VS1005 APPNOTE: DEVBOARD PERFORMANCE

VS1005

Revision History

Rev.	Date	Author	Description
1.20	2014-02-24	HH	Added VSOS3 / 0.306 binary.
1.12	2013-07-19	HH	Modified for better rendering under VSOS 0.24.
1.11	2013-02-21	HH	Analyzer now includes optional A-weighting filter.
1.10	2013-02-19	HH	Frequency response measurements redone.
1.02	2013-02-15	HH	Further minor typo corrections.
1.01	2013-02-13	HH	Terminology and typo corrections.
1.00	2013-02-12	HH	Initial version.

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1 Introduction

VS1005 is a system DSP processor with integrated high-quality 24-bit audio Analog-to-Digital Converters (ADCs) and Digital-to-Analog Converters (DACs).

This document presents the VS1005 Loopback Test Program, and tells how to use it to measure the performance of the VS1005 Developer Board, or a compatible board. It also presents example reference values from a randomly selected VS1005 Developer Board.

2 Definitions

ADC Analog to digital converter.

DAC Digital to analog converter.

dB Decibel, a logarithmic unit that indicates the ratio of two powers. 1 bel, which equals 10 decibels, is a power ratio of 10. With additional qualifiers (like dBfs, or dbV), it can also be used to quantify absolute signal levels.

dB(A) Decibel, but with the signals run through A Weighting curve before calculation. A Weighting usually gives results more relevant to how humans hear differences than measurements done without a weighting curve.

dBfs Decibel full scale. Decibel scale where zero point is bound to a digital full scale sine wave.

dBV Decibel volt. Decibel scale where zero point is bound to 0 dBV = 1 Vrms.

% Per cent. Sometimes used to present THD instead of the dB scale. To convert from dB scale to per cent scale, use the following formula: $pc = 100 \times 10^{-THD/20}$.

THD Total Harmonic Distortion.

THD+N Total Harmonic Distortion plus Noise.

Vpp Volts, peak-to-peak. A sine signal of 1 Vpp = $\frac{1}{2\times\sqrt{2}}$ Vrms.

Vrms Volts, root mean square. A sine signal of 1 Vrms has an amplitude of $\sqrt{2}$ V, and its peak-to-peak voltage is $2 \times \sqrt{2}$ Vpp.

3 Prerequirements

The following prerequirements need to be met so as to be able to get relieable results.

3.1 Hardware

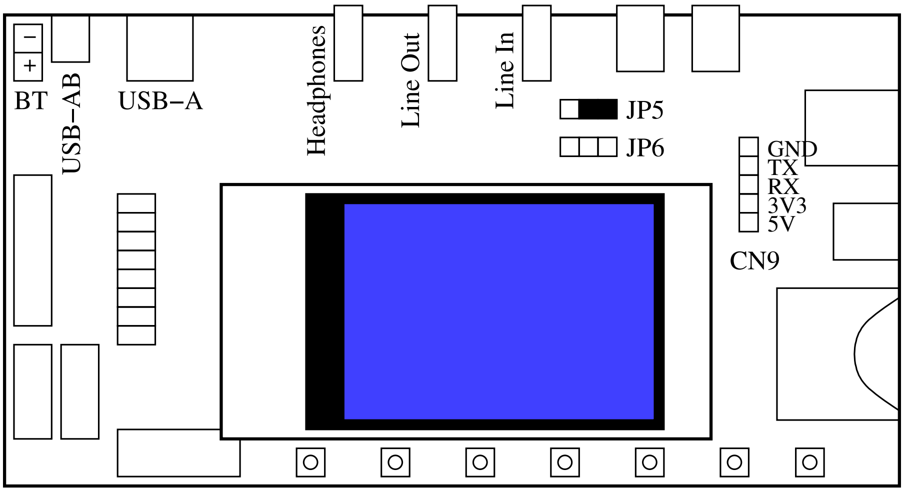

Figure 1: VS1005 Developer Board.

The VS1005 Developer Board v1.4 or newer, as shown in Figure 1, or a compatible board, is required.

Set the Line In jumper JP5 as shown in the figure.

3.2 Software

The Loopback Test Program can be downloaded from
http://www.vlsi.fi/en/support/software/vs1005applications.html .

Unzip the package.

If using VSOS3 series 0.306 or newer, copy AudioLoopback.ap3 to the SD card main folder. To work, the program requires that the 2-way audio driver AUDIO.DL3 (available as a template in VSIDE) has been installed to the SYS/ folder.

If using VSOS 2 series 0.23 or newer, copy AudioLoopback.app to the SD card main folder.

Boot VSOS and start the program.

3.3 Low-Noise Power Source

For best results, a good quality power source with low noise on the audio band is required.

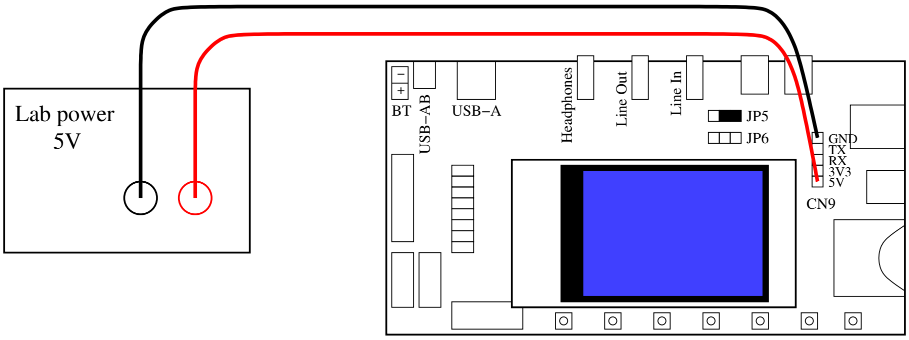

Figure 2: VS1005 Developer Board with lab power.

Recommended power sources are either a 5 V lab power, connected to CN9 pins GND and 5 V, as shown in Figure 2. The lab power may also be connected to the 5 V pin of either the USB-AB or USB-A connector on the VS1005 Developer Board.

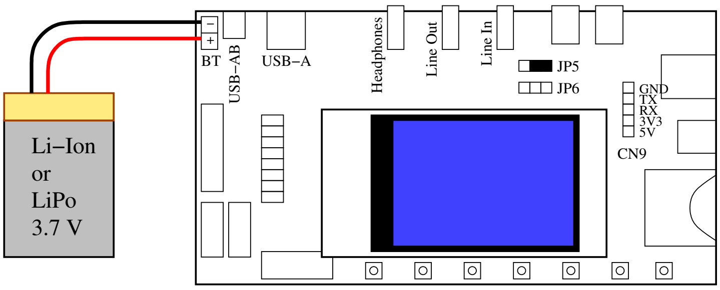

Figure 3: VS1005 Developer Board with Li-Ion or LiPo battery.

Another recommended way of powering the VS1005 Developer Board is to connect a 3.7 V Li-Ion or LiPo battery to the BT connector, as shown in Figure 3.

Note that the VS1005 Developer Board is equipped with charging logic for the battery. So when you connect the battary and any 5 V power source to the developer board, the battery will automatically charge. As long as the batter is charging, a CHARGE LED close to the BT connector will be lit.

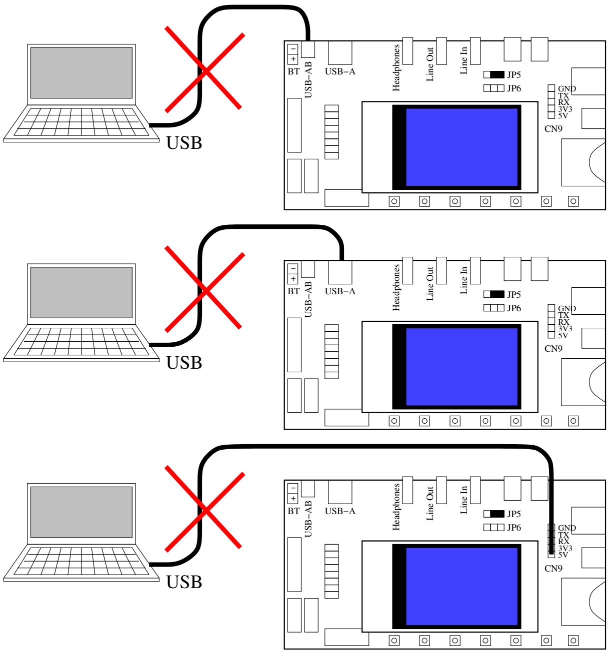

Figure 4: For proper measurement results, do *not* power the VS1005 Developer Board from a PC computer port. Use a stabilized laboratory power or a battery as shown in Figures 2 and 3.

As shown in Figure 4, do *not* power the VS1005 Developer Board directly from computer USB using the USB-AB or USB-A connectors, or with a USB-to-RS232 cable using the RS232 connector. PC powers are notoriously noisy and will cause unnecessary noise in both the inputs and outputs. For the same reason, do not use cheap AC-to-USB adapters.

Note also that even if you power the VS1005 Developer Board from a good power source, an electrical connection to a PC can still degrade performance. So, before doing any measurement, disconnect any cables between the DevBoard and the PC that you don't need for the specific measurement, particularly the RS232 cable.

3.4 Audio Signal Generator and Analyzer

A high-quality audio signal generator and analyzer, like the Rohde & Schwarz UPV Audio Analyzer / Signal Generator, is required. PC sound cards are in general not nearly of sufficient quality to be able to show the dynamic range potential of the VS1005 Developer Board.

Note: A volt meter in AC mode is *not* sufficient to measure the power of output signals. Because of the sigma-delta digital-to-analog converters of the VS1005, the outputs contain out-of-hearing-band white noise that cannot be heard, but which a volt meter will see.

4 Loopback Test Program

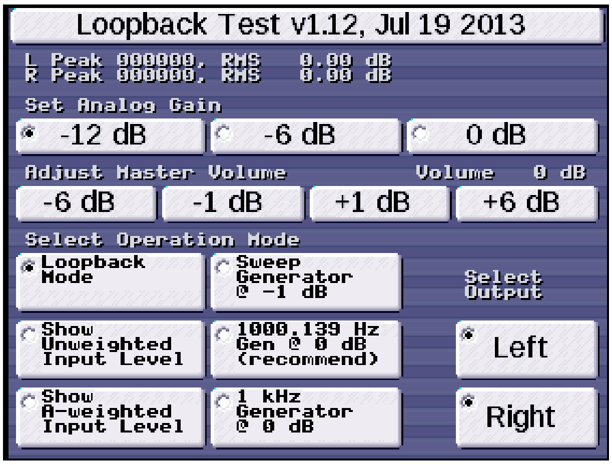

Figure 5: Loopback mode.

The Loopback Test Program looks as shown in Figure 5.

The top of the display shows the result of the RMS & Peak analyzer if Show Unweighted Input Level mode (Chapter 4.4.2) or Show A-weighted Input Level mode (Chapter 4.4.3) is selected. Otherwise they will show zeros.

Next is the Analog Gain control (Chapter 4.2).

Followed by that is the Master Volume adjustment control (Chapter 4.3).

Finally are the Operation Mode controls (Chapter 4.4) and Left/Right Output selection controls (Chapter 4.5).

4.1 Test Program Signal Paths

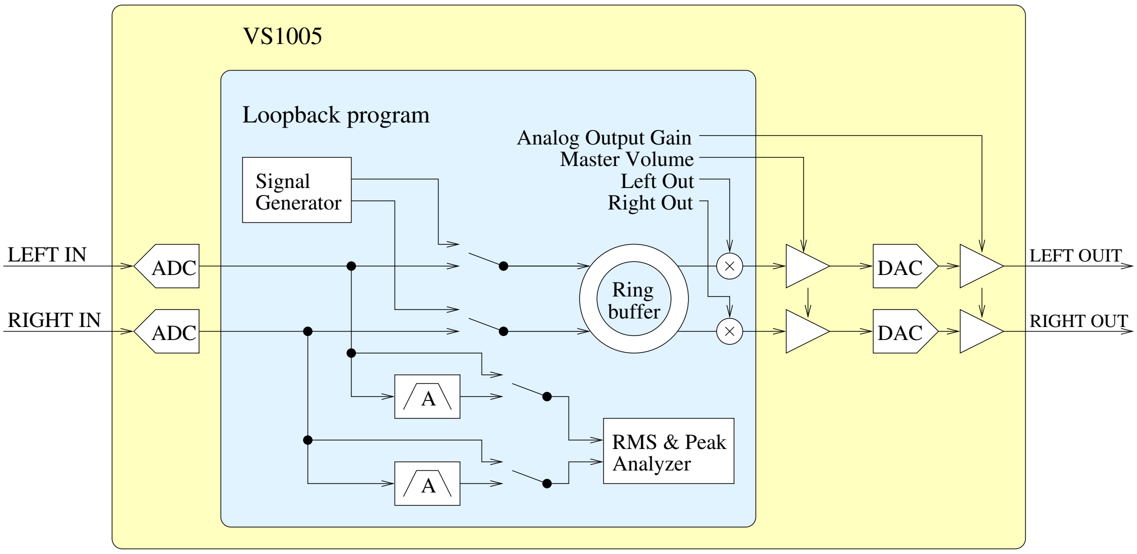

Figure 6: Loopback Program 24-bit signal paths.

The Test Program signal paths are shown in Figure 6.

Data is read at 48 kHz from the left and right ADCs that are connected to analog line inputs Left In and Right In. This signal is divided into two paths: it is forwarded to the RMS and Peak Analyzer either directly or through an A-weighting filter. The signal is also forwarded without filtering to the ring buffer input selection multiplexer.

Figure 7 shows the frequency response of the A-weighting filter.

The ring buffer input selection multiplexer selects between the Left and Right inputs and the Signal Generator, and writes the resulting data to the Ring Buffer.

The Ring Buffer delay is approximately 0.17 ms. (Note: the hardware in the ADC and DAC cause their own delays which are significantly larger.)

The left and right outputs of the Ring Buffer is, depending on Left Out and Right Out controls, multiplied by either 0 or 1, and sent at 48 kHz through the VS1005 hardware volume control, DAC, and Analog Output Gain, to the analog outputs Left Out and Right Out.

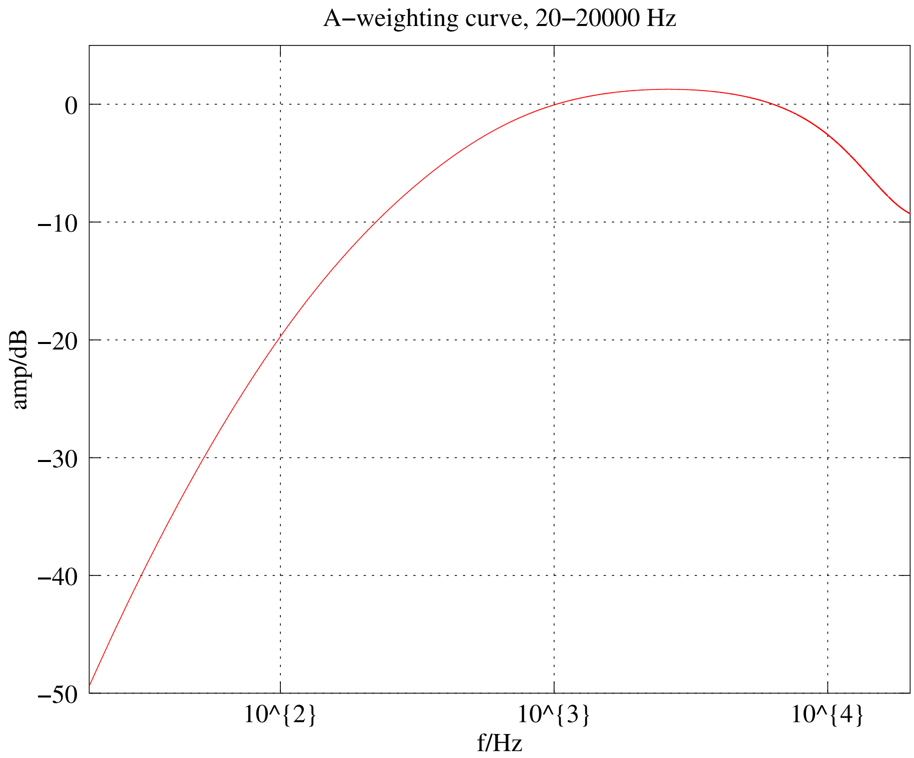

Figure 7: Loopback Test Program A-weighting filter frequency response.

4.2 Analog Gain Control

Analog Gain control lets the user to set one of VS1005's analog gain controls: -12 dB, -6 dB, or 0 dB. At lower settings background white noise is significantly lower, but harmonic distortion may be slightly higher with full-scale signals, and if Master Volume (Chapter 4.3) is set close to maximum.

Generally speaking best audio can be obtained when Analog Gain is at its lowest setting that offers enough sound pressure.

Note: Analog Gain controls are not exact. They are measured in Chapter 5.1.4.

4.3 Master Volume Control

The digital Master Volume control lets the user set a digital volume control. This digital volume control operates in the 24-bit digital domain, which makes its quality very high.

The user can adjust master volume in 1 dB and 6 dB steps.

4.4 Operation Mode Controls

4.4.1 Loopback Mode

The basic mode in the Loopback test program is the Loopback mode, shown in Figure 5 on Page 9. This mode is intended for measuring the performance of the board using an audio analyzer.

In this mode, the analog inputs are read and copied through the ring buffer directly the the analog output. Otherwise the program does as little as possible as as not to cause any extra EMC emissions that would interfere with best performance.

4.4.2 Show Unweighted Input Level Mode

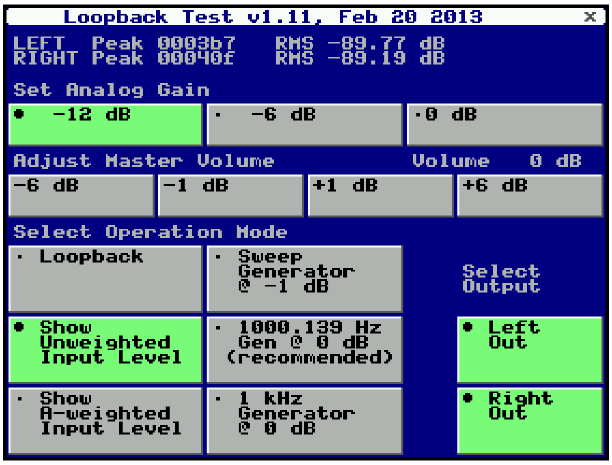

Figure 8: Show Unweighted Input Level mode.

The Show Unweighted Input Level mode, as shown in Figure 8, shows the current left and right line input peak and RMS levels on the LCD screen.

The peak level is a 24-bit hexadecimal number with 0x800000 (displayed as 800000) as the maximum value.

The RMS level is on the decibel scale in relation to a full-scale sine input wave.

In this mode the digital input signal is run through a DC offset removal filter. Otherwise is not filtered.

This mode is best suited for input frequency response measurements.

4.4.3 Show A-weighted Input Level Mode

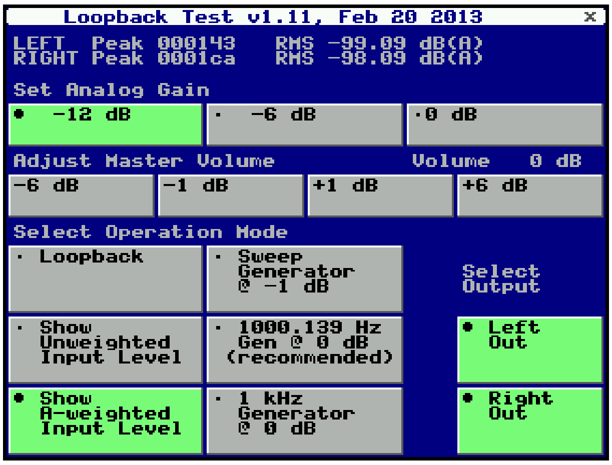

Figure 9: Show Unweighted Input Level mode.

The Show A-weighted Input Level mode, as shown in Figure 9, works just like Show Unweighted Input Level mode as shown in Chapter 4.4.2, except that the input signal is run through an A-weighting filter before analysis.

The frequency response of the A-weighting filter is prestented in Figure 7 on Page 11.

This mode is best suited for e.g. dynamic range and channel separation measurements.

4.4.4 1000.139 Hz Sine Generator @ 0 dB Mode

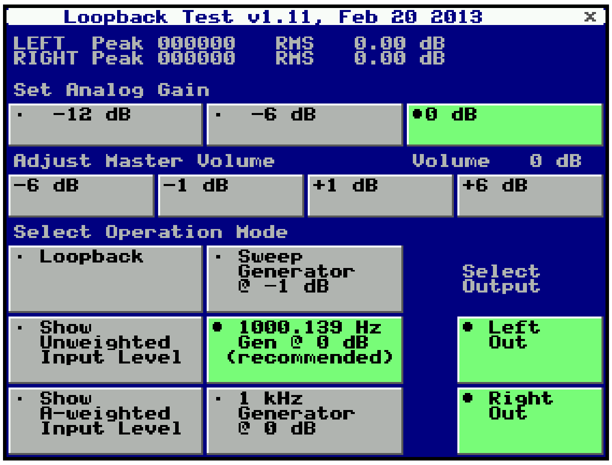

Figure 10: 1000.139 Hz Generator mode.

The 1000.139 Hz Sine Generator, as shown in Figure 10, offers a high-quality sine signal output at full digital range. It is recommended for audio quality measurements.

4.4.5 1 kHz Sine Generator @ 0 dB Mode

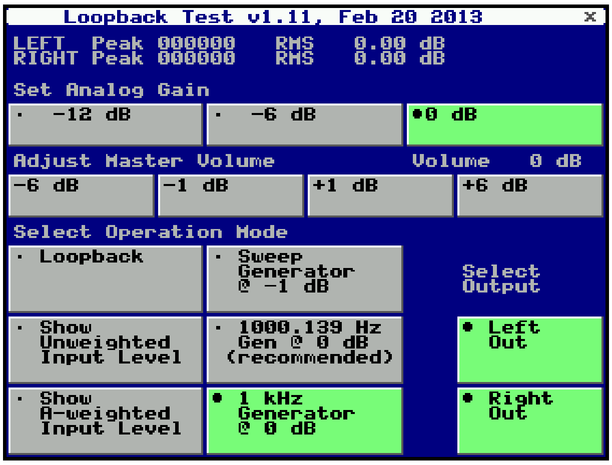

Figure 11: 1 kHz Generator mode.

The 1 kHz Sine Generator, as shown in Figure 11, generates an exactly 1 kHz signal at full digital scale.

Note that because the system sample rate of 48 kHz is divisable by 1 kHz ($\frac{48000Hz}{1000Hz} = 48$), this mode may show a signal spectrum that is not representative of the true quality of VS1005's outputs. For quality measurements, use 1000.139 Hz Sine Generator instead.

4.4.6 Sweep Generator @ -1 dB Mode

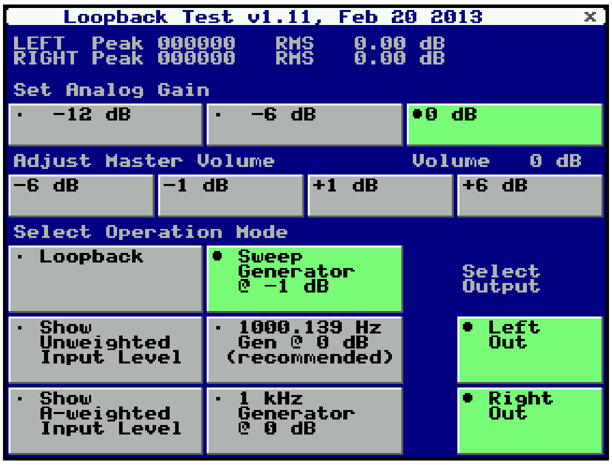

Figure 12: Sweep Generator mode.

The Sweep Generator, as shown in Figure 12, generates a sine sweep from 20 Hz to 20 kHz at a digital signal level of -1 dBfs. Each frequency is output for exactly two seconds. After the sweep has been finished, the generator waits for 10 seconds before a restart.

4.5 Left/Right Out Controls

The Left Out and Right Out controls can be used to individually turn the left and right outputs on and off.

5 Measuring DevBoard Performance

This Chapter will show how to measure the VS1005 Developer Board performance, and gives examples of a randomly chosed DevBoard for each case.

5.1 Measuring Analog Output

Set up your audio analyzer so that it analyses only the audio range 20 Hz to 20 kHz, and that it used A-weighting.

5.1.1 Baseline Line Output Measurements

Start by measuring the following values which will be needed later. Set the measuring program as follows:

1. Analog Gain as stated in the table below, Master Volume 0 dB, 1000.139 Hz Generator, Left Out On except where noted, Right Out On except where noted, analyzer input impedance high.

Boxes that are marked N/A are not needed. The data for the example card is presented below.

Output levels at different Analog Gain Settings, Volume 0 dB					
Name	Symbol	Analog Gain/ dB	Output level		
			Left/ mVrms	Right/ mVrms	Mean/ mVrms
Full swing output	OUT0_L/R/M	0	931	939	935
Output at -6 dB	OUT6_L/R/M	-6	476	479	478
Output at -12 dB	OUT12_L/R/M	-12	242	243	243
Left muted	OUT0MUTEL_L	0	0.032	N/A	N/A
Right muted	OUT0MUTER_R	0	N/A	0.042	N/A
Muted at 0 dB	OUT0MUTE_L/R/M	0	0.0128	0.0118	0.0123
Muted at -6 dB	OUT6MUTE_L/R/M	-6	0.0078	0.0072	0.0075
Muted at -12 dB	OUT12MUTE_L/R/M	-12	0.0055	0.0055	0.0055

Results for the left and right channel should always be similar and symmetrical. If they are far from each other, there is a problem with the measurement setup, cables, PCB, or IC.

5.1.2 Measuring Line Output Dynamic Range

Dynamic range is the ratio of the energy of the strongest signal that can be output to the background noise on an empty channel.

To calculate the dynamic range over the full analog gain range, and using the values from the baseline measurements as explained in Chapter 5.1.1, the dynamic range is calculated as follows:

$dr = 20 \times \frac{\log \frac{OUT0\_M}{OUT12MUTE\_M}}{\log 10}$ dB(A).

Example:
$dr = 20 \times \frac{\log \frac{935}{0.0055}}{\log 10} = 104.6$ dB(A).

Switching Analog Gain causes a slight glitch in sound. So in an application where the user doesn't change the volume level, it should be used with caution. For an application that uses Analog Gain, we can calculate the dynamic range as follows:

$dr_{g0} = 20 \times \frac{\log \frac{OUT0\_M}{OUT0MUTE\_M}}{\log 10}$ dB(A).

Example:
$dr_{g0} = 20 \times \frac{\log \frac{935}{0.0123}}{\log 10} = 97.6$ dB(A).

5.1.3 Measuring Line Output Channel Gain Mismatch

Left/Right channel mismatch tells the mismatch between the left and right analog outputs. This mismatch depends on the setting of the Analog Gain, but not the digital Master Volume. So it needs to be calculated for different Analog Gain settings.

Using the values from the baseline measurements as explained in Chapter 5.1.1, the line output L-R channel gain mismatches are calculated as follows:

$e_{c0} = 20 \times \frac{\log \frac{OUT0\_L}{OUT0\_R}}{\log 10}$ dB.
$e_{c-6} = 20 \times \frac{\log \frac{OUT6\_L}{OUT6\_R}}{\log 10}$ dB.
$e_{c-12} = 20 \times \frac{\log \frac{OUT12\_L}{OUT12\_R}}{\log 10}$ dB.

Example:
0 dB channel mismatch is $e_{c0} = 20 \times \frac{\log \frac{931}{937}}{\log 10} = -0.07$ dB.
-6 dB channel mismatch is $e_{c-6} = 20 \times \frac{\log \frac{476}{479}}{\log 10} = -0.05$ dB.
-12 dB channel mismatch is $e_{c-12} = 20 \times \frac{\log \frac{242}{243}}{\log 10} = -0.04$ dB.

5.1.4 Measuring Line Output Analog Gain Accuracy

Using the values from the baseline measurements as explained in Chapter 5.1.1, the analog gain is calculated as follows:

$e_{gx} = 20 \times \frac{\log \frac{OUTx\_M}{OUT0\_M}}{\log 10}$ dB.

Example:
Actual analog gain for the -6 dB setting is $e_{g-6} = 20 \times \frac{\log \frac{478}{935}}{\log 10} = -5.83$ dB.
Actual analog gain for the -12 dB setting is $e_{g-12} = 20 \times \frac{\log \frac{243}{935}}{\log 10} = -11.70$ dB.

5.1.5 Measuring Line Output Channel Separation

Output channel separation tells how much the left audio channel bleeds to the right, and vice versa.

Using the values from the baseline measurements as explained in Chapter 5.1.1, the left/right channel separation is calculated as follows:

$s_l = 20 \times \frac{\log \frac{OUT0\_R}{OUT0MUTEL\_L}}{\log 10}$ dB(A).
$s_r = 20 \times \frac{\log \frac{OUT0\_L}{OUT0MUTEL\_R}}{\log 10}$ dB(A).
Choose the lower value as your channel separation.

Example:
$s_l = 20 \times \frac{\log \frac{939}{0.032}}{\log 10} = 89.4$ dB(A).
$s_r = 20 \times \frac{\log \frac{931}{0.042}}{\log 10} = 86.9$ dB(A).
$s = 86.9$ dB(A)

If you want to test the earphone output under maximum load, you may connect both the left and right earphone channel to CBUF with two 30 Ω resistors, then measure again. Note that output channel separation is always a combination of the performance of the PCB and the IC. If there are vias on the PCB with even a 0.1 Ω resistance, it will severely affect output channel separation if a low-impedance load is connected to the device.

5.1.6 Measuring Line Output Signal to Noise and THD+N Ratios

Measure the A-weighted noise and THD+N voltages for each channel with these parameters:

1. Analog Gain as needed, Master Volume as needed, 1000.139 Hz Generator, Left Out On, Right Out On, analyzer input impedance high.

Depending on your requirements, repeat with different Master Volume, Gain Settings, and analyzer impedance settings. Plot as needed.

Example for left channel on DevBoard:

Output noise and THD+N ratios						
	Analog Gain 0 dB		**Analog Gain -6 dB**		**Analog Gain -12 dB**	
Volume /dB	**S/N / dB(A)**	**THD+N / dB(A)**	**S/N / dB(A)**	**THD+N / dB(A)**	**S/N / dB(A)**	**THD+N / dB(A)**
0	92.5	65.8	92.3	69.9	90.8	74.6
-1	92.7	67.1	92.0	71.1	90.7	76.0
-2	92.5	69.0	91.6	72.1	90.1	77.1
-3	92.0	70.4	91.3	73.2	89.4	78.1
-4	91.5	71.3	90.8	74.2	88.7	79.1
-5	91.3	71.2	90.1	75.2	88.0	79.9
-6	90.6	72.2	89.5	76.1	87.0	80.6
-9	88.4	75.6	87.1	78.9	84.4	81.8
-12	85.9	77.5	84.6	80.6	81.6	80.8
-18	80.2	79.0	78.7	78.2	75.7	75.5
-24	73.5	73.5	72.2	72.0	69.5	69.4
-36	61.5	61.5	60.2	60.1	57.5	57.4
-48	49.1	49.1	47.9	47.6	45.2	45.3
-60	37.1	38.0	35.8	36.8	33.1	33.0
-72	25.0	25.0	23.9	23.6	21.2	21.2
-78	19.0	19.0	18.0	17.7	15.4	15.3
-84	13.2	13.4	12.1	11.9	9.6[1]	9.6[1]
-90	7.8[1]	8.0[1]	6.4[1]	6.7[1]	5.1[1]	5.1[1]

[1] Numbers below 10 dB(A) are unreliable with the analyzer used for this example.

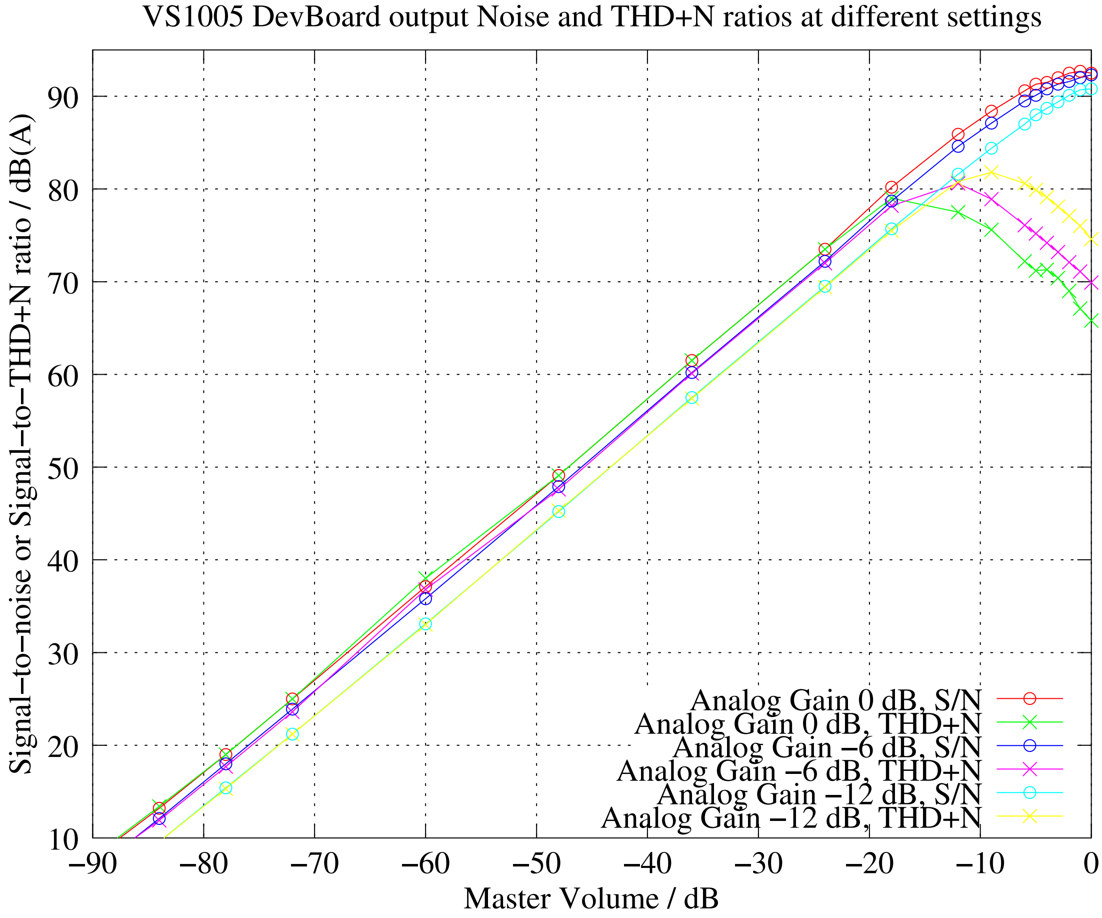

Figure 13: VS1005 DevBoard output signal to noise and THD+N ratios at different Analog Gain and Master Volume settings.

Figure 13 presents graphically the DevBoard noise and THD+N ratios for different volume settings at different analog gain settings.

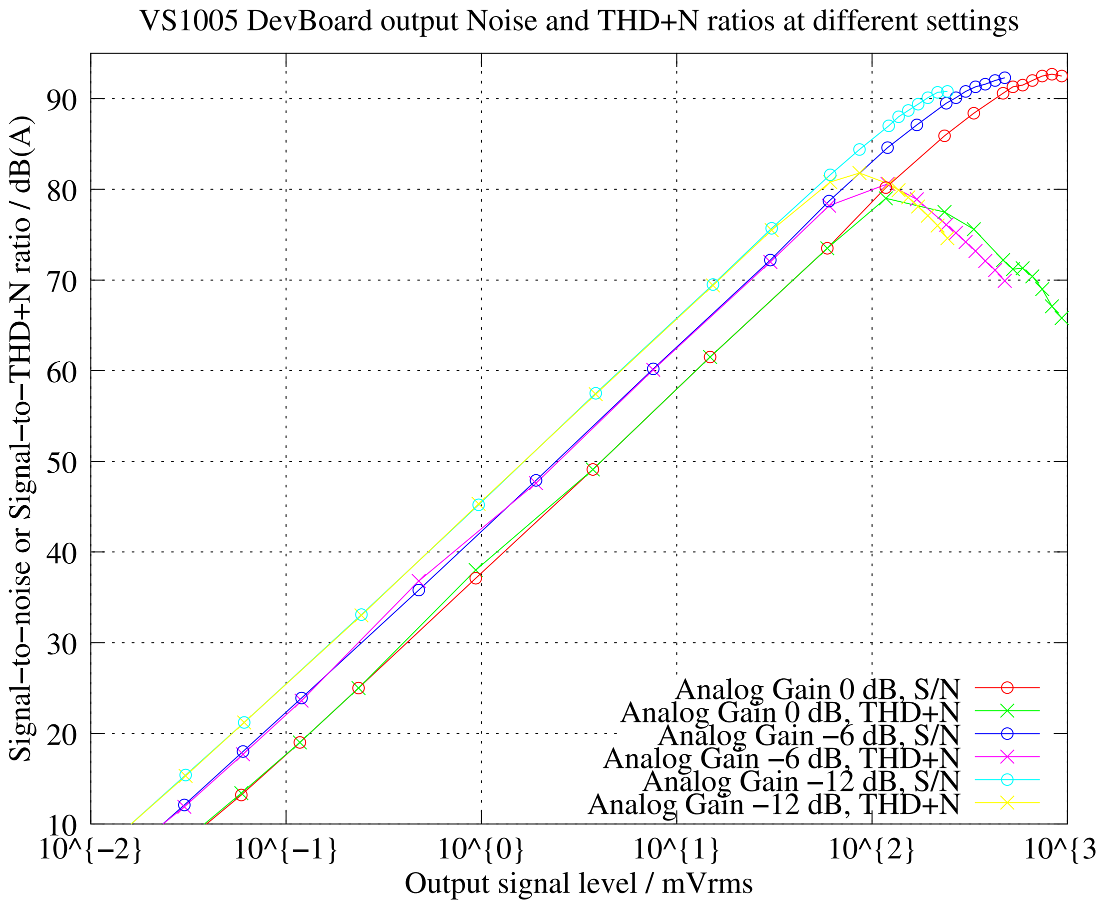

Figure 14: VS1005 DevBoard output signal to noise and THD+N ratios at different output signal levels.

Figure 14 presents graphically the DevBoard noise and THD+N ratios in relation to the output signal level.

The maximum signal level for Master Volume = 0 dB is 935 Vrms, 478 Vrms, and 243 mVrms for Analog Gains -0 dB, -6 dB, and -12 dB, respectively, as calculated in Chapter 5.1.1.

As can be seen from the Figure, in general the best performance at a given output level can be obtained by using the lowest possible Analog Gain.

Example: For an output of 10 mVrms, Analog Gain -12 dB gives a THD+N ratio of approximately 66 dB(A), while Analog Gain -6 dB and 0 dB give THD+N ratios of 62 dB(A) and 58 dB(A), respectively.

5.1.7 Measuring Output Frequency Response

Set your signal analyzer to sine sweep analyzer mode. Set the DevBoard as follows:

1. Analog Gain 0 dB, Master Volume 0 dB, Sweep Generator, Left Out On, Right Out On, analyzer input impedance high.

The two outputs, Line Out and Earphone, are connected differently on the DevBoard: the Line Out has an analog low-pass filter. Because of this, the frequency responses are slightly different.

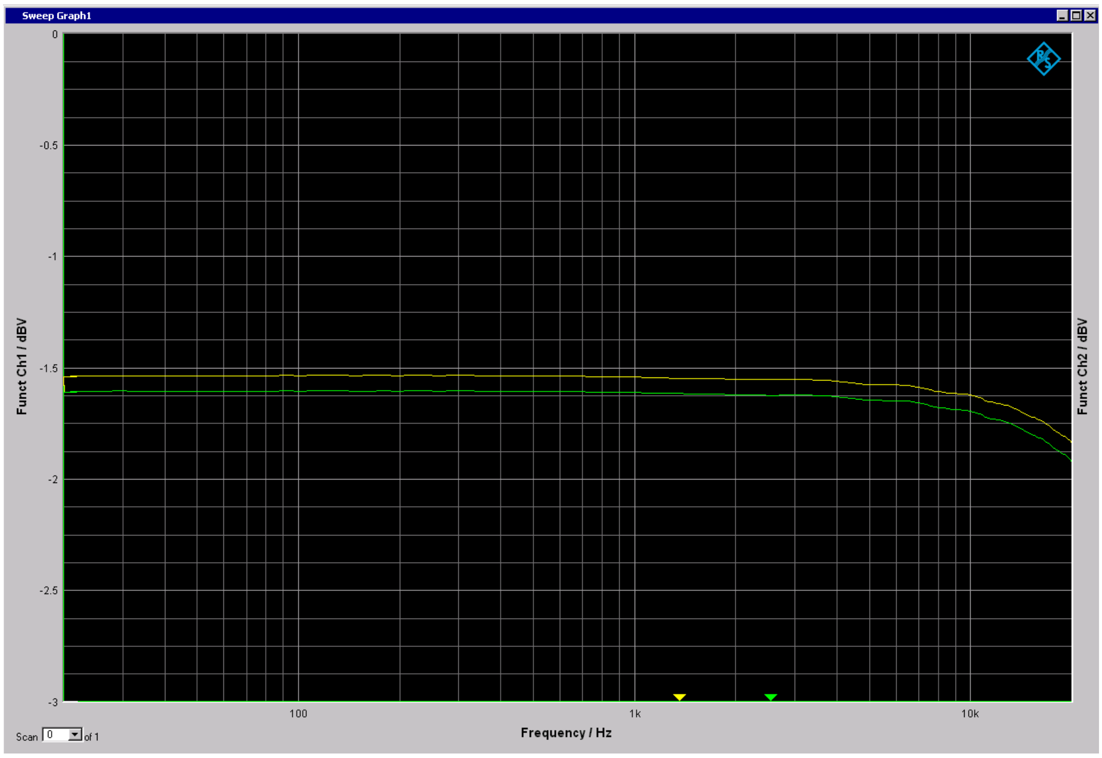

Figure 15: VS1005 DevBoard output frequency response, 20 to 20000 Hz, Line Out.

Example DevBoard Line Out frequency response is shown in Figure 15. The frequency response is ±0.15 dB between 20 and 20000 Hz.

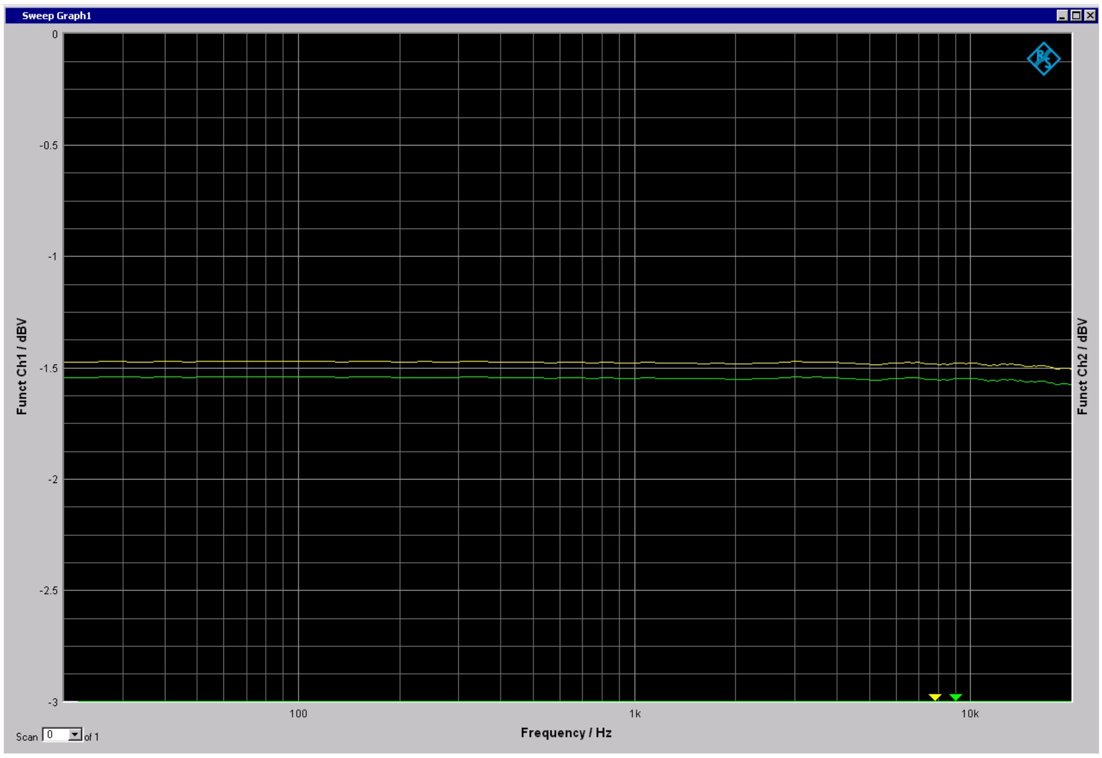

Figure 16: VS1005 DevBoard output frequency response, 20 to 20000 Hz, Earphone.

Example DevBoard Earphone frequency response is shown in Figure 16. The frequency response is ±0.03 dB between 20 and 20000 Hz.

5.2 Measuring Analog Input

To measure the analog input, you need a high-quality audio signal generator. Connect the generator to the left and right line input of the DevBoard.

5.2.1 Measuring Line Input Background Noise and Dynamic Range

First measure the input background noise without any other connectors to the board than the power connector from either the external high-quality lab power or the Li-Ion / LiPo battery. Then set the following parameters:

1. Analog Gain -12 dB, Master Volume 0 dB, Show A-Weighted Input Level, Left Out On, Right Out On.

You should now see a very low RMS number on the display. It should be -95 dB(A) or better. An example if this display is shown in Figure 9 on Page 14. This background noise level is also the dynamic range of the system.

Example: The example DevBoard's background noise level is -99 dB(A) for the left channel and -98 dB(A) for the right channel. The dynamic range is thus 98 dB(A).

Note that there is some board-to-board variation, so even if the numbers are in the 95 dB(A) range, it doesn't necessarily mean that there are any specific problems with the board.

Now connect the line input to the signal generator. If there is a change in the RMS value then either your cable or your signal generator is not of sufficient quality to measure the DevBoard, or there is a ground loop that is affecting your measurements.

5.2.2 Measuring Maximum Line Input Level

Set you signal generator to generate a low voltage, e.g. 100 mVrms, sine signal. Then set the DevBoard to:

1. Analog Gain -12 dB, Master Volume 0 dB, Show Unweighted Input Level, Left Out On, Right Out On.

You should now see RMS values of approximately -21.3 dB, like on the Example DevBoard.

Slowly increase the voltage until the Peak detectors just cannot reach their maximum value 0x800000. This should happen at approximately 1.16 Vrms, like on the Example DevBoard.

5.2.3 Measuring Line Input Channel Gain Mismatch

Set you signal generator to generate a low voltage, e.g. 100 mVrms, sine signal. Then set the DevBoard to:

1. Analog Gain -12 dB, Master Volume 0 dB, Show Unweighted Input Level, Left Out On, Right Out On.

The difference between the left and right channel level is the input channel gain mismatch.

Example: Devboard shows left RMS at -21.55 dB and right RMS at -21.53 dB, so the mismatch is $-21.55 - -21.53 = -0.02$ dB.

5.2.4 Measuring Line Input Channel Separation

Set the DevBoard to:

1. Analog Gain -12 dB, Master Volume 0 dB, Show A-weighted Input Level, Left Out On, Right Out On.

Set your signal generator to generate a 1 V signal to the left channel and no signal to the right channel. Take the difference between the right and left RMS outputs on the LCD. Repeat with channels switched. The results should be almost identical. Use the value that's worse.

Example: Left channel at -1.50 dB(A) and right channel at -92.01 dB(A), so channel separation is $-1.50 - -92.01 = 90.51$ dB(A). When reversed right level is is -93.70 dB(A) and left is -1.48 dB(A), so separation is $-1.48 - -93.70 = 92.22$ dB(A). The worse number is 90.5 dB(A), which is the channel separation.

5.2.5 Measuring Line Input Signal to Noise and THD+N Ratios

The VS1005 Developer Board and its current software doesn't offer any easy way to determine input Noise and THD+N figures, although in the future an updated version may be released which outputs the analog input signal digitally.

However, a loopback test gives the lowest possible performance values as follows. Set DevBoard to:

1. Analog Gain -12 dB, Master Volume 0 dB, Loopback, Left Out On, Right Out On, analyzer input impedance high.

Generate different amplitude signals, upto 1.1 Vrms, to the DevBoard, and use your audio analyzer to analyze the results. For signals lower than 100 mVrms, set Analog Gain to 0 dB.

5.2.6 Measuring Line Input Frequency Response

Set the DevBoard to:

1. Analog Gain -12 dB, Master Volume 0 dB, Show Unweighted Input Level, Left Out On, Right Out On

Use an e.g. 1 Vrms signal on your signal generator at different frequencies. Record the RMS value for each frequency.

Then, normalize the result around 0 dB by subtracting the mean passband value from all the results.

The following table presents the frequency response for the left channel. The right channel was identical within ±0.02 dB, so it is not presented here.

Input frequency response, left channel			
Freq / Hz	**Meas Level / dB**	**Offset[1] / dB**	**Corrected / dB**
20	-1.49	1.50	+0.01
30	-1.46	1.50	+0.04
40	-1.45	1.50	+0.05
50	-1.45	1.50	+0.05
100	-1.44	1.50	+0.06
200	-1.44	1.50	+0.06
500	-1.44	1.50	+0.06
1000	-1.45	1.50	+0.05
2000	-1.47	1.50	+0.03
5000	-1.46	1.50	+0.04
10000	-1.49	1.50	+0.01
12000	-1.48	1.50	+0.02
14000	-1.50	1.50	0.00
16000	-1.53	1.50	-0.03
17000	-1.53	1.50	-0.03
18000	-1.52	1.50	-0.02
18500	-1.52	1.50	-0.02
19000	-1.54	1.50	-0.04
19500	-1.55	1.50	-0.06
20000	-1.57	1.50	-0.07

[1] Offset has been selected in such a way that the results are normalized around 0 dB.

The input frequency response as shown in the table above and Figure 17 shows a frequency response of ±0.07 dB at 20 to 20000 Hz.

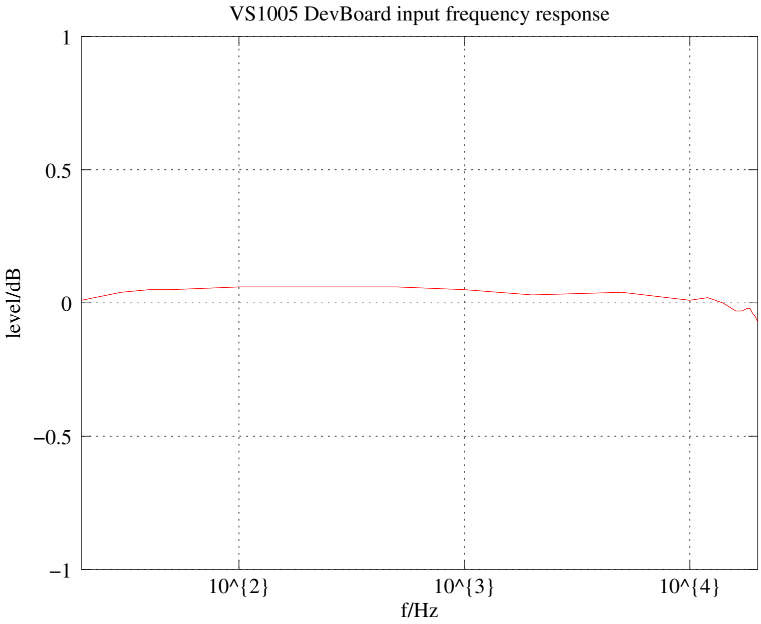

Figure 17: DevBoard Input Frequency Response, 20 to 20000 Hz.

6 VS1005 Developer Board Performance Summary

Below are tables that show a summary of the measurements results to a random VS1005 Development Board. When you design your own board, please verify that the results you get are consistent with the ones presented here.

VS1005 DevBoard Line/Earphone Output Performance			
Parameters	**Result**	**Unit**	**Presented in**
Line out maximum signal level	935	mVrms	Chapter 5.1.1
Line out dynamic range	104.6	dB(A)	Chapter 5.1.2
Line out dynamic range, Analog Gain 0 dB	97.6	dB(A)	Chapter 5.1.2
Line out channel gain mismatch, A.Gain 0 dB	-0.07	dB	Chapter 5.1.3
Line out channel gain mismatch, A.Gain -6 dB	-0.05	dB	Chapter 5.1.3
Line out channel gain mismatch, A.Gain -12 dB	-0.04	dB	Chapter 5.1.3
Line out real analog gain, Analog Gain -6 dB	-5.83	dB	Chapter 5.1.4
Line out real analog gain, Analog Gain -12 dB	-11.70	dB	Chapter 5.1.4
Line out channel separation	86.9	dB(A)	Chapter 5.1.5
Line out signal to noise, A.Gain 0 dB, Volume 0 dB	92.5	dB(A)	Chapter 5.1.6
Line out signal to noise, A.Gain 0 dB, Volume -18 dB	80.2	dB(A)	Chapter 5.1.6
Line out THD+N, A.Gain 0 dB, Volume 0 dB	65.8	dB(A)	Chapter 5.1.6
Line out THD+N, A.Gain 0 dB, Volume -18 dB	79.0	dB(A)	Chapter 5.1.6
Line out frequency response, 20-20000 Hz	±0.15	dB	Chapter 5.1.7
Earphone frequency response, 20-20000 Hz	±0.03	dB	Chapter 5.1.7

VS1005 DevBoard Line Input Performance			
Parameters	**Result**	**Unit**	**Presented in**
Line in dynamic range	98	dB(A)	Chapter 5.2.1
Line in maximum signal level	1.16	Vrms	Chapter 5.2.2
Line in channel gain mismatch	-0.02	dB	Chapter 5.2.3
Line in channel separation	90	dB(A)	Chapter 5.2.4
Line in frequency response, 20-20000 Hz	±0.07	dB	Chapter 5.2.6

7 Latest Version Changes

Version 1.20, 2014-02-24

Added executable file for VSOS3 / 0.306. See Chapter 3.2, *Software*, for details.

Functionality is unchanged.

Version 1.12, 2013-07-19

The display has been slightly changed to better render under VSOS 0.24. Figure 5, *Loopback mode*, has been replaced with one with the VSOS 0.24 look.

Functionality is unchanged.

Version 1.11, 2013-02-21

For this release the pre-filter was replaced with two alternative signal analyzer paths: unweighted and A-weighted. As a consequence, the following changes took place:

- Changed Figure 6, *Loopback Program 24-bit signal paths*.
- Replaced two pre-filter frequency response curves with Figure 7, *Loopback Test Program A-weighting filter frequency response*.
- Replaced Chapter *Show Input Level Mode* with Chapters 4.4.2, *Show Unweighted Input Level Mode*, and 4.4.3, *Show A-weighted Input Level Mode*.
- Rewrote significant portions of Chapter 5.2, *Measuring Analog Input*, to include measurements done with the new unweighted and A-weighted filters.

Version 1.10, 2013-02-19

For this release the frequency response measurements were redone. Now they are done better, and the results are much more representetive of VS1005's capabilities.

- Added Chapter 2, *Definitions*.
- Modified Loopback Test Program's Sweep Generator output. With the new output, redid the line output frequency response and added earphone frequency response to Chapter 5.1.7.
- Corrected typos and slightly changed wordings in several Chapters.
- Corrected Prefilter frequency response curves in Figures (removed in v1.11) and (removed in v1.11). The corrected curves were then applied to the correction table in Chapter 5.2.6, and also the frequency response curve in Figure 17.

Version 1.02, 2013-02-15

- Further typo corrections.
- Software version number changed to 1.02, no other changes to software.

Version 1.01, 2013-02-13

Terminology and typo corrections, particularly to table in Chapter 6, *DevBoard Performance Summary*.

Version 1.00, 2013-02-12

Initial version.

8 Contact Information

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