Hi-End Audio Server

By Bohdan Raczynski

With the release of new Realtek audio codes, ALC1150, some entirely new possibilities in computer audio have arrived. The new codec boosts an impressive 115dB SNR and this figure is on par or exceeds that of many Hi-Fi CD-players.

Based on this level of performance and suitably selected software, it is possible to built a very powerful audio server with a complete loudspeaker management system.

Here is a basic recipe.

Historical perspective

http://www.hardwaresecrets.com/article/Audio-Codec-Comparison-Table/520/2.

Model	Channels	Input Resolution	Output Resolution	Input Max. Sampling Rate	Output Max. Sampling Rate	Input SNR	Output SNR
ALC101	2	16-bit	16-bit	48 kHz	48 kHz	70 dB	75 dB
ALC202	2	18-bit	20-bit	48 kHz	96 kHz	85 dB	90 dB
ALC203	2	18-bit	20-bit	48 kHz	96 kHz	90 dB	100 dB
ALC250	2	18-bit	20-bit	48 kHz	96 kHz	92 dB	100 dB
ALC260	2	20-bit	24-bit	96 kHz	192 kHz	90 dB	95 dB
ALC262	4	20-bit	24-bit	96 kHz	192 kHz	90 dB	100 dB
ALC268	4	20-bit	24-bit	96 kHz	192 kHz	90 dB	95 dB
ALC269	4	24-bit	24-bit	96 kHz	192 kHz	98 dB	98 dB
ALC650	5.1	18-bit	20-bit	48 kHz	96 kHz	85 dB	90 dB
ALC655	5.1	16-bit	16-bit	48 kHz	48 kHz	86 dB	86 dB
ALC658	5.1	18-bit	20-bit	48 kHz	96 kHz	92 dB	96 dB
ALC662	5.1	20-bit	24-bit	96 kHz	96 kHz	90 dB	98 dB
ALC850	7.1	16-bit	16-bit	48 kHz	48 kHz	86 dB	92 dB
ALC861	7.1	16-bit	24-bit	96 kHz	96 kHz	82 dB	90 dB
ALC861-VD-GR	7.1	24-bit	24-bit	96 kHz	96 kHz	85 dB	95 dB
ALC880	7.1	20-bit	24-bit	96 kHz	192 kHz	85 dB	100 dB
ALC880D	7.1	20-bit	24-bit	96 KHz	192 KHz	85 dB	100 dB
ALC882	7.1+2	20-bit	24-bit	96 kHz	192 kHz	90 dB	101 dB
ALC883	7.1+2	24-bit	24-bit	96 kHz	192 kHz	85 dB	95 dB
ALC885	7.1+2	24-bit	24-bit	192 kHz	192 kHz	101 dB	106 dB
ALC887	7.1	24-bit	24-bit	192 KHz	192 KHz	90 dB	97 dB
ALC888	7.1+2	24-bit	24-bit	96 kHz	192 kHz	90 dB	97 dB
ALC888S	7.1+2	20-bit	24-bit	96 kHz	192 kHz	90 dB	97 dB
ALC888DD	7.1+2	24-bit	24-bit	96 kHz	192 kHz	90 dB	97 dB
ALC888S-VC	7.1+2	24-bit	24-bit	192 KHz	192 KHz	90 dB	97 dB
ALC888-VC2-GR	7.1+2	24-bit	24-bit	192 KHz	192 KHz	90 dB	97 dB
ALC888S-VD	7.1+2	24-bit	24-bit	192 KHz	192 KHz	90 dB	97 dB
ALC889	7.1+2	24-bit	24-bit	192 kHz	192 kHz	104 dB	108 dB
ALC892	7.1+2	24-bit	24-bit	192 KHz	192 KHz	90 dB	97 dB
ALC898	7.1+2	24-bit	24-bit	192 kHz	192 kHz	104 dB	110 dB

About 20 years ago (see table above), computer motherboards were really struggling to make any inroads into audio experience. Initially, audio codecs would only offer 2 channels, 16bit depth, 48kHz sampling rates and most importantly, a mere 70-75dB SNR. Even thought 16-bit technology offered theoretical 96dB SNR, the computers only managed 75dB at best. It is therefore no surprise, that sound card industry stepped-in and offered at least 20dB improvement on SNR.

Things started to change with Microsoft decision to enter audio/video industry. This turned out to be a right call, and motherboards started to improve rapidly. The ALC882/883 codecs already offered significant improvement, as they brought the specification very close to typical CD-player.

It is evident from the table above, that motherboard audio: ALC889 (released in 2008) or ALC898 (released in 2011) exemplify what becomes a norm in contemporary PC. But the PC industry did not rest on the laurels.

The latest ALC1150 offers further improvement on SNR (115dB). This device makes external DAC pretty much redundant. This is not to say, that an external DAC can not offer even bigger SNR, however, this will not be audible at normal-to-loud listening levels, so extra 10dB improvement does not justify the expenditure anymore.

Audio Server

It is quite conceivable, that "audio server" means different things to different people. Therefore, this paper does not attempt to provide a complete, all-encompassing definition. However, the audio server described in this paper is much more than just a playback device. Wikipedia (http://en.wikipedia.org/wiki/Sound_server) offers the following definition:

"….A **sound server** is software that manages the use of and access to audio devices (usually a soundcard). It commonly runs as a background process. The term could also apply to a complete computer which is in a server role, dedicated to audio streaming or a networked or stand-alone appliance for playing sounds and sound files…."

Basic functions of an Audio Server playback device can summarized as follows:

1. Must provide means to manipulate (copy, erase, name, etc..) audio files. This function is actually provided by any operating system, such Windows.
2. Must provide some means to group any number of files into a "playlist", in other words, must support creating, editing and naming of "playlists".
3. Must support playback of a whole "playlist", or individual music files via associated sound device (motherboard or sound card).
4. Must support volume control, and preferably display volume level of each channel.

It's tempting to continue to dwelve into more detailed description, but I am sure, you get the idea of what the server needs to be – a convenient, easy to use, software driven device allowing you to listen to your favourite music for hours at a time.

It's detailed functionality and level of sophistication will depend on software and hardware employed – which simply means – the cost you are willing to pay.

OK, let's now take a closer look at one possible hardware option, that would make a sound foundations not only for a good audio server, but more importantly, for further enhancements, additions and improvements, thus making your expenditure a good investment for years to come.

Computer Hardware Specification

1. Intel Z97 Chipset + Intel Core i7 4770k CPU
2. Motherboard with 2 PCI slots and PCIe slots
3. ALC1150 Realtek Audio Codec
4. Quiet and low-electrical noise PSU
5. 256Gb SSD to hold OS + all software
6. 2Tb HD to store all audio and video files.

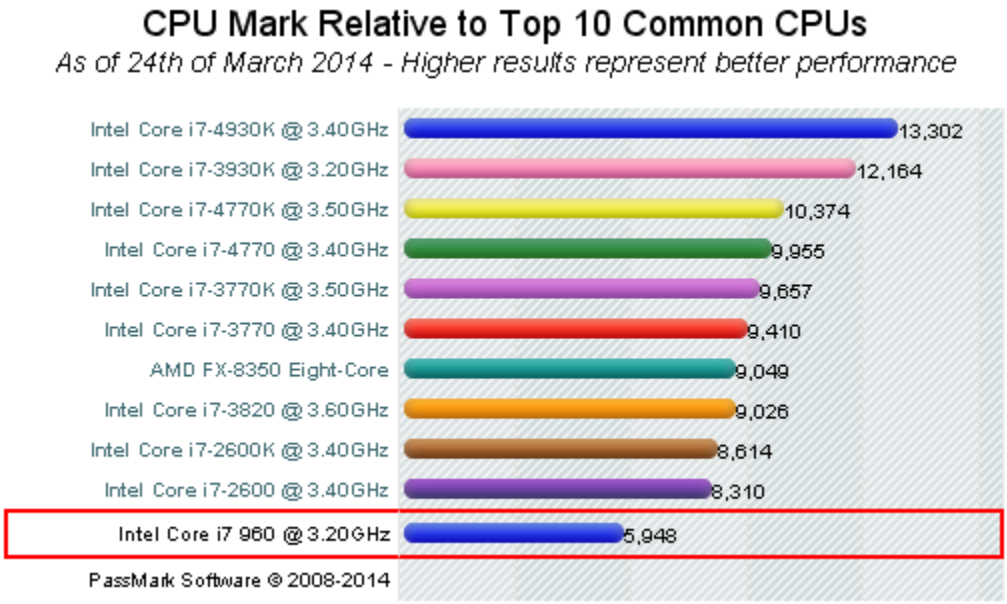
A commercial invoice for such a computer is shown below. Prices are in Australian dollars.

QTY	Component Type	Description	Price	Discount	Amount
1	**CPU**	Intel Core i7 4770K (3.50GHz / 8MB / LGA1150 / Quad Core / Overclocking Enabled)	$395.00	$0.00	$395.00
1	**Motherboard**	GIGABYTE GA-Z97X-UD5H MB, Z97, 4x DDR3, 3x PCI-E 3.0 x16, 8x SATA III, 8x USB 3.0, 1x SATA Express, 1x M.2, VGA, DVI, HDMI, ATX, Killer NIC	$255.00	$0.00	$255.00
1	**Memory**	Kingston 8GB (2x4GB), PC3-12800 (1600MHz) DDR3, HyperX Fury Black, 10-10-10, 1.5V, Dual Channel Kit	$99.00	$0.00	$99.00
1	**HDD/SSD**	Samsung 250GB SSD, 840 EVO Series, SATA III, 7mm, Read up to 540MB/s, Write up to 520MB/s	$179.00	$0.00	$179.00
1	**HDD/SSD #2**	WD 2TB Red, SATA III, IntelliPower, 64MB, NAS HDD for 1 to 5 Bay NAS	$133.00	$0.00	$133.00
1	**Optical Drive**	ASUS 16x Blu-Ray Burner, 16x Blu-Ray, 16x DVD-+R, BDXL, M-Disc Support, SATA, Black, Retail Box, with Cyberlink Software	$129.00	$0.00	$129.00
1	**Case**	Fractal Design Define R4 Arctic White ATX Case, Side Panel Window, No PSU, 2x USB 3.0, 2x USB 2.0, Audio In/Out, 8x 3.5" HDD Trays, 2x 5.25" Bays	$155.00	$0.00	$155.00
1	**Power Supply**	Seasonic 560W Modular PSU, 80PLUS® Gold Certified, San Ace Silent Fan, Voltage Regulation Module, Solid Capacitors	$209.00	$0.00	$209.00
1	**Monitor**	ASUS 23.6inch LED Monitor, Black, 1920x1080, 5ms, 50M:1 Contrast, VGA, DVI, HDMI, VESA	$175.00	$0.00	$175.00
1	**Operating System**	Microsoft Windows 7 Professional 64bit with Service Pack 1 DVD OEM	$175.00	$0.00	$175.00
1	**Software Installation**	Custom System Software Installation	$30.00	$0.00	$30.00
1	**System Assembly**	Custom System Parts Assembly 7 to 11 Parts	$105.00	$0.00	$105.00

CPU

A contemporary CPU such as i7-4770K was selected, and it's performance compared to older i7 960 processor. The **i7 960 CPU**, benchmarked at 5948. This is quite old CPU, and currently available CPUs, like **i7-4770K** scores the benchmark figure of 10374. This CPU would be a better option for our server.

http://www.cpubenchmark.net/high_end_cpus.html



http://www.cpubenchmark.net/cpu.php?cpu=Intel+Core+i7+960+%40+3.20GHz&id=838

Selecting a stronger CPU makes it possible to accommodate future expansions of the audio server system. For instance, there should be a clear progression path for the audio server to become an audio/video server.

Motherboard

The Gigabyte GA-Z97X-UD5H motherboard provides a good mixture of PCI/PCIe expansion slots, it has a HDMI output, it has ALC1150 audio codec and support for SPDIF output. This is also for future support of full-digital audio processing.

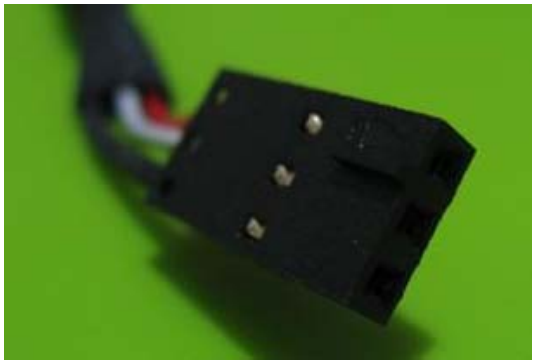
http://www.gigabyte.com/products/product-page.aspx?pid=4950#ov

Output Connectors

Please note, that optical SPDIF output is provided as a back-plane connector, however coaxial SPDIF is supported via motherboard header pins. This server will use coaxial SPDIF support and additional back-plane connector.

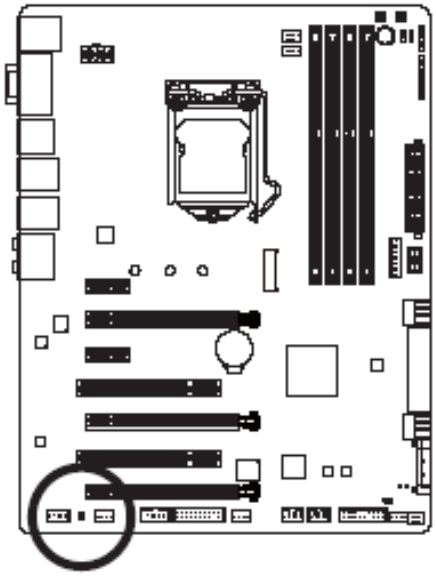
http://www.ebay.com/itm/Gigabyte-Motherboard-S-PDIF-SPDIF-Out-Cable-Bracket-/251494719529?ssPageName=ADME:L:OU:US:3160

The SPDIF header connector works up to 96kHz sampling rate, and it has 3 pins – Pin 1 is the DC power for optical transmitter. This pin will not be used.



Pin No.	Definition
1	Power
2	SPDIFO
3	GND

The motherboard has only two pins: SPDIF Output and Ground. It is clear, that the connector has to be plugged such a way, that only cable ports 2 + 3 make the connection with motherboard pins 1 + 2 respectively.



Pin No.	Definition
1	SPDIFO
2	GND

Power Supply

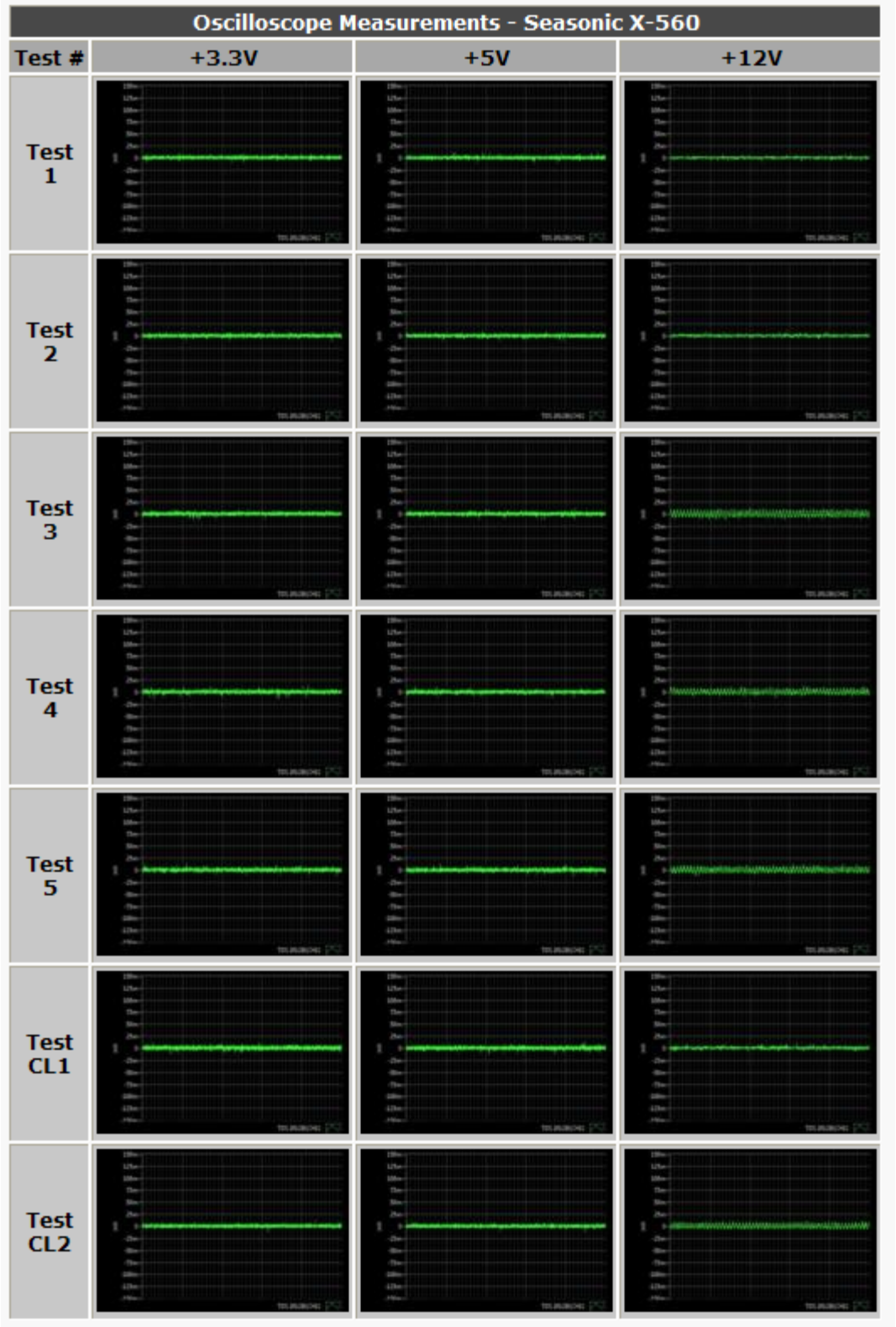
Power supply is an important part of the server. Excessive voltage noise on the three main (+3.3V, +5, +12V) supply rails can be detrimental to the overall performance.

A good place to check the performance of your power supply before you buy is:
http://www.jonnyguru.com/modules.php?name=NDReviews&op=Story3&reid=202

Seasonic company is known for taking an extra special care of the noise in their power supplies. The Seasonic X-560W power supply performs very well for noise on DC power supply lines. Specifications of all dynamic (hot) tests are shown below.

Results from Seasonic X-560 HOT load tests						
Test #	+3.3V	+5V	+12V	DC Watts/ AC Watts	Eff.	Intake/ Exhaust
Progressive load tests						
1	1A	1A	8A	111.1W/ 128.2W	86.7%	27Â°C/ 28Â°C
	3.37V	5.01V	12.23V			
2	2A	2A	17A	231.6W/ 259.4W	89.3%	31Â°C/ 35Â°C
	3.36V	5.00V	12.20V			
3	3A	3A	25A	339.7W/ 377.2W	90.1%	36Â°C/ 39Â°C
	3.35V	4.99V	12.19V			
4	4A	4A	34A	459.1W/ 512.0W	89.7%	40Â°C/ 42Â°C
	3.34V	4.98V	12.16V			
5	5A	5A	42A	568.6W/ 639.7W	88.9%	44Â°C/ 47Â°C
	3.32V	4.97V	12.14V			
Crossload tests						
CL1	15A	15A	0A	129.1W/ 158.1W	81.7%	33Â°C/ 37Â°C
	3.32V	4.96V	12.23V			
CL2	0A	0A	46A	563.3W/ 630.5W	89.3%	42Â°C/ 45Â°C
	3.34V	4.99V	12.14V			

The test results are best shown on CRO screen shots below. Vertically, the CRO screen resolution is 55mV/div, so all three major supply voltages have lass then 26mVpp of noise. You'll hardly get any better than this.



Excellent performance of Seasonic X560W power supply – see above.

HDMI Output and 4k Resulution

4K Ultra HD Support

4K resolution is the next technological milestone in high-definition content delivery, utilizing approximately 4,000 pixels on the horizontal axis, more than four times today's standard HD pixel density. GIGABYTE motherboards provide native 4K support with integrated Intel® HD Graphics via HDMI.

HDMI™-The Next Generation Multimedia Interface

HDMI™ is a High-Definition Multimedia Interface which provides up to 5Gb/s video transmitting bandwidth and 8-channel high quality audio all through a single cable. Able to transmit superior, uncompressed digital video and audio, HDMI™ ensures the crispest rendering of digital content up to 1080p without the quality losses associated with analog interfaces and their digital-to-analog conversion. In addition, HDMI™ is compatible with HDCP (High-bandwidth Digital Content Protection), allowing the playback of Blu-ray/HD DVD and other protected media content.

Case

DEFINE R4 Arctic White - Window

The Fractal Design Define R4 is the midi tower in the Define Series of computer cases offering minimalistic and stunning Scandinavian design fused with maximum sound reduction, configurability and functionality.

Now featuring the option to have your Define R4 case with a large fully transparent window allowing you to display your setup in style.

The acrylic window side panel features the same clean, Scandinavian design as the case itself, and has a completely flat outer surface without any plastic bezel or rivets.

Key features

- High density noise-reducing material lining acrylic window
- Patent pending ModuVent™ design allowing the user to choose between optimal silence or maximum airflow
- Top HDD cage (5 trays total) can be rotated 90 degrees or removed for additional airflow or to accommodate long graphic cards up to 430mm in length
- Three-speed fan controller is strategically integrated in the front panel and supports up to 3 fans
- Two Silent Series R2 fans included, featuring hydraulic bearings contributing to a longer life expectancy – Silent Series R2 retail fans will now come standard in all cases
- Wider case body that allows for improved cable routing behind the motherboard – now 26mm wide
- New tool-less front fan holder makes switching front fans a breeze
- Two SSDs can be mounted on the back of the motherboard plate in addition to the 8 slots in the HDD trays, for a total of 10 SSD positions available

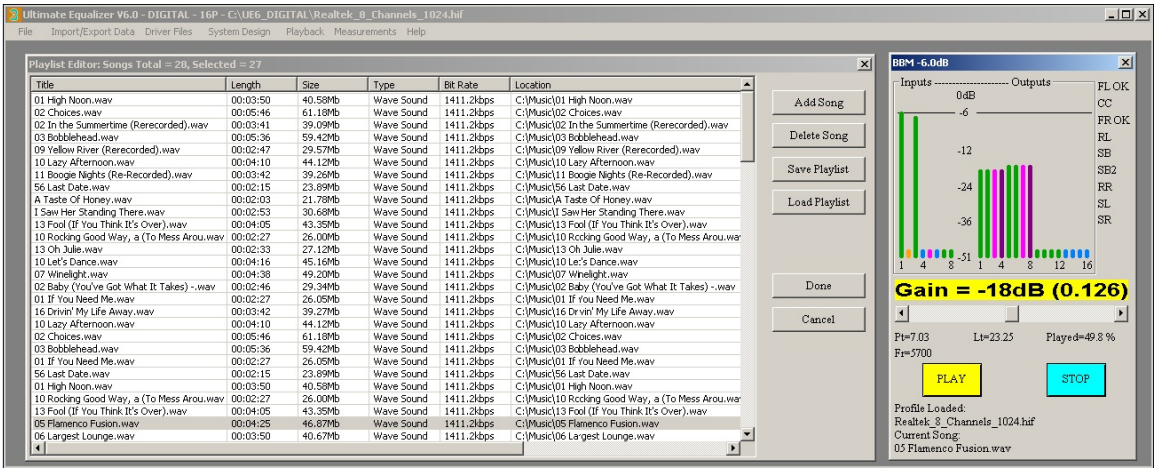
Hard Drives

There are two HD mounted in the case. One is a 256Gb SSD, on which the operating system and server software will be located, and the other is 2Tb hard disc for storing all audio and future video data.

Audio Server Functionality

It is best to explain right from the start, that we are seeking something much more elaborate than just a traditional “playback” device for a server. Our server will also offer unprecedented loudspeaker management functionality. Benefits provided by the UE Technology come at normal listening levels, and are therefore quite audible.

1. WAV Player



The built-in “WAV Player” allows you to acquire standard 16-bit/44.1kHz CD-quality sound files from your hard disk, and play them back on a 24-bit/44.1kHz audio device provided by the Realtek ALC1150 codec.

Consequently, a correctly set-up motherboard Realtek codec device should provide a playback device, capable of 24bit/44.1kHz playback of 8 output channels. It is not necessary to set up motherboard input recording device, since it will not be used by the WAV Player. The “.WAV” file is read directly from the hard disk and after UE processing, it’s send to the motherboard output device – which on a typical Windows 7/8/8.1 computer can be set to 24bit depth. It is worth noticing, that such computer is also capable of running audio engine in WASAPI Exclusive Mode, which is also used by UE6.

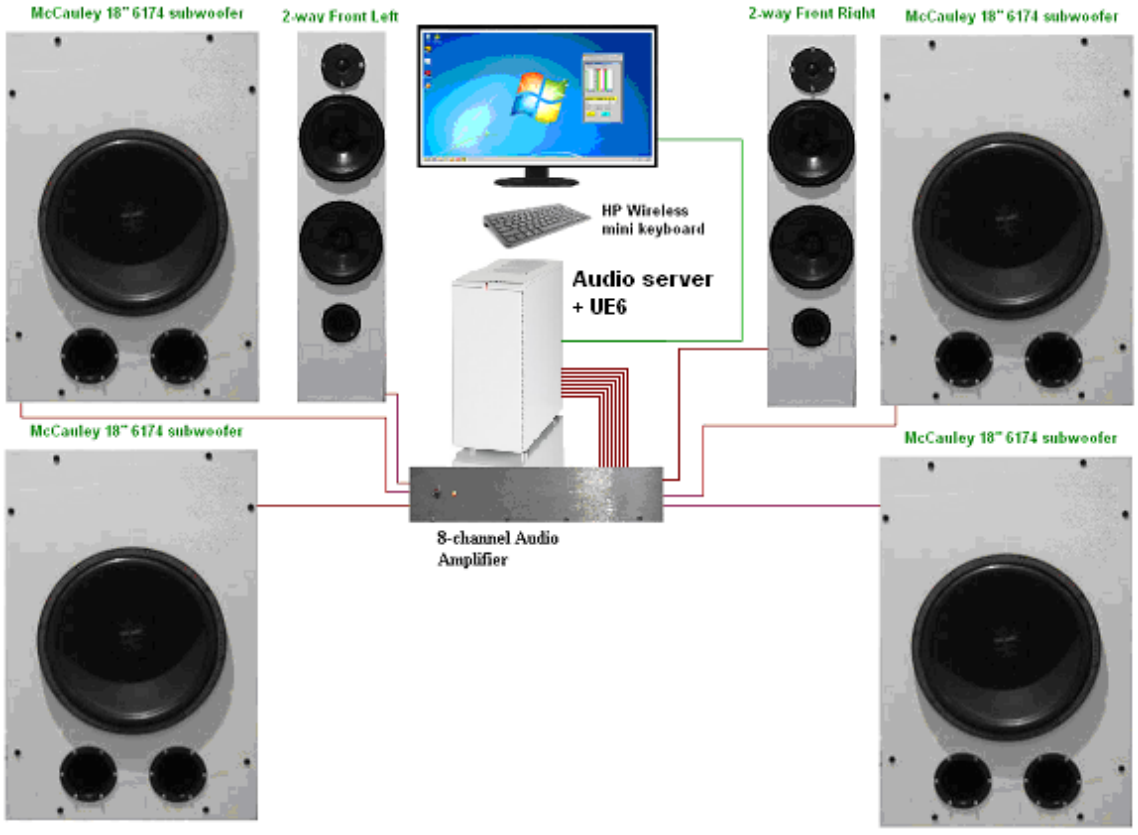
Simple instructions for using WAV Player are provided in
http://www.bodziosoftware.com.au/UE6_Manual.pdf and will not be repeated here.

2. Loudspeaker Management System

There are significant and audible benefits provided by the Ultimate Equalizer V6.

These are:

1. HBT equalization of individual drivers (flat SPL and corresponding smooth phase).
2. Linear phase (perfect time domain performance and localization accuracy, better bass).
3. RoomEQ (removal of the most obnoxious room modes)
4. BBM for enhanced spatial bass performance.
5. CABS for active room mode suppression.
7. Multi-way crossover.
8. Rich array of DSP functions for exceptional voicing abilities.
9. Converting stereo to 4.4 system (QUADRO with CABS) for additional "spatial effects".



CABS system is explained in
http://vbn.aau.dk/files/62729248/LF_sound_field_control.pdf and implementation in http://www.bodziosoftware.com.au/UE6_Manual.pdf and will not be duplicated here.

Loudspeakers construction is described in the following publications:

1. Left and right loudspeakers

http://www.bodziosoftware.com.au/Front%20Loudspeaker.pdf
http://www.bodziosoftware.com.au/Front_Loudspeaker_Measurements.pdf

2. Subwoofers

http://www.bodziosoftware.com.au/LP_MP_Subwoofer_Tests.pdf
http://www.bodziosoftware.com.au/Subwoofer_Design.pdf

Amplifier construction and alternatives are described in the following publications:
http://www.bodziosoftware.com.au/Power_Amplifiers.pdf
http://www.bodziosoftware.com.au/10_Channel_PA_Construction.pdf
http://www.bodziosoftware.com.au/Home_Theatre_Alternatives.pdf

Current and Future Expansions

1. All-digital Audio Server

http://www.bodziosoftware.com.au/AES_EBU_24Bit_96kHz_System.pdf

This system has also been tested with Windows7/64bit, Windows 7 Media Player, the Gigabyte GA-Z97X-UD5H motherboard and LynxAES16e (PCIe) sound card, in 96kHz/24bit configuration.

2. Hybrid 5.2 HT System

http://www.bodziosoftware.com.au/Hybrid%20AES_EBU_Analogue_System.pdf
http://www.bodziosoftware.com.au/AES_EBU_Amplifier_Construction.pdf

This system has also been tested with Windows7/64bit, Delta1010LT, the Gigabyte GA-Z97X-UD5H motherboard and LynxAES16e (PCIe) sound card, in 48kHz/24bit configuration.

3. Evolution

http://www.bodziosoftware.com.au/AES_EBU_System_Evolution.pdf

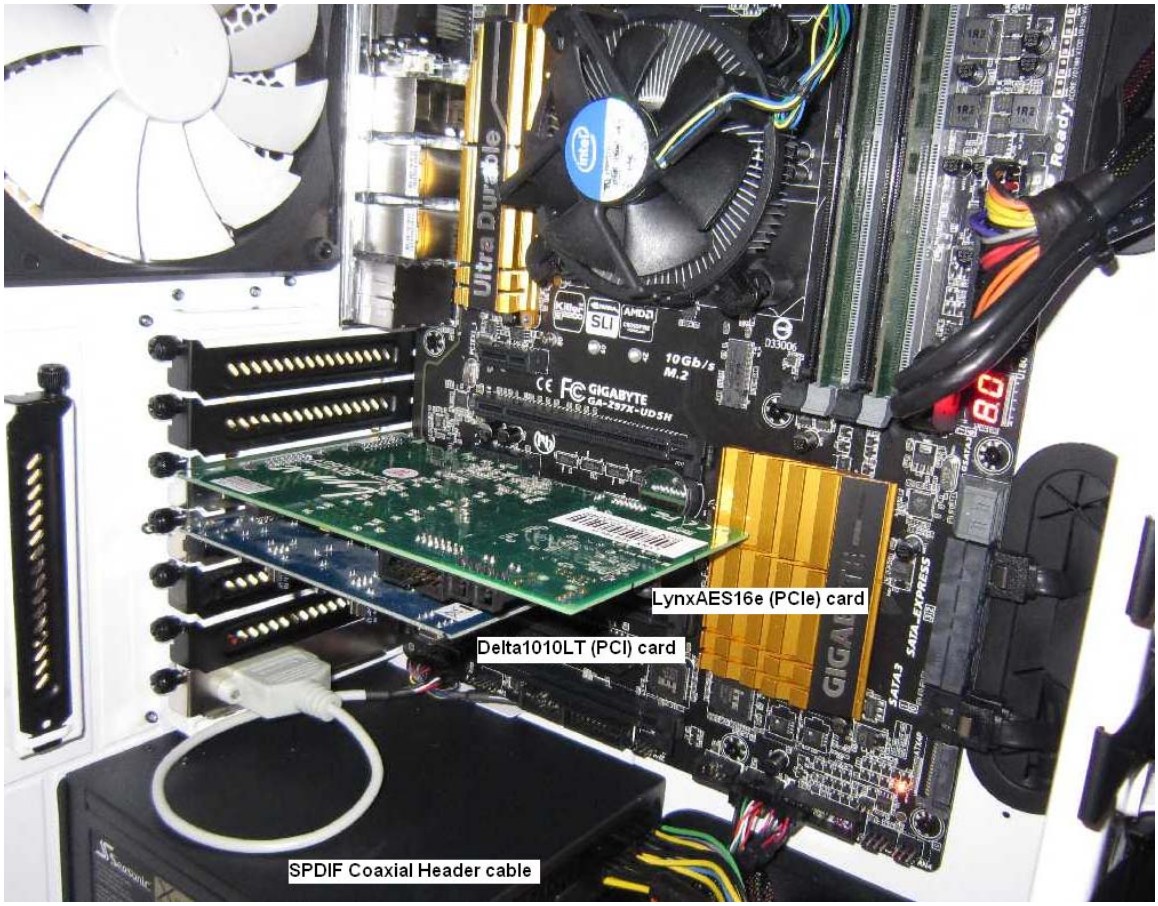
4. Ultimate All-Digital 7.4 HT System

It is planned to replace Delta1010LT sound card in the 7.2 Hybrid HT system described in the last page of (3), with the second LynxAES16e sound card and using PowerDVD software with the built-in BlueRay DVD tray for the media Player.

This system has not been tested yet.

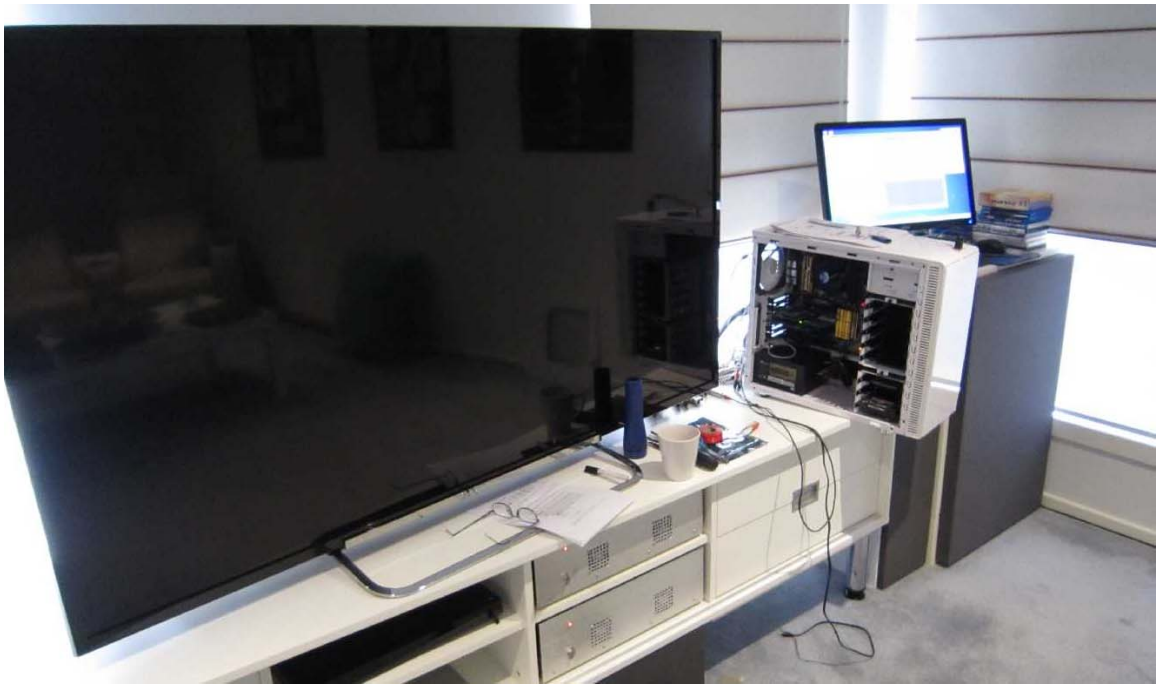
Photo Gallery

Picture below shows the Gigabyte GA-Z97X-UD5H motherboard, LynxAES16e and Delta1010LT sound cards. Also the SPDIF cable is plugged in the motherboard and secured to the back plane.



Testing UE6 with LynxAES16e card.

Installing cards and connecting the system cables.



Conclusions

Given, that all DSP processing is performed by the computer, we need to establish a couple of definitions:

1. **"Analogue"** system here is defined as the system, in which the computer acquires the input via A/D converter (typically a sound card, or motherboard audio codec) and after DSP processing, outputs the resulting signal via D/A converter – again, typically a sound card or codec. A system such as this, has been described in this paper, and another good example of such system is described in:
   http://www.bodziosoftware.com.au/Home_Theatre_Conclusions.pdf

2. **"Hybrid"** system in which the computer acquires the input via A/D converter (typically a sound card) and after DSP processing, outputs the resulting signal via digital sound card. Therefore, the signal remains "digital" right up to the remote loudspeaker amplifier. An example of such system is described in:
   http://www.bodziosoftware.com.au/Hybrid%20AES_EBU_Analogue_System.pdf

3. **"Digital"** system in which the computer acquires the input directly from the digital music file via media player, or from digital music source via SPDIF link, and after DSP processing, outputs the resulting signal via digital sound card. Therefore, the signal remains "digital" right up to the remote loudspeaker amplifier. A good example of such system is described in:
   http://www.bodziosoftware.com.au/AES_EBU_24Bit_96kHz_System.pdf

The basic ***analogue audio server*** system described in this paper offers an impressive 115dB SNR. It also offers a state-of-the-art loudspeaker management system, which allows you to extract maximum performance from your loudspeakers and your room acoustics.

System configuration has been explained on page 12, and it is the most acoustically advanced version, that can be accomplished with the 8 outputs offered by the Realtec ALXC1150 codec.

The SPDIF header connector has been installed already in anticipation of future expansion into digital system explained in (3) above.

Lastly, but importantly, the progression paths have been explained on page 13, and I am currently running 5.2HT system on Windows7/64bit, Delta1010LT, the Gigabyte GA-Z97X-UD5H motherboard and LynxAES16e (PCIe with driver 21) sound card, in 48kHz/24bit configuration.

Thank you for reading.

Bohdan