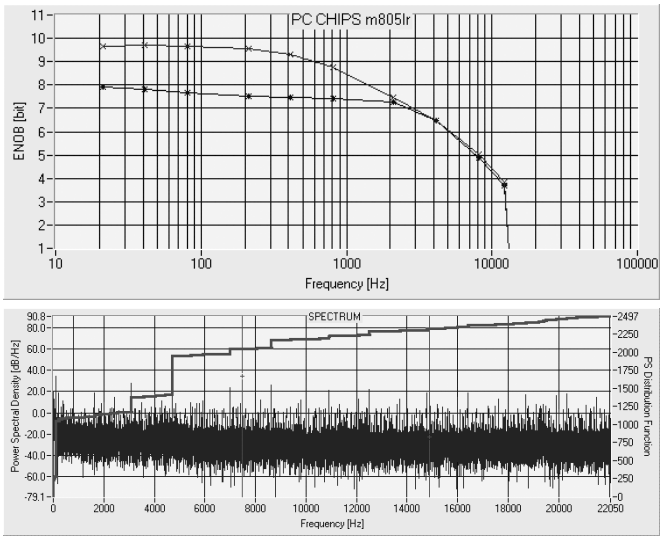


Fig. 3 - ENOB dependence on test signal frequency in 8 and 16 bit modes and typical spectrum in 16 bit mode of sound blaster of PCCHIPS m805lr

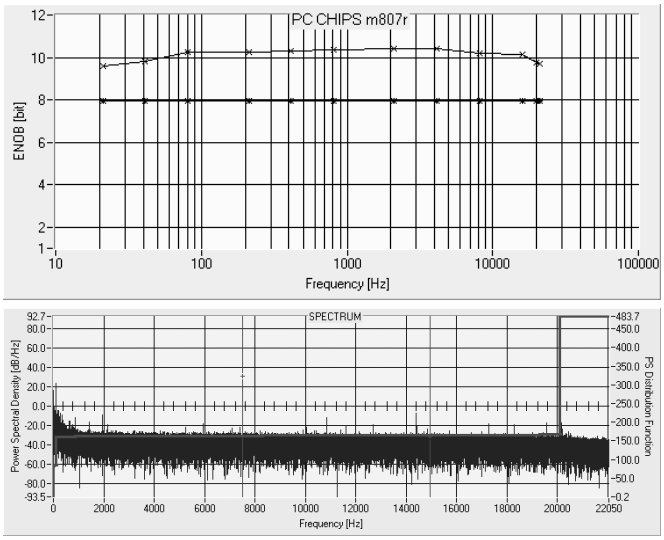


Fig. 4 - ENOB dependence on test signal frequency in 8 and 16 bit modes and typical spectrum in 16 bit mode of sound blaster of PCCHIPS m807r

Table II - Results from ENOB testing of sound CODECs implemented on mainboard PC CHIPS l807r

| Test freq. [Hz] | 8 bits mode | | 16 bits mode | |
|---|---|---|---|---|
| | mono | stereo | mono | stereo |
| 21 | 7.93 | 7.91 / 7.94 | 9.6 | 9.60 / 9.71 |
| 41 | 7.95 | 7.94 / 7.95 | 9.79 | 9.89 / 9.84 |
| 81 | 7.96 | 7.95 / 7.97 | 10.25 | 10.29 / 10.16 |
| 211 | 7.97 | 7.96 / 7.97 | 10.25 | 10.34 / 10.18 |
| 411 | 7.97 | 7.96 / 7.98 | 10.31 | 10.35 / 10.20 |
| 811 | 7.96 | 7.95 / 7.98 | 10.35 | 10.37 / 10.21 |
| 2.1k | 7.97 | 7.97 / 7.98 | 10.41 | 10.44 / 10.20 |
| 4.1k | 7.97 | 7.97 / 7.98 | 10.41 | 10.47 / 10.11 |
| 8.1k | 7.97 | 7.96 / 7.97 | 10.21 | 10.41 / 10.08 |
| 16.1k | 7.96 | 7.96 / 7.97 | 10.14 | 10.14 / 10.08 |
| 20.1k | 7.95 | 7.94 / 7.97 | 9.75 | 9.75 /9.74 |
| 21.1k | 7.94 | 7.94 / 7.96 | 9.72 | 9.72 / 9.71 |

The achieved results show a big gap between vendor's declared parameters and the real parameters. Especially in 16 bit mode, the maximal reached ENOB value was only lightly less than 10 bits at m805lr and lightly more than 10 bits at m807r. Moreover, the sharp decrease of ENOB in dependence of the input test signal frequency on frequencies over about 5kHz was assigned at m805lr. Also a DC offset of the ADC input range center – 112, resp. 28846 instead of 128, resp. 32768 – was detected. It deteriorates the input voltage range. A bit better values of the last mentioned parameters were detected for m807r. It is rather strange because both motherboards used the same sound chips. Changing the sampling frequency did not achieve any changes overcoming 0.1 bit in the results on both l80x boards.

The next tested sound blaster was built on chip CM8330 [14] integrated on an older AT mainboard m559 by PC CHIPS The first test results indicated a very low quality of the sound blaster recorder part and led to the cancellation of any next test. The reasons can be seen in Fig. 5 - .the bottom limitation of test signal at level 16000, resp. 62 in the tested recorder degrades all quality parameters of CM 8330 sound blaster chip and prevent correct determination of others recorders parameters.

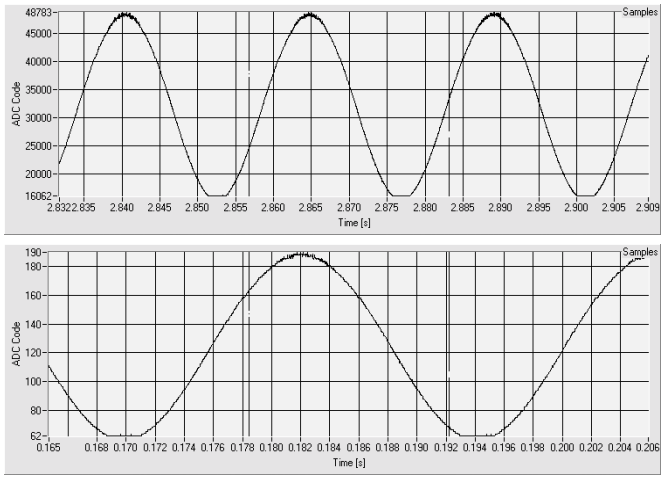


Fig. 5 - Recorded sine wave in 8 and 16 bit modes. The limitation on level 16062, resp. 62 totally degrades the CM8330 blaster parameters.

The last example of sound card test results is results of the "stand-alone" plug-in board SoundBlaster PCI64 by Creative Technology, Ltd. [15]. Some achieved results are listed in tab. III and in Fig. 6. Unfortunately, the more precise parameter determination for 16 bit mode was prevented by insufficient test signal source quality as can be seen from Fig. 6a. Anyway, in comparison with previous sound blasters, this

card proved much better qualitative parameters in accordance with vendor's declaration.

Tab. III - ENOB dependence on the test signal frequency for Sound Blaster PCI64. The values marked by * need to be approved with more precise signal source.

| Test freq. [Hz] | 8 bits mode | | 16 bits mode | |
|---|---|---|---|---|
| | mono | stereo | mono | stereo |
| 21 | 7.91 | 7.90 / 7.94 | 9.46 | 9.46 / 9.56 |
| 41 | 7.97 | 7.97 / 7.97 | 11.68 | 11.67 / 11.70 |
| 81 | 8.00 | 8.00 / 8.00 | >12* | >12* |
| 211 | 7.98 | 7.98 / 7.98 | >12* | >12* |
| 411 | 8.0 | 8.00 / 8.00 | >12* | >12* |
| 811 | 8.00 | 8.00 / 8.00 | >12* | >12* |
| 2.1k | 8.00 | 8.00 / 8.00 | >12* | >12* |
| 4.1k | 8.00 | 8.00 / 8.00 | >12* | >12* |
| 8.1k | 8.00 | 8.00 / 7.97 | >12* | >12* |
| 12.1k | 8.00 | 8.00 / 7.97 | >12* | >12* |
| 16.1k | 8.00 | 8.00 / 7.97 | >12* | 10.81 / 10.83 |
| 21.1k | 8.00 | 8.00 / 7.97 | >12* | 9.94 / 9.94 |

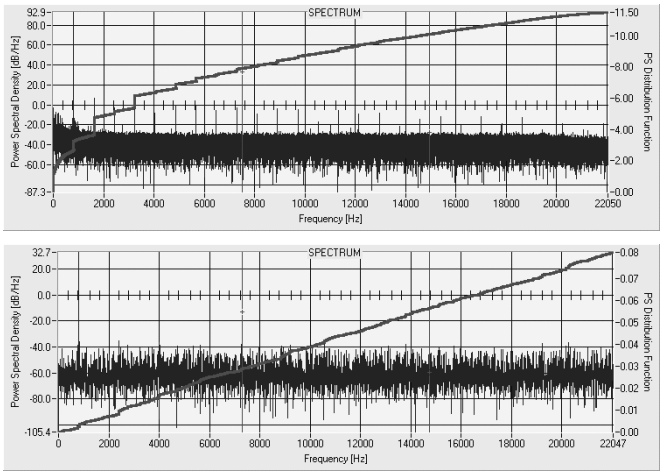


Fig. 6 – Spectrum of signals recorded by SoundBlaster PCI64 in 16 and 8 bit modes.

## 6. CONCLUSIONS

The developed software was applied and tested at assessments of a few sound cards as can be seen therein before. It seems to be very useful tool – it enable assessment of any sound card and earn many complex parameters of tested board in a relatively short time. Except exploitation of the software by computer system retailers at improving quality and confidence of they offer, the presented software will be used in educational process at teaching of electronic measurement and data acquisition systems at the Technical University in Kosice as a demonstration virtual instrument for explanation and demonstration standard ADC test methods. For this purpose, the authors intend to improved it and extend its function to enable a user to choose a testing procedure in accordance with a preferred standard ([1], [2], [3]) The automatic control of test signal generator will be added to the school version of the software including some ideas published in [16].

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