

# Realiser A16 – Additional Technical Information

**1 August 2016**

## **A16 Head Tracking**

Like the A8 the Realiser A16 uses an accurate 200Hz low latency head tracking unit to de-rotate the virtual loudspeakers in the presence of listener head movement. However the A16 head tracker is significantly improved over the previous generation. First its core is built around a 3-axis gyroscope and 3-axis accelerometer (known as an Inertial Measurement Unit or IMU) giving it the ability to simultaneously track heading, pitch and roll. Second it incorporates a 3-axis magnetic stabilisation circuit as well as the single axis optical measurement feature of the first generation system. This gives the listener three ways in which to use the new head tracker.

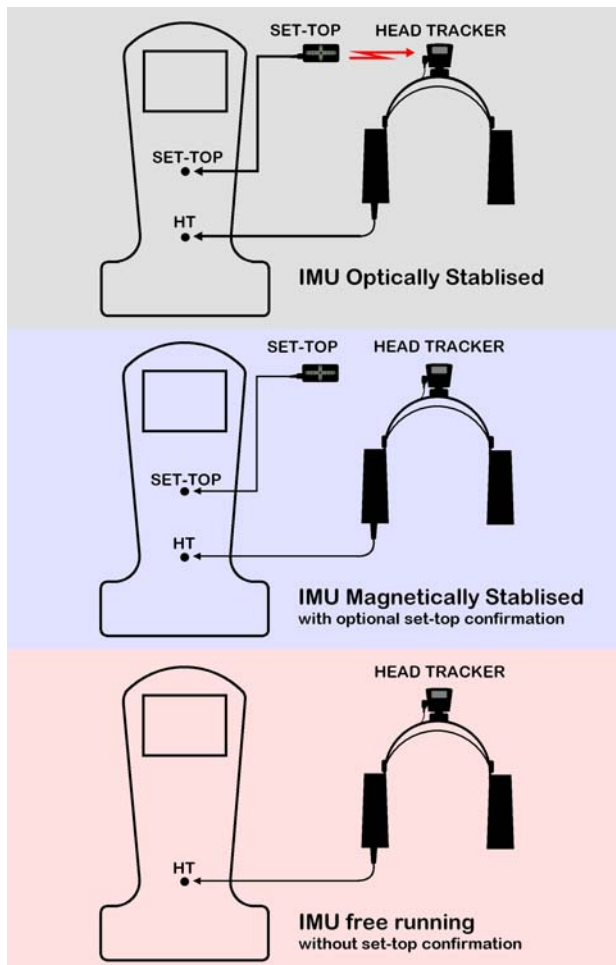
- 1) IMU only operation. In this mode the head tracker operates entirely on its own. The listener first resets the head tracker direction reference while looking centre. The IMU is stabilised using only the accelerometer meaning that the tracker heading can slowly drift over time. However we incorporate an exponential leakage algorithm that can largely mitigate this effect for normal listening situations. This mode of operation is recommended for casual listening situations or for live applications where slight drift is acceptable.
- 2) IMU combined with magnetic stabilisation. In this mode the head tracker operates entirely on its own and a magnetic heading is used to recalibrate the IMU heading thereby cancelling any tracker drift. Since the earth's magnetic field around the tracker depends on the type of headphone and the electromagnetic environment that surrounds the listener, the magnetometer must be calibrated using a very simple procedure with the head tracker mounted on the headphone and in the listening environment. This mode of operation is recommended for more critical listening situations.
- 3) IMU combined with optical stabilisation. In this mode the listener must use the supplied SVS set-top to provide the optical looking-centre reference, usually located on the TV set or monitor. As with the magnetic stabilisation, the idea is for the optical reference to recalibrate the IMU thereby cancelling drift. Although this mode seems similar to the first generation head tracker the new head tracker will continue to function even when the optical path is interrupted. The superb tracking accuracy and repeatability of the optical stabilised mode is particularly useful when undertaking PRIR measurements but can also be used for general listening.

In the IMU only (1) and IMU with magnetic stabilisation (2) modes the user has the option to connect the supplied SVS set-top unit to display the heading and pitch output from the tracker.

## Mounting the Head Tracker to the Headphone

The SVS head tracker unit is connected to the listeners headphone via a universal bracket that is itself strapped around the head band using a custom designed rubber strap. The rubber strap is supplied in three different lengths to accommodate different headphone designs.

A light weight head tracker cable will be supplied with the A16 system. Typically the user will run this wire alongside the headphone signal cable using retainer clips supplied with the cable. We plan to manufacture the head tracker cable in various lengths to accommodate different headphones. Supporters will be able to choose the length following completion of the campaign.





### **Controlling the Realiser A16**

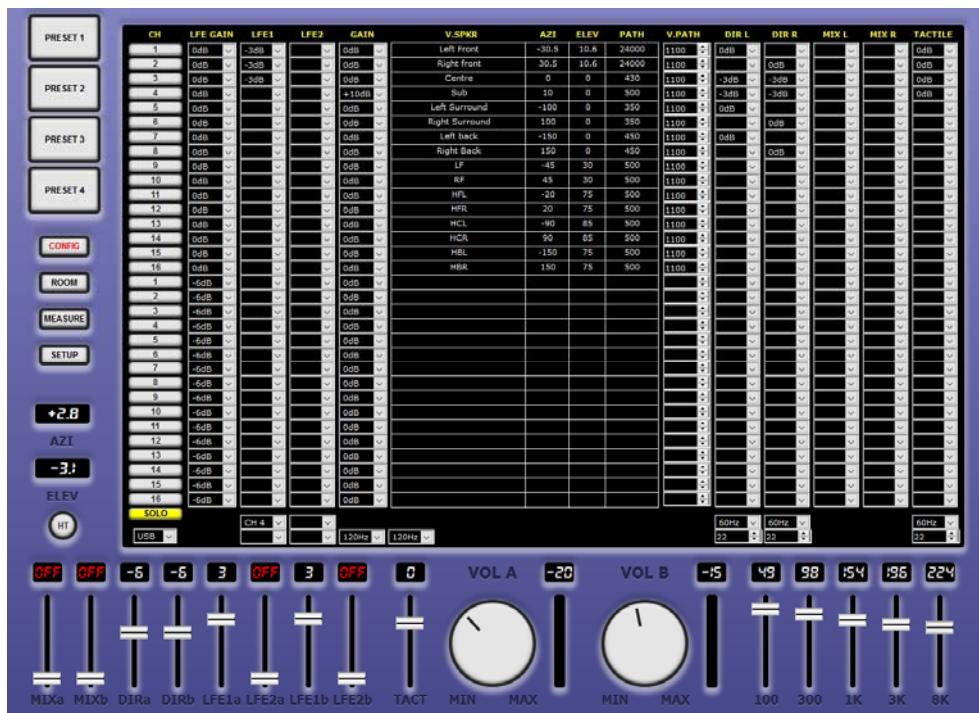
The A16 can be operated in three different ways.

- 1) Using the front panel controls the listener can alter the volume, select one of four virtual room presets and sequentially solo the virtual loudspeakers in that preset. Unless the listener wishes to reconfigure these presets this is the only control the user really needs for day to day usage.
- 2) Using the supplied remote control the user can also control volume and select presets but also control every single internal operation of the A16 including making PRIR measurements, reading and writing PRIR files via the micro SD card interface and general preset configuration.
- 3) Connecting the A16 network port to your home network and accessing the A16 internal web server using a browser running on your computer, tablet or phone. The A16 web server generates dynamic web content that simulates a graphical user interface normally found in a dedicated app. The benefit of using a web server rather than an app is that the same dynamic web page control system is compatible with Windows, Apple, Linux and Android operating systems found in a wide range of appliances. Like the remote control, a web browser can control every aspect of the A16. In addition it is also possible to upload and download PRIR and firmware files via the network connection.

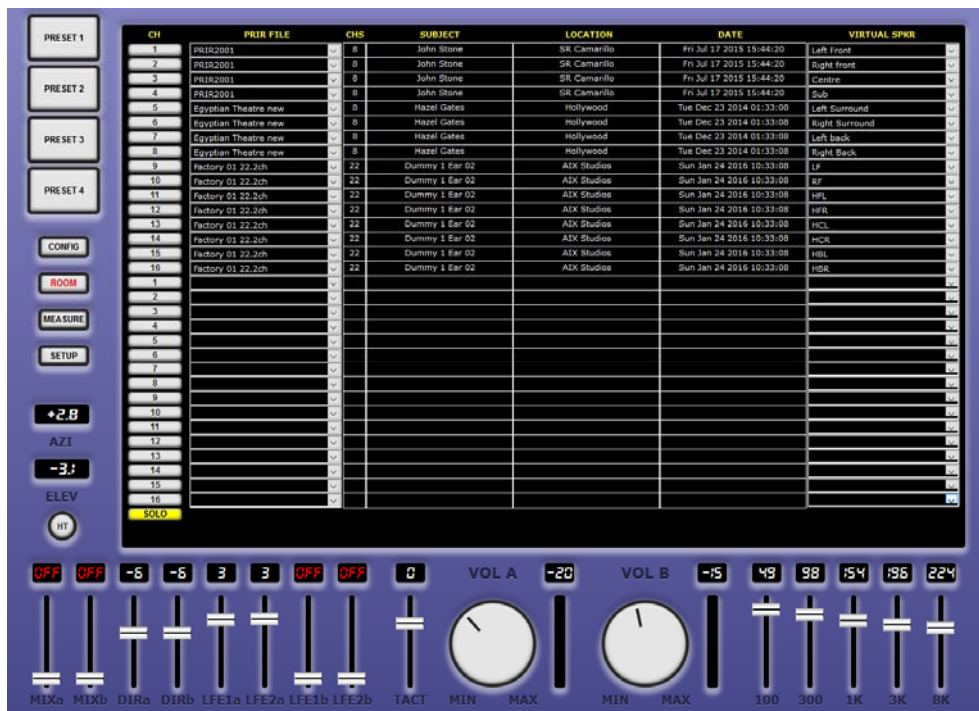


This screen shot shows an example of the general playback user interface for dual listeners. The normal audio controls are set along the bottom of the frame while menu navigation appears down the left side frame. Sliders are dual function in that the slider track also serves as a volume level meter for that signal. The group of five faders on the bottom right are a new feature to the Realiser. These sliders allow the listener to alter the reverberation characteristics of the virtual room in the frequency domain, much like a 5 band graphic equalizer except it is decay time that is altered rather than gain. This feature has the ability to dramatically improve the quality of any mediocre sound room particularly in the low frequency regions.

In the pane itself the listener can solo the loudspeakers, confirm audio levels on the inputs and have the virtual loudspeaker layout of the selected preset rendered using a 3D room and speaker graphical simulator.



This screen shot shows input selection, audio routing, bass management, direct bass redirection and down mix for both listeners for the selected preset. A8 owners will be familiar with many of these functions, but just not seeing them on one screen. Unlike the A8, the input selection and speaker assignments now form part of the preset configuration.



This screen shot shows the virtual room speaker set up menu for the selected preset. Each of the inputs can be assigned any virtual speaker from any PRIR file the user has stored in the A16, on the micro SD card, or, if connected to the internet, any PRIR or BRIR file the user has in their account in our Realiser Exchange website. This is a major improvement from the A8 which could only load entire PRIR files to presets.

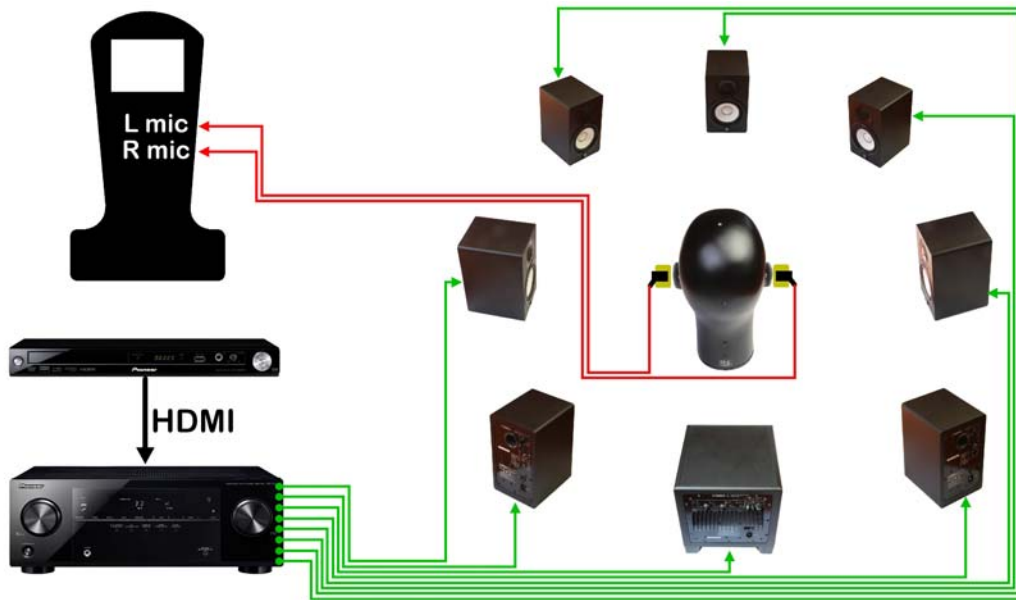
Other screens for general configuration, file handling, making measurements, headphone equalisation, parametric equalisation, hybrid operation and AV only routing modes are not shown.

### **Personalisation(PRIR) Measurement using the Realiser A16**

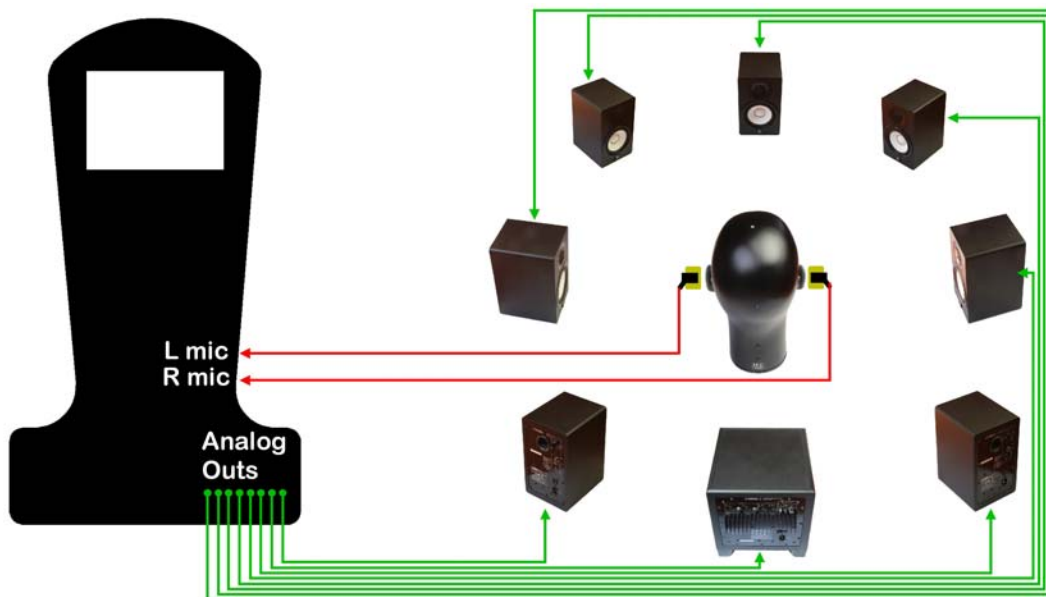
Where the owner wishes to recreate their own stereo hi-fi or home theatre system (or perhaps that of a friends) over their headphones then it is necessary to undertake a personalisation, or PRIR, measurement of that sound system. The most straight forward way of doing this is to use the supplied Blu-ray test disc to generate the appropriate sweeps. The procedure is as follows.

- 1) Turn on the sound system and select the Blu-ray player as the source. Place the test disc into the player and select the appropriate track that matches the sound system you are measuring, ie 2ch, 5.1ch, 7.1ch, 7.1.4ch etc.
- 2) Insert the supplied in-ear microphones in each ear and plug them into the front of the A16.
- 3) Configure the A16 measurement menu to use the test disc and trigger the mode. The A16 will now wait for the disc to play.
- 4) Sit in the sweet spot of the sound system.
- 5) Play the Blu-ray track and turn you head to generate the look angles as prompted by the disc.

The entire measurement takes just a few minutes to complete and can easily be conducted without third party assistance. Measuring a 7.1ch sound system using the test disc is illustrated below. A DVD test disc will be available for measuring up to 7.1ch speaker system. A Blu-ray disc will be available to measure sound rooms up to 9.1.6ch.

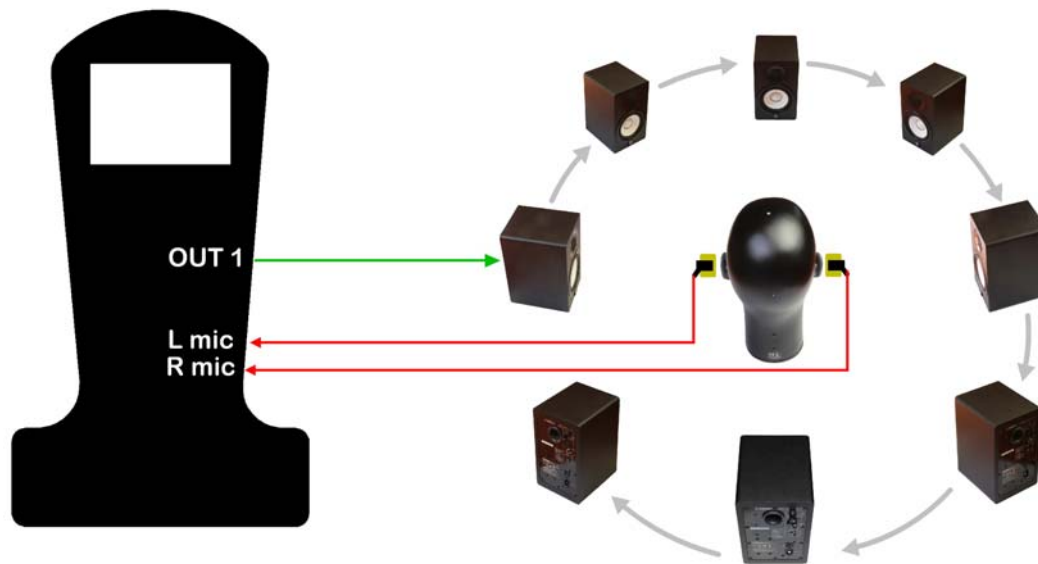


A sound system can also be measured by generating the test signals from the Realiser itself, perhaps where a DVD/Blu-ray player is not part of the audio chain, as illustrated below. In this case the line outputs of the Realiser must be connected directly to the amplifier inputs or to the pre-amplifier inputs of an AV receiver. This measurement method is faster than previous test disc method since the Realiser does not spend time synchronising to the Blu-ray signals and so is the preferred method where a lot of measurements need to be made in quick succession. Using the Realiser A16 to generate the test signals in this way allows up to 16 loudspeakers to be measured at a time.



Another measurement technique that became popular with the A8 is known as the one speaker method as illustrated below. In this case the owner is using just a single speaker to build up a multi-speaker measurement. The idea is that you place the loudspeaker in the desired location in the

sound room, say left front, and then you make a measurement of just that speaker with the subject sitting in the sweet spot. Then you move the speaker to the next position, say right front, return to the sweet spot, and make a new measurement, and continue moving the speaker and repeating the measurements until all the desired positions have been captured. In the illustration below 8 speaker positions are measured running clockwise from Left Surround all the way round to Left Back using the same physical loudspeaker. Since the number of positions the loudspeaker can take is essentially unlimited, the one method can build virtual sound rooms from stereo to 22.2ch and beyond.



### A16 Headphone Equalisation Procedures

A personalisation measurement actually consists of two parts. First is the PRIR measurement (loudspeakers measured in a sound room) while the second part measures how the headphones deviate from flat when placed on the head and driving into the ears of the listener. The A16 uses this 'unflatness' information to generate a headphone equalisation filter (we call this HPEQ) that then flattens the binaural signals just before they are output to the headphones. The HPEQ measurement is a very simple procedure and does not require any equipment other than the listeners own headphones and is conducted as follows.

- 1) Place the supplied in-ear microphones in each ear and plug these into the Realiser.
- 2) Place your headphones on your head without dislodging the microphones.
- 3) Plug the headphones into the User-A headphone output.
- 4) Activate the HPEQ measurement in the menu.

The entire HPEQ measurements takes about 20 seconds to complete and this HPEQ measurement file would typically be loaded into the system each time you use those same headphones with the A16.



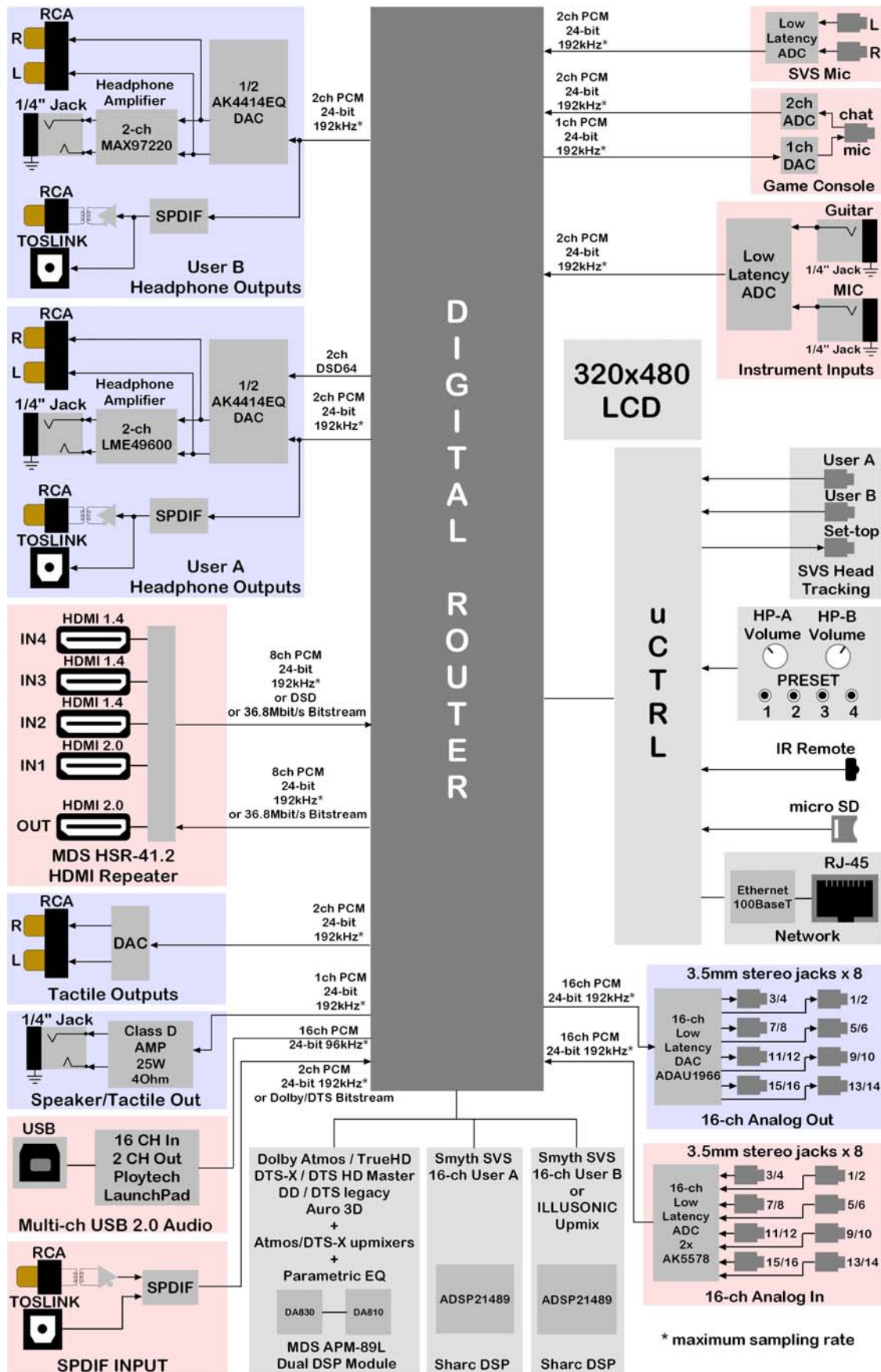
The A16 expands on the HPEQ procedures that were available on the A8. We have introduced a low latency procedure to be used for the low latency gaming and live applications. We have added a second HPEQ filter option that uses a causal filter structure that has the potential to generate a cleaner headphone impulse response than our traditional symmetrical FIR approach. Finally we have increased the sub-band resolution of the manual HPEQ method and made the procedure less clunky. We also have a third parametric HPEQ option in development to be released in firmware updates following the initial launch of the product.

### **Electronic Design of the Realiser A16**

A block schematic diagram of the electronic and signal processing sub-functions are illustrated below. This description supersedes all previous diagrams issued prior to this campaign. The design is built around a centralised digital router that allows any block to be digitally connected to any other block. For example, if the user wishes to input a Dolby Digital bit stream via the optical SPDIF input and listen to a 5.1ch movie sound track over a virtual sound room, the Toslink SPDIF input signal (bottom left) would be routed through to the MDS APM-89L decoding board whose 5.1ch PCM outputs would then be routed to the Smyth SVS User A DSP whose binaural PCM outputs would then be routed to the User A headphone output block and converted to analog using the AK4414EQ DAC. Input signal blocks are generally pink and output signal blocks blue, although some blocks (HDMI, USB) do both. Some processing blocks are multi-purpose and so limit the combinations that are possible. For example the Illusonic up-mixer runs on the User B SVS DSP, hence for applications that use this up-mixer, dual user SVS virtualisation is not possible.

#### **Analog Line I/O**

The A16 incorporates 16 low-latency analog input and output channels (bottom right). Due to space restrictions these signals are handled via stacked stereo 3.5mm jack sockets. These blocks use very



high quality ADC and DAC units resulting in a noise floor around -118dB below peak. See the specification table for more information. These analog inputs are typically used for live instrument applications or for general experimentation (Ambisonics) or where the source signals have been decoded elsewhere. The analog outputs are most often used for PRIR measurements and for AV and Hybrid routing modes discussed herein.

#### Multi-channel USB 2.0

A 16 channel in and 2 channel out USB interface is implemented using a PloyTech GmbH Launchpad chip set. This implementation is limited to a maximum sampling rate of 96kHz and 24-bit PCM and follows the multi-channel audio USB 2.0 standard. See the specification table for more information. Windows and OS drivers are supplied covering native operational modes as well as ASIO. All USB PCM clocking is sourced from the A16 internal low jitter oscillator, ie the host computer slaves to the A16. Hence where the sample rate in the computer matches the sample rate in the A16 the raw PCM data is losslessly delivered to the A16 processors without intervention from the host operating system.

#### HDMI I/O

The A16 incorporates a Momentum Data Systems HSR-41.2 HDMI repeater module configured with 4 inputs and a single output. All inputs support HDMI 1.4a while the first input also supports HDMI 2.0 and HDCP 2.2 authentication, as is required for many 4K services and Ultra HD Blu-ray players. See the specification table for more information.

The primary purpose of the repeater is to strip out the audio data from the incoming HDMI signal for processing within the A16, but pass the video back to the output. Another purpose is to insert test sweeps into the HDMI signal passing to the output where the user wishes to make a PRIR measurement of a downstream audio system. Still another purpose is to simultaneously strip out the incoming audio for internal processing and also to insert audio back into the HDMI output as is the case for the A16 AV Only and Hybrid routing modes of operation.

The A16 can receive and decode PCM (8-ch 192kHz 24-bit), DSD (64xFs) and all DTS, Dolby and Auro bit streams over this HDMI repeater. It cannot decode other audio bit streams such as AAC, MP3, MPEG, FLAC, etc. When a compatible bit stream is encountered it is routed to the Momentum Data Systems APM-89L DSP module for decoding.

#### SPDIF Input

DTS and Dolby bit streams as well as 2ch 24-bit 192kHz PCM can be input via either RCA co-axial or Toslink optical inputs. Where the incoming sample rate matches the internal A16 sample rate the PCM can either be re clocked or passed through a sample rate convertor for jitter removal.

#### Microphone Input

Suitable for dynamic (typical professional vocal) or electret microphones (typical gaming or computer microphone). The microphone signal can simultaneously be mixed directly into the headphone output, fed to the SVS virtualisation engine, fed to the game console jack and fed to any analog line output.

## Guitar Input

High Impedance input suitable for any electric guitar. The guitar signal can simultaneously be mixed directly into the headphone output, fed to the SVS virtualisation engine and fed to any analog line output.

## Game Console Jack

This connects directly to the PS3/PS4 controller or the XBOX ONE controller fitted with the XBOX Stereo headset adaptor. This allows the game chat signals to be fed to the SVS virtualisation engine and hence to the A16 headphone, and for the player's microphone signal to be sent back to game console.

## Dolby, DTS and Auro Decoding

All compatible audio bit streams, input either on the HDMI or SPDIF, are decoded using Momentum Data Systems APM-89L DSP module. This module uses two high power DSPs and implements the Dolby Atmos, DTS-X and Auro-3D suite of algorithms. Presently this module is limited to decoding up to 12 loudspeaker channels but this may be improved in future firmware updates. Formats higher than 12 channels are still decoded but only rendered to 12 loudspeakers. However the output of the APM-89L module can be passed to the Illusonic up-mixer DSP for rendering to the full 16 loudspeakers if desired.

The algorithm suite also implements the Dolby and DTS up-mixing routines so that legacy 5.1ch and 7.1ch bit streams can still be decoded and rendered to 7.1.4ch formats, for example. It is also possible to access both up-mixers directly via the APM-89L PCM inputs allowing PCM audio input via the analog, HDMI or USB to be up-mixed prior to virtualisation through the SVS engine as an alternative to using the Illusonic up-mixer.

The APM-89L also implements Dolby and DTS bass management and the MDS 32 bi-quad per channel parametric equaliser for all 16 channels. Again the PCM that passes through these blocks can be sourced from the decoders or from the APM-89L PCM inputs allowing PCM audio input via the analog, HDMI or USB to be EQ'd prior to virtualisation through the SVS engine.

## Tactile Output

Tactile signals are created within the SVS virtualisation DSPs. Their purpose is to drive tactile transducers (or shakers) in order to try to create the effect of body conducted bass not reproduced by headphones. Tactile transducers we have used for many years are those from Crowson Technology. Other transducer manufacturers include Buttkicker, Clark Synthesis and TADS.

The tactile signals are output both on stereo RCA connectors, for users that wish to use external amplification, and a mono version is fed to a 25 Watt (35 Watt peak into 40ohms) class D amplifier for direct connection to a transducer of your choice.

## Loudspeaker Output

When not being used to drive tactile transducers this output can be connected to a passive loudspeaker and used for one-speaker PRIR measurements. More information about using this procedure will be made available in due course.

## Headphone Outputs

The stereo headphone signals for both User A and B are output to four different interfaces simultaneously. Analog headphone signals are available as line outputs (2Vrms) on stereo RCA connectors and through a ¼" stereo jack via a headphone amplifier. Digital headphone PCM audio is available via SPDIF co-axial RCA socket and optical Toslink connectors.

The User A headphone amplifier is designed around the TI LME49600 audio buffer amplifier giving high drive levels where low efficiency headphone are in use. The User B headphone amplifier is designed around the Maxim MAX97220 headphone amplifier and is suitable for the vast majority of headphones. See the specification table for more information.

## Internal Clocking

Not shown in the diagram, the internal A16 clocking design is built around an ultra low jitter VCXO based PLL clock generation system. This gives the A16 increased flexibility (compared to the A8) when it comes to handling incoming audio clocks such as those from the HDMI, or SPDIF receivers. For example, the traditional method is to pass the PCM coming from the HDMI (or from the APM-89L decoder board) into a sample rate converter (SRC) before handing it over to the SVS virtualiser. In this way the SRC effectively removes the HDMI clock jitter. While the A16 can also use the SRCs in this way, it now also has the means to lock to the HDMI/SPDIF clocks and then re-clock the PCM audio using the internal low jitter VCXO clock. This allows the SRCs to be bypassed entirely when the internal and external sample rates match and in this case the operator will be given the option of SRC or re-clock in the A16 menu.

## A16 Modes of Operation

The Realiser A16 will operate in four distinct modes mirroring the intended application. Most of the specifications down the left column are self explanatory but some require a little elaboration.

INT FS is the highest internal sampling frequency for that mode - multiples of 44.1kHz or 32kHz will also work.

LATENCY is the time it takes for the signal to input the A16 and arrive at the ear.

LEGACY means all previous bit stream variants of Dolby and DTS can be decoded.

UP MIX means the input audio can be fed to the DTS and Dolby up-mixer functions built into the Atmos and DTS-X decoding suites.

SPDIF-CODEC means DTS and Dolby bit streams may be input via the SPDIF input.

INPUT EQ means audio may be routed to the MDS parametric equaliser prior to being sent to SVS.

GAME means the game chat audio can be input via, and the microphone signal fed to, the console jack.

IEM means the User B headphone output will become the output for an in-ear monitor (IEM) while the User A headphone output will generate the virtual concert hall sound.

		Realiser A16 Modes of operation												
		Movie			Music						Game		Live	
		Single User 48	Single User 96	Dual User	Single User 48	Single User 96	Single User 192**	Single User 48 -L **	Single User 48 -XL **	Dual User	Single User 48	Single User 48 upmix	Single User 48	Single User 48 **
Max Chs	16	16	16	16	16	4	16	8	16	16	16	16	8	
Int Fs	48k	96k	48k	48k	96k	192k	48k	48k	48k	48k	48k	48k	48k	
Reverb	0.75s	0.75s	0.75s	0.75s	0.75s	0.75s	2.75s	6.75s	0.75s	0.75s	0.75s	0.75s	2.75s	
Latency	32ms	16ms	32ms	32ms	16ms	8ms	32ms	32ms	32ms	3ms	32ms	3ms	3ms	
Atmos	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
DTS-X	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Auro-3D	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Legacy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
up mix	✓		✓	✓			✓	✓	✓	✓	✓	✓	✓	
illusonic	✓			✓							✓			
HDMI-PCM	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
HDMI-DSD						✓								
USB-PCM	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	
SPDIF-PCM	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
SPDIF-codec	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	
Line In	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Input EQ	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	
Game										✓	✓			
Instrument										✓	✓	✓	✓	
IEM												✓	✓	
Direct Bass	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
Bass Redir	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
Tactile Redir	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
5-band Rev	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
Vspkr Path	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

\*\* Planned Firmware Release Q4 2017

### Realiser A16 AV only mode

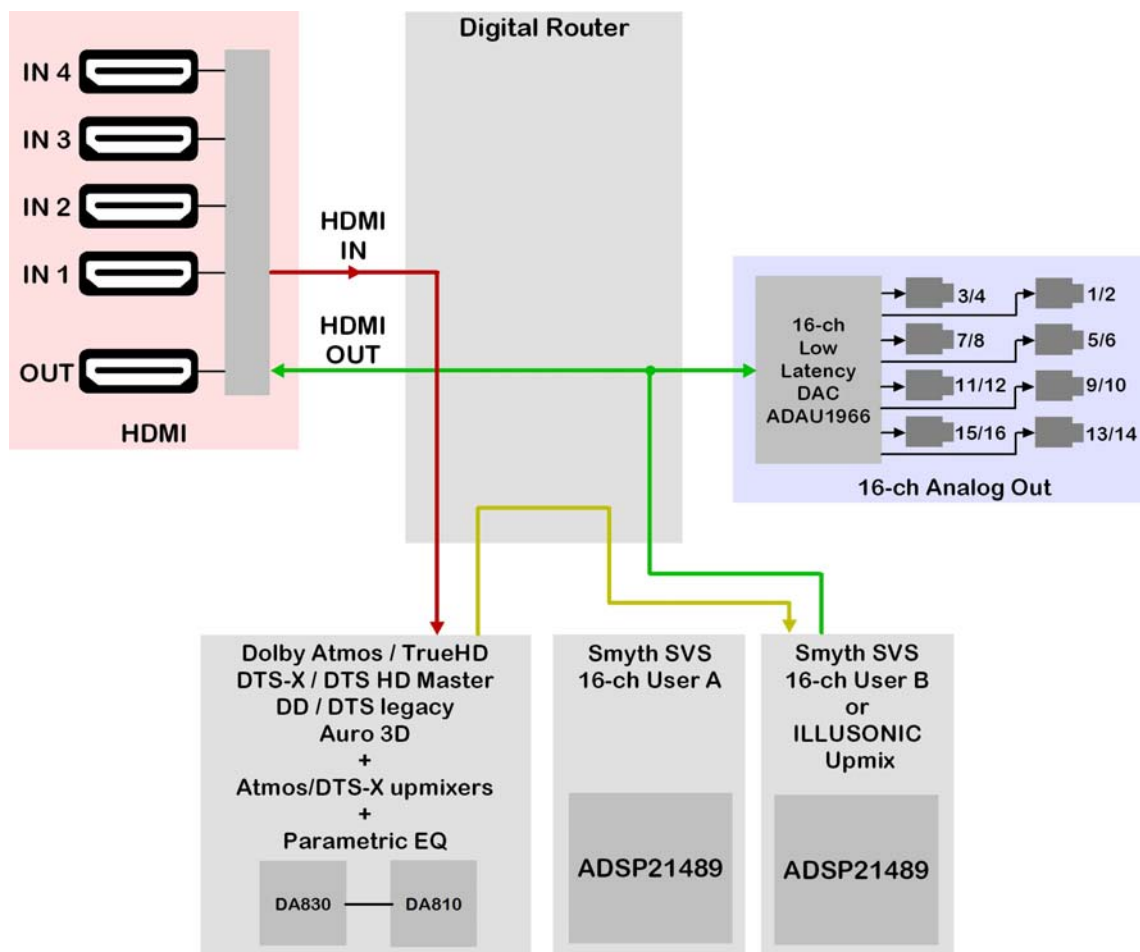
The AV only mode switches the purpose of the Realiser A16 from headphone processor to AV decoder. In this mode the user inputs a bit stream via HDMI or SPDIF for decoding in the APM-89L and then outputs the resulting PCM back out the HDMI or analog outputs. All of the APM-89L bass

management, up-mixing and parametric EQ functionality will be available to the user, as well as the Illusonic up-mixer.

The user also has the option to input PCM via the HDMI, USB or analog and to process this using the APM-89L bass management, up-mixing and parametric EQ functionality as well as the Illusonic up-mixer.

Another feature of the AV only mode is the ability to route the processed or decoded PCM audio channels to any HDMI and/or analog output channel. This is useful where the user wishes to output some of the channels to a downstream sound system over HDMI and some of the channels to the analog outputs.

The diagram below illustrates the typical AV only signal path where the PCM or bit stream is input via the HDMI interface.

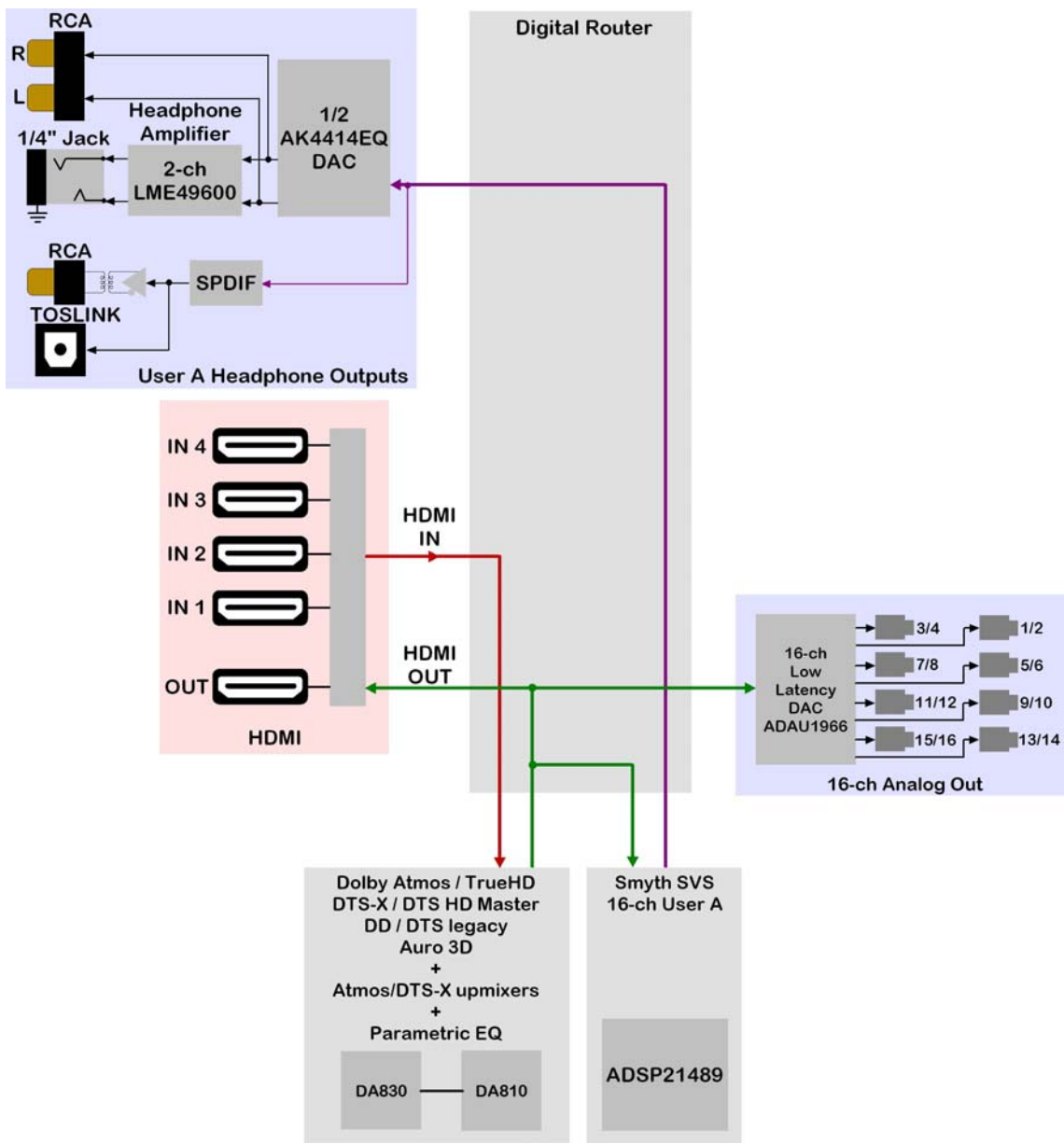


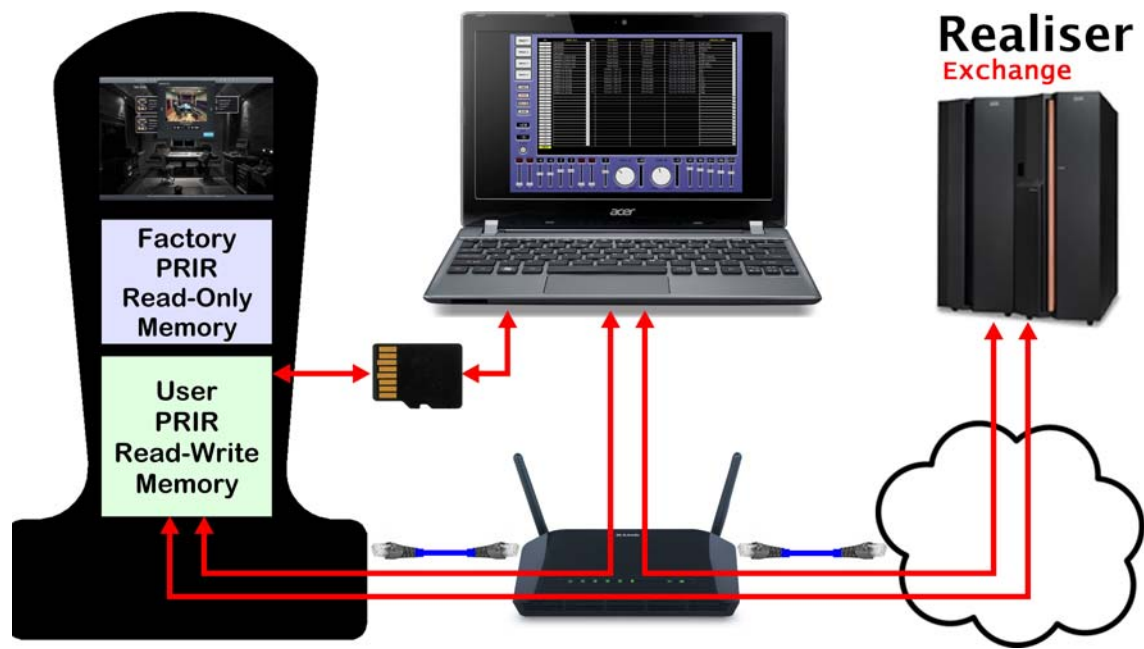
### Realiser A16 Hybrid SVS-AV mode

The Hybrid SVS-AV mode combines the AV only mode with the normal headphone processing mode. The purpose of this mode is to allow some channels to pass downstream to a TV or soundbar via the HDMI output and for other channels to be virtualised over headphones. This mode is useful where



the headphone listener needs to co-exist with others who are listening just to the TV or soundbar speakers

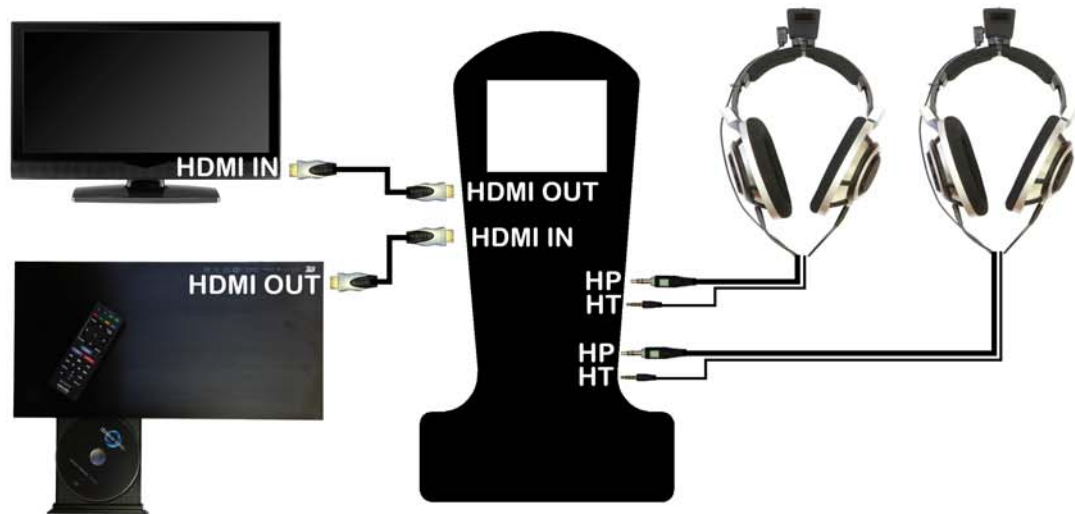




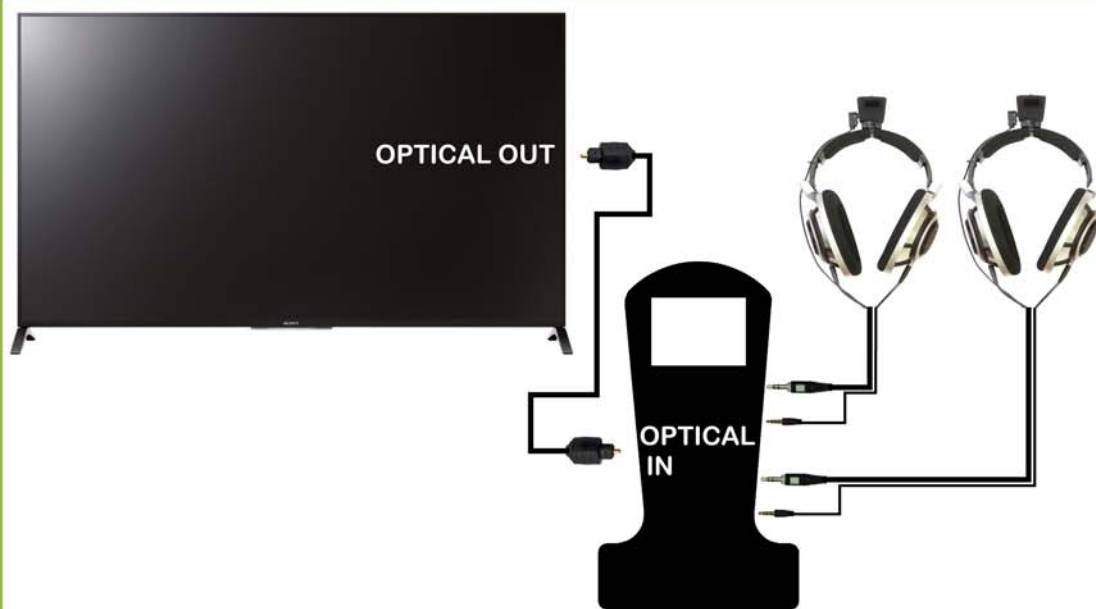
Options for reading and writing PRIR and HPEQ files

REALISER A16...

# excellent for UHD/Blu-ray



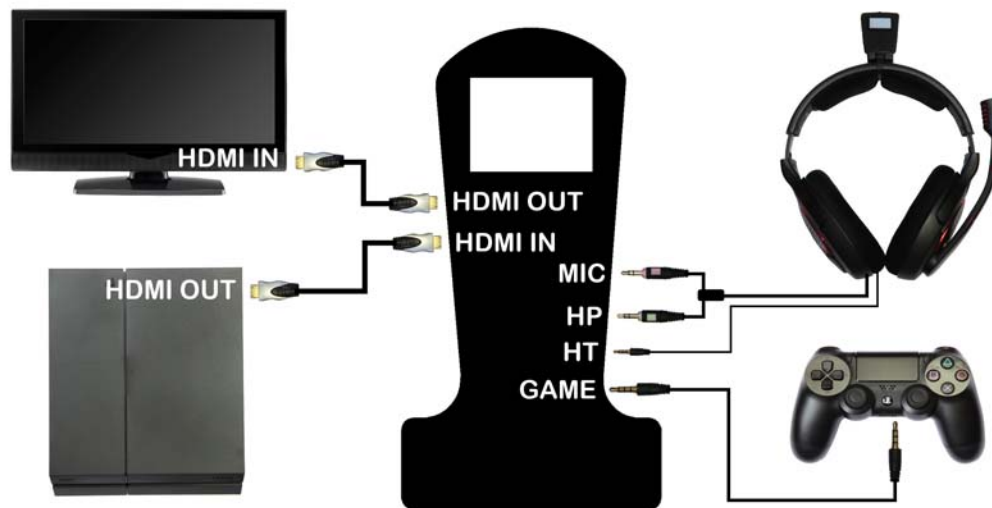
## & DTV / streaming movies



Dual listeners, independent head tracking, personalised movie theatre virtualisation and decoding for the latest immersive Dolby Atmos, DTS:X and Auro-3D cinematic formats built in, the Realiser A16 brings watching movies in the home to a new level.

**REALISER A16...**

# **essential gamer gear**



**Immersive 5.1ch, 7.1ch, 7.1.4ch sound for PS4, XBOX ONE gamers. Frighteningly realistic game sound, superb spatialisation, precise head tracking and low latency (3ms) all combine to make the A16 an ideal companion in tricky situations.**

REALISER A16...

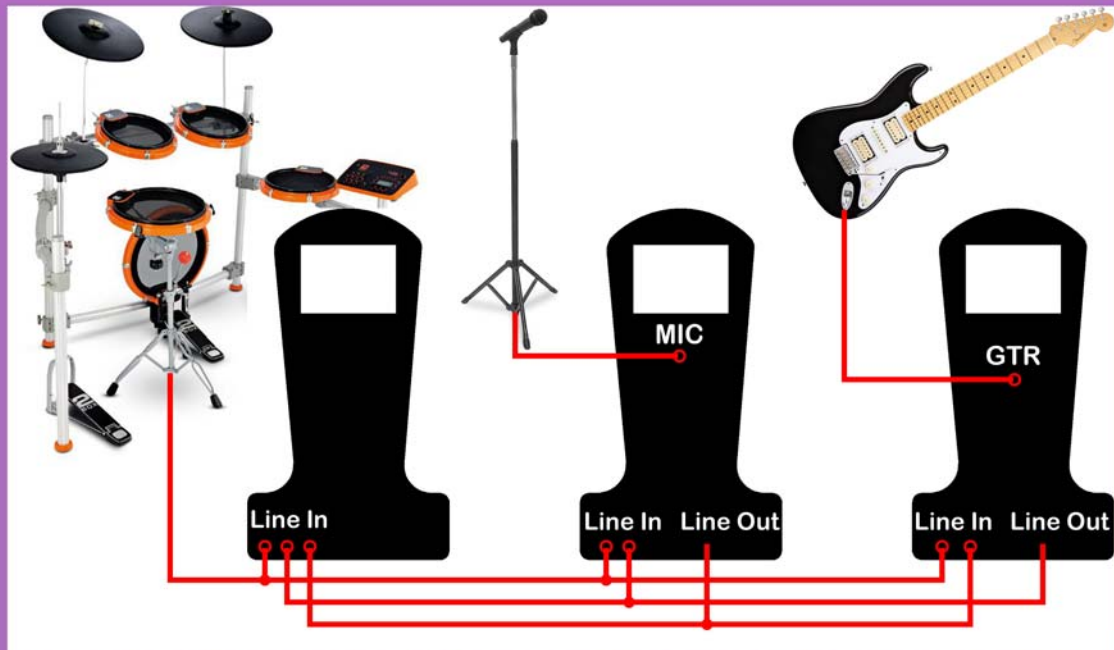
# audio workstation dream



Precisely emulates studios, auditoriums and dubbing stages with up to 16 loudspeakers (2.0ch, 5.1ch, 7.1ch, 7.1.4ch, 9.1.6ch etc). Ideal for Auro-3D, Dolby Atmos and DTS:X movie sound editing. Direct connection to Protools, Reaper etc using supplied ASIO driver.

REALISER A16...

# a revolution for musicians



Put on headphones and practice on a virtual stage in a real concert hall. Connect A16s together and have your entire band on the same stage. Dedicated guitar, mic inputs + 16 auxiliary ins & outs. Precise spatial emulation of halls up to 2.7s reverb. Latency 3ms. Also works with IEMs





