DASDEC-1EN Encoder Audio Tests

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1.0 - Introduction

Audio output tests were conducted on the Digital Alert Systems,LLC EAS Encoder/Decoder Unit on May 13,2004 and July 29-30,2004. The purpose of the tests are to document compliance to certain specific sections of FCC Part 11.32 for EAS Encoders.

2.0 - Conducted Tests

The following tests were conducted:

1. Audio output voltages at a variety of output levels for 853Hz and 960Hz tones.
2. Audio frequency accuracy for 853Hz and 960Hz tones.
3. Standard EAS Attention signal duration.
4. Audio quality, noise, and harmonic distortion for a broad spectrum of audio frequencies.
5. Audio attenuation of low and high frequencies during EAS mark/space output.

3.0 - Test Discussion: Procedure, Setup and Results

Each of the five tests will be discussed in order, with the test procedure and setup being described, and then the test result plots presented.

3.1 - Audio Output Voltage

Audio output voltages were measured at increasing volumes for the two single tone frequencies that comprise the EAS Attention Signal, 853Hz and 960Hz. The tests were conducted by measuring Volts RMS at the common ground and the + and - (refered to as L and R in the test plots) leads of the DASDEC main and auxiliary audio output, while the DASDEC was made to play each of the two tones for 5 or more seconds using the DASDEC Web interface tone calibration feature. The DASDEC sound system relies on commercial sound IC's. The main audio is built into the VIA mainboard. The auxiliary output is from a Creative Labs Soundblaster 16 PCI sound card. Except were noted, the output PCM levels were set to the maximum (100% PCM) for the tests.
The tests were conducted using a Fluke 79 Series II multimeter. Results were read from the meter. Tests were conducted May 13,2004 and July 29,2004.

Results

Main Audio Output - VIA mainboard Audio output voltages RMS

With PCM at 100%

Silence at 0% volume: 0.0013 V

Playing WAV file 853 Hz sine wave:

volume Voltage L R

0%	0.0013 V	0.0013 V
2%	0.0131 V	
4%	0.0147 V	
6%	0.0147 V	
8%	0.0172 V	
10%	0.0197 V	0.0188 V
24%	0.0368 V	
30%	0.0511 V	
40%	0.0871 V	
50%	0.1493 V	
60%	0.3021 V	0.2982 V
64%	0.3602 V	
68%	0.428 V	
70%	0.512 V	0.505 V
75%	0.588 V	
80%	0.865 V	0.849 V
84%	1.028 V	
86%	1.225 V	
90%	1.458 V	1.433 V
92%	1.672 V	
94%	2.053 V	
98%	2.335 V	
100%	2.335 V	2.314 V

Playing WAV file 960 Hz sine wave is close to the same results:

90%	1.434 V	1.459 V
100%	2.316 V	2.278 V

Auxiliary Audio Output -Soundblaster 16PCI Audio output voltages RMS

With PCM at 84% (this is closest to VIA audio)

Silence at 0% volume: 0.0012 V

Playing WAV file 853 Hz sine wave:

volume	Voltage L	R
0%	0.0012 V	
2%	0.0265 V	
10%	0.0348 V	
20%	0.0475 V	
30%	0.0685 V	
40%	0.1043 V	
50%	0.1909 V	
60%	0.3085 V	
64%	0.3637 V	
68%	0.428 V	
70%	0.506 V	
74%	0.597 V	
76%	0.706 V	
80%	0.837 V	0.848 V

86%	1.174 V	
90%	1.391 V	1.409 V
94%	1.956 V	
100%	2.319 V	2.344 V

With PCM at 100%

Playing silence:
0.0012 V at 0% vol,
0.0016 V at 82% vol,
0.0043 V at 100% vol

Playing WAV file 853 Hz sine wave:

volume	Voltage L	R
0%	0.0012 V	
10%	0.0573 V	
20%	0.0783 V	
30%	0.1129 V	
40%	0.1720 V	
50%	0.2711 V	
60%	0.508 V	
70%	0.834 V	
74%	0.985 V	
76%	1.164 V	
80%	1.380 V	
82%	1.635 V	
86%	1.935 V	
90%	2.294 V	
94%	3.226 V	
98%	3.608 V	
100%	3.608 V	

The measured results for the 960 Hz tone were virtually the same and thus bear no consequence on the conclusions.
These test result values are converted into dBm using the conversion equation of Vrms to dBm at 600 ohms

dBm = 20*LOG10(Volts_rms*SQRT(8)/SQRT(0.008*Z))

for Z = 600 ohms

the maximum output for VIA sound at 2.335 Vrms
is 20*LOG10(2.335*SQRT(8)/SQRT(0.008*600)) = **9.58 dBm**

the maximum output for Soundblaster PCI at 3.608 Vrms
is 20*LOG10(3.608*SQRT(8)/SQRT(0.008*600)) = **13.36 dBm**

SQRT(8) = 2.828427125
SQRT(4.8) = 2.19089023

SQRT(8) / SQRT(4.8) = 1.29099445

2.335*1.29099445 = 3.014472038
LOG10(3.014472038) = 0.479211259
20 * 0.479211259 = 9.5842252 dBm

3.608*1.29099445 = 4.65781
LOG10(4.65781) = 0.668191
20 * 0.479211259 = 13.36382 dBm

3.2 - Audio Frequency Accuracy

Audio output frequency was measured for the two single tone frequencies that comprise the EAS Attention Signal, 853Hz and 960Hz. The procedure was the same as for test 3.1 above. The DASDEC Web interface was used to play each single tone for at least 5 seconds. The frequency was measured using Fluke 79 Series II multimeter with probes connected to common ground and the + or - connection. Results were read from the meter. Tests were conducted May 13,2004 and July 29,2004.

DASDEC main output (VIA mainboard):
At PCM 100% and volume 100%
Playing digital WAV file encoding 853 Hz sine wave file:
measured 852.9 Hz without fluctuation.

Playing digital WAV file encoding 960 Hz sine wave file:
measured 959.9 Hz without fluctuation.

DASDEC auxiliary output (Soundblaster 16PCI):
At PCM 100% and volume 100%
Playing digital WAV file encoding 853 Hz sine wave file:
measured 853.0 Hz without fluctuation.

Playing digital WAV file encoding 960 Hz sine wave file:
measured 960.0 to 960.1 Hz

3.3 - Attention Signal Duration

To play the attention signal portion of an EAS message, the DASDEC EAS encoder simply plays a digital WAV file that is encoded for 8 seconds duration at 16000 samples a second. It can be encoded to any length, but a standard file is included on the DASDEC that is 8 seconds duration. The play time was measured on the DASDEC with software that output the starting at the beginning of playing the file and then at the ending time. The test was conducted July 30,2004. Here is the test script :

```
#!/bin/csh
date
play eas_attn.wav
date
```

Here is the result of running the script:

```
root@dasdec1: attn_time_test

Fri Jul 30 13:18:23 MDT 2004
Fri Jul 30 13:18:31 MDT 2004
```

The difference is exactly 8 seconds. The audio play software uses the open source Linux sound package called **sox**. The play command actually runs the following sox command, **'sox eas_attn.wav -t ossdsp /dev/dsp0'.**

3.4 - Audio Quality
Audio quality was measured for the DASDEC main audio output using an open source software program, crdtest, available on the web, at http://axion.physics.ubc.ca/sndcrd-test.04.tar.
The test was conducted several times on May 13,2004 and July 29,2004 using this software running on the DASDEC. According the to author of this test, "This is a relatively severe test of the card, much more severe that the usual distortion tests,..". Refer to the appendix below to see an applicable excerpt explaining this test software from it's author.

Using **crdtest -s**, I tested the main audio output of the DASDEC. Here are the results:

PCM=~72 VOL=~78 IGAIN=~63 for Channel= 0

Spectrum:

Freq	dB
16	54.64
18	55.34
21	56.12
24	56.66
27	57.06
32	57.52
36	57.78
42	58.04
48	58.22
55	58.36
64	58.49
73	58.57
84	58.64
97	58.69
111	58.73
128	58.77
147	58.79
168	58.81
194	58.82
222	58.83
256	58.84
294	58.85
337	58.85
388	58.86
445	58.86
512	58.86
588	58.87
675	58.87
776	58.87
891	58.87
1024	58.87
1176	58.87
1351	58.87
1552	58.86

1782	58.86
2048	58.86
2352	58.86
2702	58.85
3104	58.84
3565	58.83
4096	58.82
4705	58.81
5404	58.79
6208	58.76
7131	58.72
8192	58.68
9410	58.62
10809	58.54
12416	58.43
14263	58.29

Total Power level: 75.48 Max ampl: 0.75116

Distortion and Noise (dB):

10Hz= -24.12 10-100= -65.02 *100-1K= -70.64* 1K-22K= -68.82

Total= -24.12

Channel= 1

Freq	dB
16	54.85
18	55.54
21	56.31
24	56.85
27	57.25
32	57.70
36	57.96
42	58.22
48	58.40
55	58.54
64	58.66
73	58.75
84	58.82
97	58.87
111	58.91
128	58.95
147	58.97
168	58.99
194	59.00
222	59.01
256	59.02
294	59.03
337	59.04
388	59.04
445	59.04
512	59.05
588	59.05
675	59.05

776	59.05
891	59.05
1024	59.05
1176	59.05
1351	59.05
1552	59.05
1782	59.05
2048	59.04
2352	59.04
2702	59.03
3104	59.03
3565	59.02
4096	59.01
4705	58.99
5404	58.97
6208	58.94
7131	58.91
8192	58.86
9410	58.80
10809	58.72
12416	58.62
14263	58.48

Total Power level: 75.66 Max ampl: 0.76608

Distortion and Noise (dB):
10Hz= -24.79 10-100= -64.55 ***100-1K= -70.37*** **1K-22K= -68.91**
Total= -24.79

The noise in the range for the two tones (100-1K) averages to an extremely low value.

The **crdtest** software was also run with the **-n** option to output a noise spectrum.

The following results were obtained:
Residual noise for 853 Hz, expressed as a power normalized to total signal power is: **8.632409e-12**

Residual noise for 960 Hz, expressed as a power normalized to total signal power is: **1.957588e-11**

This shows that the signal to noise ratio is excellent for the intended purpose of encoding and decoding EAS Attention Signal. Furthermore, the test was minimally optimized.

3.5 - Audio Attenuation

Audio output attenuation below 200Hz and above 4000Hz was measured by plotting a frequency spectrum for a digital file sample of the EAS mark and space frequencies (2083.3 Hz mark and 1562.5 Hz space). Two digital audio WAV files were encoded using the DASDEC encoder software, one for each frequency. Each file was played out of the DASDEC main audio output and recorded back into the line input of the DASDEC. This resulted in two new files that were then input into software to run a plot of the Fast Fourier Transform output in dB over the attenuated ranges and for the mark and space frequencies. This is a more severe test then just measuring the audio output of the encoder, since it involves the extra step of recording, which can add some noise. The test was conducted July 30,2004.

Here are the results for the mark frequency:

DASDEC output volume was 80% L and R, PCM 72% L and R, and input gain 59% L and R

Value measured at **2083.3 Hz** =**20.534868 dB**

Values in dB for plots up to 200Hz are:

Frequency (Hz)	**Level (dB)**
7.812500	-60.565258
11.718750	-60.804108
15.625000	-61.765205
19.531250	-62.541351
23.437500	-61.470932
27.343750	-61.268257
31.250000	-65.154137
35.156250	-64.693481
39.062500	-63.202953
42.968750	-66.279160
46.875000	-65.195633
50.781250	-59.051823
54.687500	-58.458694
58.593750	-56.422203
62.500000	-60.802013
66.406250	-59.832890
70.312500	-53.213650
74.218750	-53.030369
78.125000	-51.116066
82.031250	-53.505810
85.937500	-53.724403
89.843750	-51.093216
93.750000	-51.868145
97.656250	-51.187565
101.562500	-56.141899
105.468750	-58.125248
109.375000	-63.679565
113.281250	-57.919754
117.187500	-55.839306
121.093750	-62.541679
125.000000	-64.467422

128.906250	-62.130779
132.812500	-62.466179
136.718750	-64.592651
140.625000	-63.471718
144.531250	-62.855511
148.437500	-61.823647
152.343750	-63.984493
156.250000	-64.462074
160.156250	-64.852905
164.062500	-60.437584
167.968750	-55.096172
171.875000	-59.552715
175.781250	-64.508606
179.687500	-61.033669
183.593750	-59.740852
187.500000	-58.961044
191.406250	-61.466736
195.312500	-62.323353
199.218750	-62.739140

All measured values above 4000 Hz were below -50db. Here are some representaive values:

4000.000000	-55.705814
4003.906250	-64.643997
4007.812500	-67.250954
4011.718750	-66.109886
4015.625000	-64.960510
4019.531250	-63.537785
4023.437500	-61.438110
4027.343750	-62.553848
4031.250000	-60.880646
4035.156250	-61.831593
4039.062500	-61.746002
4042.968750	-65.983009
4046.875000	-56.756924
4050.781250	-52.194706
4054.687500	-58.080124
4058.593750	-60.937565
4062.500000	-57.047894
4066.406250	-55.492199
4070.312500	-52.626942
4074.218750	-51.643002
4078.125000	-52.114002
4082.031250	-55.627941
4085.937500	-53.248913
4089.843750	-50.825478
4093.750000	-51.144497
4097.656250	-52.831120
4101.562500	-62.154915
4105.468750	-64.641861
4109.375000	-65.082848
4113.281250	-58.314350
4117.187500	-59.354889
4121.093750	-61.778877
4125.000000	-62.352425
4128.906250	-61.155800

4132.812500	-61.481396
4136.718750	-62.928612
4140.625000	-68.018677
4144.531250	-64.502884
4148.437500	-61.572819
4152.343750	-56.088417
4156.250000	-57.626148
4160.156250	-65.453575
4164.062500	-55.380737
4167.968750	-53.528915
4171.875000	-57.605400
4175.781250	-59.722084
4179.687500	-62.022125
4183.593750	-63.260887
4187.500000	-60.988071
4191.406250	-56.097057
4195.312500	-58.816338
4199.218750	-63.256817
4996.093750	-62.152920
5000.000000	-54.842972
5003.906250	-56.905067
5007.812500	-62.498146
5992.187500	-66.868362
5996.093750	-59.701805
6000.000000	-58.844505
6003.906250	-58.428120
6007.812500	-60.505512
6011.718750	-60.952686
6988.281250	-67.161240
6992.187500	-66.236320
6996.093750	-62.472649
7000.000000	-57.375046
7003.906250	-61.416801
7007.812500	-66.976273
7984.375000	-63.893669
7988.281250	-62.612057
7992.187500	-62.454742
7996.093750	-64.858513

Here are the results for the space frequency:

DASDEC output volume was 80% L and R, PCM 72% L and R, and input gain 59% L and R

Value at **1562.5 Hz** = **20.252909 dB**

Values in dB for plots up to 200Hz are:

Frequency (Hz)	**Level (dB)**
7.812500	-63.327320
11.718750	-66.956619
15.625000	-68.795135
19.531250	-70.316330
23.437500	-71.914452

27.343750	-71.602295
31.250000	-72.629379
35.156250	-71.796242
39.062500	-71.225067
42.968750	-71.394753
46.875000	-69.868416
50.781250	-68.169609
54.687500	-67.221413
58.593750	-50.037373
62.500000	-44.131664
66.406250	-50.056614
70.312500	-67.561043
74.218750	-69.555603
78.125000	-70.596703
82.031250	-71.464455
85.937500	-69.885269
89.843750	-70.413254
93.750000	-72.346909
97.656250	-70.855576
101.562500	-70.594414
105.468750	-72.499619
109.375000	-72.538391
113.281250	-70.410736
117.187500	-67.654572
121.093750	-53.051846
125.000000	-47.205975
128.906250	-53.053024
132.812500	-68.744225
136.718750	-70.368980
140.625000	-70.687439
144.531250	-70.995102
148.437500	-72.260597
152.343750	-73.725296
156.250000	-72.653580
160.156250	-72.222015
164.062500	-72.762390
167.968750	-71.626228
171.875000	-70.382874
175.781250	-69.708191
179.687500	-67.073593
183.593750	-66.521599
187.500000	-65.063370
191.406250	-66.825302
195.312500	-68.329430
199.218750	-70.014725

All measured values above 4000 Hz were below -50db. Here are some representaive values:

4000.000000	-51.210331
4003.906250	-57.202339
4007.812500	-69.496613
4011.718750	-70.740059
4015.625000	-70.432579
4019.531250	-72.396057
4023.437500	-72.457108
4027.343750	-72.265388

4031.250000	-72.905006
4035.156250	-72.278099
4039.062500	-71.909721
4042.968750	-72.098442
4046.875000	-70.881958
4050.781250	-70.490196
4054.687500	-69.206902
4058.593750	-58.057449
4062.500000	-52.430141
4066.406250	-58.221848
4070.312500	-68.647377
4074.218750	-70.780464
4078.125000	-71.813622
4082.031250	-72.373924
4085.937500	-71.767067
4089.843750	-71.258400
4093.750000	-73.000938
4097.656250	-70.659546
4101.562500	-71.442474
4105.468750	-71.612717
4109.375000	-70.723785
4113.281250	-70.190216
4117.187500	-69.589134
4121.093750	-56.787800
4125.000000	-51.195862
4128.906250	-56.796284
4132.812500	-69.042900
4136.718750	-70.155632
4140.625000	-70.815262
4144.531250	-71.015862
4148.437500	-71.763115
4152.343750	-70.823868
4156.250000	-71.458557
4160.156250	-72.546532
4164.062500	-72.287575
4167.968750	-71.682587
4171.875000	-71.012604
4175.781250	-69.462692
4179.687500	-66.878960
4183.593750	-50.857479
4187.500000	-44.851574
4191.406250	-50.724533
4195.312500	-66.439445
4199.218750	-69.496727
4984.375000	-70.953331
4988.281250	-70.865570
4992.187500	-70.589256
4996.093750	-65.356361
5000.000000	-60.155510
5003.906250	-64.478729
5007.812500	-70.859917
5011.718750	-71.596313
5015.625000	-70.189590
5988.281250	-69.604919
5992.187500	-68.180763

5996.093750	-53.069996
6000.000000	-47.154842
6003.906250	-52.998886
6007.812500	-68.144493
6011.718750	-68.377663
6015.625000	-70.065651
6984.375000	-72.149750
6988.281250	-71.973259
6992.187500	-70.871185
6996.093750	-58.475796
7000.000000	-52.992378
7003.906250	-58.852444
7007.812500	-68.701645
7976.562500	-72.517029
7980.468750	-71.945213
7984.375000	-71.202675
7988.281250	-70.777054
7992.187500	-68.599655
7996.093750	-50.432678

4.0 - Conclusions: Application of Test Results to FCC Part 11.32

These results directly apply to certain specific conditions set forth for EAS Encoders in FCC part 11.32.
Here is an explaination of the conclusions.

Part 11.32.(8) Spurious Response. All frequency components outside 200 to 4000 Hz shall be attenuated by 40 dB or more with respect to the output levels of the mark or space frequencies.
FFT spectral analysis of the DASDEC's frequency components, in test 3.5 above, demonstrates that the DASDEC outputs the mark and space audio frequencies well beyond 40db above the frequencies below 200 Hz and above 4000 Hz. The files are available if needed.

(9) Attention Signal generator. The encoder must provide an attention signal that complies with the following:
(i) Tone Frequencies. The audio tones shall have fundamental frequencies of 853 and 960 Hz and not vary over ± 0.5 Hz.
The DASDEC's frequency output for the two specified fundamental frequencies was measured by test 3.2 above to be within 0.1 Hz for each tone. This complies with the ruling.

(ii) Harmonic Distortion. The total harmonic distortion of each of the audio tones may not exceed 5% at the encoder output terminals.
The DASDEC's digitally created audio tones play at far below the maximum allowable 5% distortion level as indicated by the test results measured in 3.4 above. Measurements of the soundcard produced around -70dB noise and distortion level for audio tones in the range of 100-1K Hz.

(iii) Minimum Level of Output. The encoder shall have an output level capability of at least +8 dBm into 600 Ohm load impedance at each audio tone. A means shall be provided to permit individual activation of the two tones for calibration of associated systems.
As indicated by the test plots in 3.1 above, the DASDEC can activate each tone beyond +8 dBm for both the Main and auxiliary output. The DASDEC allows individual activation of each tone.

(iv) Time Period for Transmission of Tones. The encoder shall have timing circuitry that automatically generates the two tones simultaneously for a time period of not less than 8 nor longer than 25 seconds. NOTE: Prior to July 1, 1995, the Attention Signal must be at least 20 and not more than 25 seconds.
As indicated by the test plots in 3.3 above, the DASDEC's standard WAV file plays for 8 seconds. The file can be regenerated on the DASDEC at any length, at will. The software is written to prevent someone from playing the Attention Signal less than 8 seconds and beyond 25 seconds.

Appendix

Sound Card Test for Linux

By W. G. Unruh.

The program crdtest (version .04) designed for testing and setting your sound card.
This program is to test the behaviour of a sound card. In its default configuration, the sound card must be capable of full duplex operation (ie be able to play and record at the same time) It also requires that you run a line directly from the output of the sound card into the input. (Ie, Line out to Line in or to Microphone input) It can also be used just as the source for the desired test signal(-P), or as the recorder of such a signal from another computer (-R)
The program generates a waveform which consists of 50 frequencies spread across the spectrum from 16Hz to 14KHz, with equal numbers in each octave and with equal amplitude.

Spectrum of signal delivered to soundcard

This sound is played for two seconds out the /dev/dsp sound port (The oss driver under Linux) , and recorded at the same time through the same device. The resultant recorded sound is saved for the 1 second period from .75 sec to 1.75 sec (This is to eliminate any "startup" noise in the recording) The recorded sound is analysed, both to see if the soundcard has preserved the amplitudes of these frequencies, and to see if it has introduced any extra sounds (noise or distortion). This is a relatively severe test of the card, much more severe that the usual distortion tests, but also comes closer to the structure of real music, and the distortions and noise inherent in real music.
The format of the command is :

crdtest [-h] [-s] [-R] [-P] [-a #] [-o] [-n]

- -h help only. Other options ignored.
- -s the recorded spectrum in each of the stereo channels is reported to stdout.
- -R Read the signal from the input only. The program will pause to allow for the other computer

preparing the input to be prepared and started. Disables full duplex

- -P Play the test spectrum to the Line out only. The program will pause to allow whatever the output goes to to be prepared. Duplex disabled.
- -a # The number # is the amplitude of the played spectrum which must be between 0 and 1. 1 corresponds to a maximum amplitude.
- -o Output the comb output and the recorded inputs to files /tmp/pinkout.sw and /tmp/pinkin.sw
- -n output the noise spectrum to /tmp/noisespect (The format is each line holds the frequency and the squared spectrum coefficient.

In all cases, the sound level (in dB, with 90 dB being the most intense sound the card can deliver) and the value of the maximum sound level as a fraction of the clipping level are displayed. Also the energy level (in dB) of the extraneous sounds are reported for each channel referenced to the energy in the signal. This distortion and noise level is reported for each frequency band from 0-10Hz, from 10-100Hz, from 100-1KHz and from 1KHz-22050Hz(the maximum frequency which the sound card running at 44100 samples per second can handle, together with the total energy.
The more negative these distortion and noise numbers the better.
This noise is a combination of noise output of the soundcard (in both recording and playing) and the distortion of the soundcard (both Harmonic and IM distortions). Since the original sound spectrum is a rough approximation of the sound in a music piece, this noise figure is a reasonable approxmation of the amount of noise which the sound card introduces in actual use (rather than the artificial Harmonic and IM distortion tests more usually done).
This test tests both the output and the input together and the noise and any spectral distortion are the combination of input and output noise and distortions. It will not be sensitive to phase jitter for example in the soundcard clock, since both the play and record timers are the same.
Most sound cards seem to direct the input into either Line In or Microphone directly into the output. This will cause feedback in this test. On the two cards I have tested, this can be eliminated by an appropriate setting of the mixer controls (eg in aumix). If you are using the Line input, choose the Line as the input (ie red dot) in aumix, but pull the Line slider all the way to zero. This slider seems to control only the sound level delivered directly from the input to the output, and not the sound level delivered to the /dev/dsp input. Control the input volume to /dev/dsp with the IGain slider.
You can get an idea both the input and output of the sound card by watching what happens to the noise figures as the amplitude sliders (eg using aumix) are adjusted. Pull down the output slider (ie the PCM slider) to about the half way mark. Adjust the input IGain slider to find the lowest value of the total distortion. Now turn up the output (PGM) until the distortion suddenly rises. (Make sure that the Max value never reaches 1 or -1. Pull down the IGain if necessary to keep it below clipping). This value of PGM is the clipping level of the output. Do not ever have it higher than that level. Now, with the output (PCM) below that clipping level, turn up the input (IGain) until again the distortion begins to rise significantly (again making sure that Max is less than 1.0-- decrease the PCM slider if necessary) . Again, you should never have the input higher than this.
Note that the best figures I achieved with an i810 on board soundcard on an Intel 845PEBT2 motherboard were :

```
              Channel= 0

 Total Power level:   77.23   Max ampl:   0.88461

            Distortion and Noise (dB):
10Hz= -67.50   10-100= -69.90   100-1K= -68.29  1K-22K= -62.70
        Total= -60.15

               Channel= 1

 Total Power level:   77.20   Max ampl:   0.88120

            Distortion and Noise (dB):
10Hz= -66.03   10-100= -70.32   100-1K= -68.26  1K-22K= -62.68
        Total= -59.87
```

These were with PCM at 78, IGain at 83 and Line and Mic at 0 to elimiate any feedback.
The best levels theoreticaly possible (i.e., no noise or distorition) for this particular signal give a total noise and distortion of about -85dB for due to roundoff errors with the 16 bit encoding (This was measured with the original signal). (It should be much better with for example 24 bit encoding).
Note that the total noise and distortion are measured by subtracting out all of the power in the final signal at the frequencies present in the original signal. Thus any noise or distortion exactly at those frequencies would not be measured.
The Total Power Level is an indication of the amplitude of the recorded signal. The highest power level possible for any signal (a square wave which just saturates the binary 16 bit representation) would have a power level of about 90.3dB, while a sin wave whose peak just saturated (Max ampl=1) would be at 87.3dB. If our complex signal just saturates (ie largest amplitude is just at the clipping level) the signal has a strength of 78.0 dB. This number says nothing about the sound card, but is an indication of whether or not the sound card is clipping (which would clearly introduce a large amount of distortion).

Spectrum

If the -s option is given, the program will also put out the spectral amplitude (in dB) of the recorded sound at the 50 frequencies which are in the input. All levels should be the same for a perfect card, however there is liable to be some rolloff in the highest treble and in the base. The absolute level is not important, just the differences in level between the various frequencies. Here is the output from my sound card.

```
               Channel= 1
Freq    dB
16        55.47
18        55.76
21        56.07
24        56.29
27        56.44
32        56.60
36        56.69
42        56.78
48        56.84
55        56.88
64        56.93
73        56.95
84        56.98
97        56.99
111        57.00
128        57.02
147        57.02
168        57.03
194        57.03
222        57.04
256        57.04
294        57.04
337        57.04
388        57.04
445        57.05
512        57.05
588        57.05
675        57.05
776        57.05
891        57.05
1024        57.05
1176        57.05
1351        57.06
1552        57.06
```

1782	57.06
2048	57.06
2352	57.06
2702	57.06
3104	57.06
3565	57.07
4096	57.07
4705	57.08
5404	57.09
6208	57.10
7131	57.11
8192	57.13
9410	57.14
10809	57.15
12416	57.16
14263	57.14

There is a mild roll off in the far bass, but between 50 Hz and the maximum there is just a slight rise of about .3dB, which would be completely inaudible.

Output and Input files

If you want to do further analysis of the input or the output, the program writes both the generated sound and the recorded sound in the files *<code>/tmp/pinkout.sw</code>* and *<code>/tmp/pinkin.sw</code>*. These are both raw soundfiles, Signed Word, Stereo, 44100 bits per second. They can be converted to .wav files with sox. Eg
sox -c 2 -r 44100 pinkout.sw pinkout.wav

Noise and distortion spectrum

At present the program is set up to also print out the residual noise spectrum for the card to /tmp/noisespect. This is in the format of ascii lines with the frequency as the first entry in the line, and power in the noise and distortion at that frequency, normalized (to the total power in the signal).