engineered ELECTRONICS

NMR

NETWORK AUDIO MEDIA RENDERER

OEM/EVALUATION BOARD DATASHEET

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NMR- DS
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Preface

I. About This Datasheet

This document provides the information needed to design and integrate the NMR Network audio Media Renderer into your product. For more information, please refer to the product description available from the engineered Web site at: www.engineered.ch

II. Company Information

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Routine maintenance is not required. This product is warranted to be free of any defect with respect to performance, quality, reliability and workmanship for a period of SIX (6) months from the date of shipment from engineered.

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VI. Documentation Release Notice

This document is under revision control and updates will only be issued as a replacement document with a new version number.

Product specifications are subject to change without notice.

1 Introduction

1.1 Highlights

The Network audio Media Renderer (NMR) is an easy-to-integrate OEM solution for high-end network audio playback systems. Key features for the NMR include:

- Digital Media Renderer
- UPnP AV 2.0 / DLNA
- Playing and decoding common audio formats* from HTTP streams
- 2-channel asynchronous endpoint for highest quality jitter-free stereo playback
- Bit-perfect data transmission
- Resolution up to 32-bit, sampling rate up to 384kHz
- Support for native DSD64 and DSD128
- On-board low-jitter oscillators
- External master clock input
- I2S and S/PDIF digital audio output
- Ethernet RJ45 interface
- Embedded 32-bit digital volume attenuator
- Support for gapless playback
- Hardware mode and SPI interface for enhanced features
- Based on Analog Device Blackfin BF537 DSP

(*) Subject to licensing by the final product manufacturer for the various audio decoders.

The NMR plays music from streams, from a file server or an Internet radio, acting as a UPnP AV/DLNA Media Renderer device. Common PCM (Pulse Code Modulation) audio formats are supported, including lossless FLAC at 192kHz 24-bit. One-bit DSD (Direct Stream Digital) is also supported via DSF and DFF files.

For the best digital audio quality, the audio stream is asynchronous, clocked by low-jitter on-board oscillators. Using this concept, the design benefits of a local high quality master clock to achieve jitter-free playback. External master clock synchronization is provided for enhanced flexibility and optimal clock distribution.

1.2 OEM Concept

The goal of the NMR project is to bring to the High End Audio market a high-tech, easy-to-integrate and affordable OEM product where small production volume is involved. Audio brands should find here a perfect solution for integrating modern connectivity to their product, with the highest possible digital sound quality, and keeping control over development and production cost.

The NMR concept is based on a powerful DSP, the heart of the system which runs the software. The DSP is integrated on a small high-density board, referenced MR-MOD, as shown in section “Functional Block Diagram” hereafter.

1.3 Functional Block Diagram

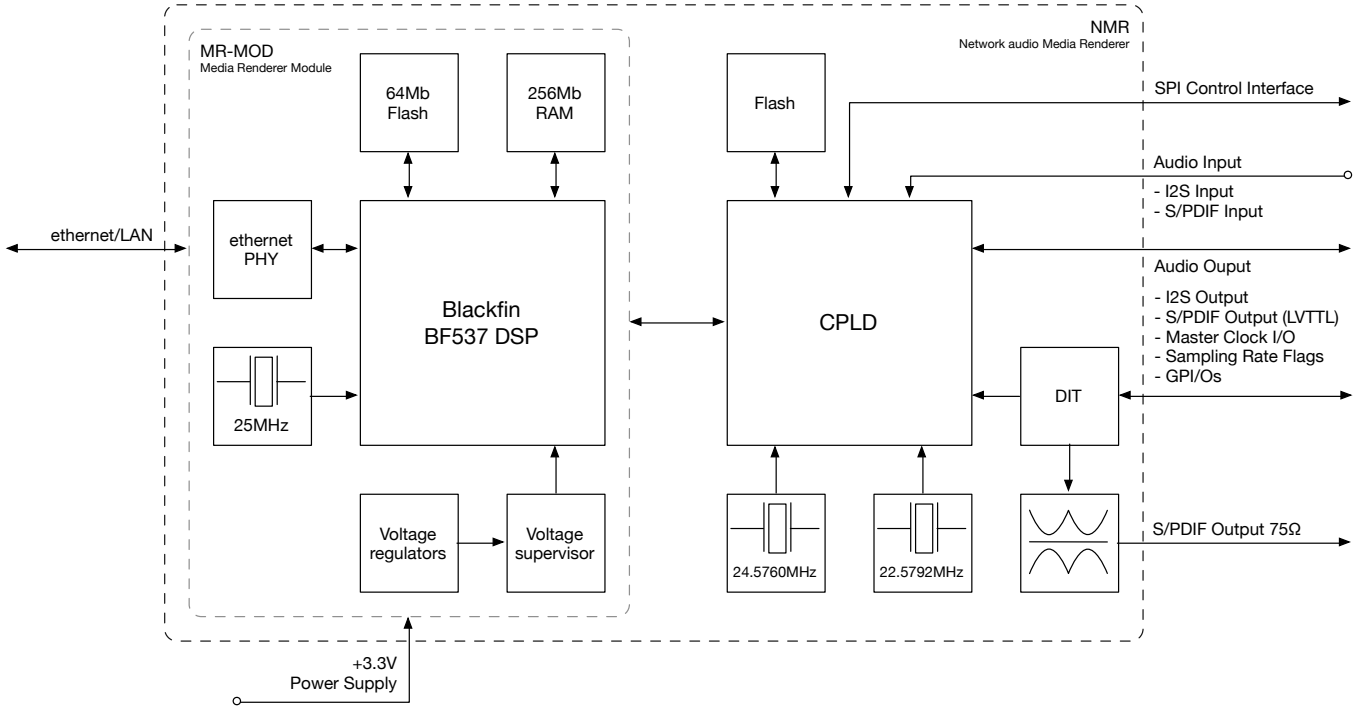

Figure 1-1 – NMR functional block diagram

The NMR board is mainly a backplane for the MR-MOD module with on-board clock management and facilitated connexions.

Audio inputs (I2S and S/PDIF), as well as GPI/Os are shown for reference only but aren't implemented in the standard version of the NMR board. These connexions are reserved for custom applications.

2 Characteristics and Specifications

2.1 Electrostatic Discharge Warning

Many of the components in this product are subject to be damaged by electrostatic discharge (ESD). Customers are advised to observe proper ESD precautions when unpacking and handling the board, including the use of a grounded wrist strap at an approved ESD workstation.

Caution: Failure to observe ESD handling procedures may result in damage to the product.

2.2 Recommended Operating Conditions

Table 2-1 indicates the recommended conditions under which the product should run properly.

Parameter	Recommend Condition	
Power supply voltage	3.30V DC	
Input signal voltage	$V_{IL\ (min/max)}$: 0.0V / 0.4V	$V_{IH\ (min/max)}$: 2.4V / 3.3V
Operating free-air temperature	$T_{A(min/max)}$: 0°C / 60°C	

Table 2-1 – Recommended operating conditions

2.3 Absolute Maximum Ratings

The user should be aware of the absolute maximum operating conditions for the NMR interface. Failure to comply with these conditions may result in damage to the product. The minimum and maximum values are indicated in Table 2-2.

Parameter	Min.	Max.
Power supply voltage	-0.30V	3.60V
Input signal voltage	-0.30V	3.60V

Table 2-2 – Absolute maximum ratings

2.4 Electrical Specifications

Parameter	Min.	Typ.	Max.
DC supply voltage	3.15V	3.30V	3.45V
DC supply current		450mA	750mA
LVTTL output high level V_{IH}	V_{DD} - 0.4V	3.10V	V_{DD}
LVTTL output low level V_{IL}	0	0.2V	0.4V
S/PDIF peak-to-peak output voltage (with R_L=75Ω)		0.5V	
S/PDIF output impedance		75Ω	

Table 2-3 – Electrical specifications

2.5 Digital Audio Specifications

Parameter	Min.	Typ.	Max.
PCM digital audio resolution	16-bit		32-bit
PCM digital audio sample rate	44.1kHz		384kHz
PCM digital audio dynamic range		32-bit	
DSD sample rate	2.8224MHz		5.6448MHz

Table 2-4 – Digital audio specifications

2.6 Audio Formats

The following audio formats are supported by the engineered's media renderer:

- FLAC (Free Losless Audio Codec)
- WAV (Waveform Audio File Format)
- MP3 (Mpeg Audio Layer 3)
- ALAC (Apple Lossless Audio Codec)
- AAC (Advanced Audio Coding)
- AIFF (Audio Interchange File Format)
- DSF and DFF (DSD stream file)

The audio data in WAV and standard AIFF files are uncompressed pulse-code modulation (PCM). Like any non-compressed, lossless format, it uses much more disk space than compressed formats. Such uncompressed PCM streams are supported up to 384kHz / 32-bit.

FLAC is an open format with royalty-free licensing. It supports for metadata tagging, album cover art, and fast seeking. The technical strengths of FLAC compared to other lossless formats lie in its ability to be streamed and decoded quickly, which is independent of compression level. Since FLAC is a lossless scheme, it is suitable as an archive format for owners of CDs and other media who wish to preserve their audio collections. The MR-MOD decodes FLAC files up to 192kHz.

MP3 and AAC are lossy compressions and encoding schemes for digital audio. These are non-free codecs covered by patents and subject to licensing by the final product manufacturer. The MR-MOD offers the technical ability to decode such formats, but engineered is not responsible for non-free audio codecs licensing.

DSF and DFF files may contain multi-channel audio data and various resolutions. The MR-MOD supports uncompressed one-bit stereo audio at 2.8224MHz and 5.6448MHz.

Note: It is the responsibility of the manufacturer of the final product (the brand) to take care of the licensing and fees for the non-free audio codecs.

3 Connectors Description

3.1 Audio Output Connector

Industry standard 24-pin connector for 0.5mm flex cable.
Suggested corresponding cable: Molex ref. 98266-0259.

Pin #	Name	Type	Description
1	GND	Ground	Ground
2	MCLK	Output	Master Clock Output – Master clock output at 22.5792MHz or 24.576MHz. Refer to Table 4-3.
3	GND	Ground	Ground
4	BCLK	Output	Serial Audio Bit Clock Output – Serial bit clock for PCM and DSD audio data.
5	GND	Ground	Ground
6	LRCLK	Output	Serial Audio Left/Right Clock Output – Frame sync clock for PCM audio data.
7	SDATA1	Output	Serial Audio Data Output – DSD audio right-channel data*.
8	SDATA0	Output	Serial Audio Data Output – Stereo PCM audio data or DSD audio left-channel data*.
9	GND	Ground	Ground
10	SPDIF	Output	S/PDIF Output – Serial encoded audio data stream, LVTTL level.
11	GND	Ground	Ground
12	MUTE#	Output	Mute signal Low: the audio data stream is not valid and the DAC must be muted. High: the audio data stream is valid.
13	44K1_EN#	Output	Sampling Frequency Low: the sampling frequency is a multiple of 44.1kHz. High: the sampling frequency is a multiple of 48kHz. Refer to Table 4-2.
14	RATE0	Output	Sampling Rate – Sampling rate information. Refer to Table 4-2.
15	RATE1	Output	Sampling Rate – Sampling rate information. Refer to Table 4-2.
16	DSD_PCM#	Output	Audio Stream Format Low: the digital audio output stream format is PCM High: the digital audio output stream format is DSD
17	GP_OUT	Output	General Purpose Output – Custom output signal available on request.
18	GND	Ground	Ground
19	GP_IN	Input	General Purpose Input – Custom input signal available on request.
20	EXT_MCLK_SEL#	Input	External Master Clock Select Input – External master clock selection. Low: external master clock synchronization is used. High: internal master clock synchronization is used. Refer to Table 4-1.
21	NC		Not connected.
22	GND	Ground	Ground
23	MCLK input	Input	Master Clock Input – External master clock input, typically a crystal-based source at 22.5792MHz or 24.576MHz. Refer to Table 4-3.
24	GND	Ground	Ground

Table 3-1 – Application connector description

(*) Refer to section “DSD Mode” for pin description in DSD mode.

3.2 Audio Input Connector

Industry standard 10-pin connector for 0.5mm flex cable.
Suggested corresponding cable: Molex ref. 98266-0105.

Reserved for future use or custom application.

Pin #	Name	Type	Description
1	GND	Ground	Ground
2	BCLK_IN	Input	Serial Audio Bit Clock Input – Serial bit clock for audio data.
3	GND	Ground	Ground
4	LRCLK_IN	Input	Serial Audio Left/Right Clock Input – Frame sync clock for audio data.
5	SDATA_IN1	Input	Serial Audio Data Input – Stereo PCM audio data.
6	SDATA_IN0	Input	Serial Audio Data Input – Stereo PCM audio data.
7	GND	Ground	Ground
8	SPDIF_IN	Input	S/PDIF Input – Serial encoded audio data stream, TTL input level.
9	GND	Ground	Ground
10	NC		Not connected.

Table 3-2 – External audio input connector description

3.3 S/PDIF Output Connector

SMB coaxial male connector: Cinch Connectivity Solutions Johnson ref. 131-8701-251
Suggested matching female receptacle: Cinch Connectivity Solutions Johnson ref. 131-8403-101.
Suggested matching cable: Cinch Connectivity Solutions Johnson 415-0011-012

Serial encoded audio data stream, isolated and buffered for coaxial cable connection.
Output level (S/PDIF standard): 0.5Vpp on 75Ω.

Pin #	Name	Type	Description
1/Inner	SPDIF pos.	Output	S/PDIF Positive Output – Serial encoded audio data stream, buffered for coaxial cable connexion.
2/Outer	SPDIF neg.	Output	S/PDIF Negative Output – Serial encoded audio data stream, buffered for coaxial cable connexion.

Table 3-3 – S/PDIF connector description

3.4 Control Interface Connector

Industry standard 10-pin connector for 0.5mm flex cable.
Suggested corresponding cable: Molex ref. 98266-0105.

Pin #	Name	Type	Description
1	GND	Ground	Ground
2	SPI_MISO	Output	SPI Data Output – Serial data from the DSP to the application MCU.
3	GND	Ground	Ground
4	SPI_MOSI	Input	SPI Data Input – Serial data from the application MCU to the DSP.
5	GND	Ground	Ground
6	SPI_SCK	Input	SPI Clock – Synchronous clock for serial data transmission and reception.
7	GND	Ground	Ground

8	SPI_SS#	Input	SPI Slave Select – Active low, used to communicate with the DSP.
9	SPI_INT#	Output	SPI Interrupt Line – Active low, goes from high to low when the DSP requests a communication.
10	GND	Ground	Ground

Table 3-4 – Control interface connector description

3.5 Power Supply Connector

Industry standard 2-pin Molex KK-series 2.54mm connector.
Corresponding box for contacts: Molex ref. 2201-2025.

Pin #	Name	Type	Description
1	GND	Ground	Electrical ground
2	VDD	Power	Power Supply Input +3.30V DC.

Table 3-5 – Power supply connector description

The MR-MOD modules integrates a voltage supervisor which resets the DSP when the power supply falls below a defined threshold. Power supply regulation, voltage precision, current capability and connexion impedance are important factors to ensure clean operation of the module.

Caution: Failure to respect the power supply polarity and voltage level may result in damage to the components.

4 Application Information

4.1 Home Network Devices

4.1.1 Digital Media Server (DMS)

Multimedia files are stored on this device and are made available to the network Digital Media Renderers.
Ex.: computer, network-attached storage (NAS) devices.

4.1.2 Digital Media Renderer (DCP)

This device is controlled by a Digital Control Point and can play the content of a Digital Media Server.
Ex.: NMR, audio/video receiver, TV, remote speakers.

4.1.3 Digital Control Point (DCP)

This device can browse the content on a Digital Media Server and control a Digital Media Renderer to play these files.
Ex.: smartphone, tablet, computer.

4.2 Typical Setup

The NMR provides a very high quality solution to play audio files on a home network. Thanks to its compatibility with the UPnP AV 2.0 standard, its integration into a home network is very easy.
Developed for high-end Hi-Fi systems, it achieves bit-perfect playback with no compromise on sound quality.

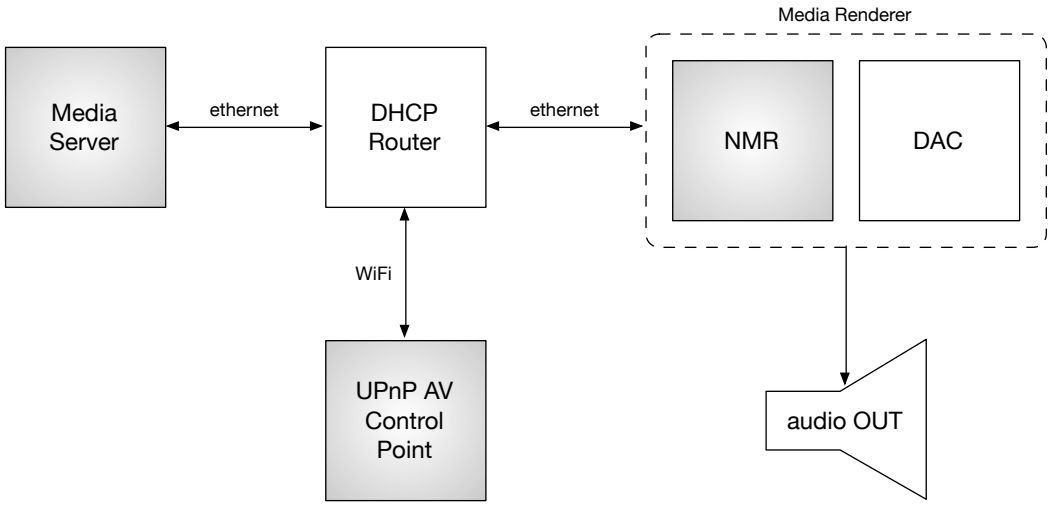

Figure 4-1 – Typical setup of a network audio system

How it works:

1. Music files are stored on the Media Server.
2. The user can browse the files and send/receive commands (play, volume, display time, cover...) via the Control Point.
3. The Network audio Media Renderer (NMR) fetches a stream to play from the Media Server, then converts it into audio data.
4. The audio data are sent to the DAC which converts them into an analog signal. This signal can then be amplified and played on speakers.

4.3 Typical Application

The designer has several options to integrate the NMR OEM board into a system. Factors like production cost, design complexity and target level of performances have to be taken into account.

Figure 4-2 shows a simple and cost effective solution, which only adds a stereo DAC, analog output buffers and the required power supply. As long as the DAC is configured in hardware mode there is no need of an MCU, which extremely simplifies the design.

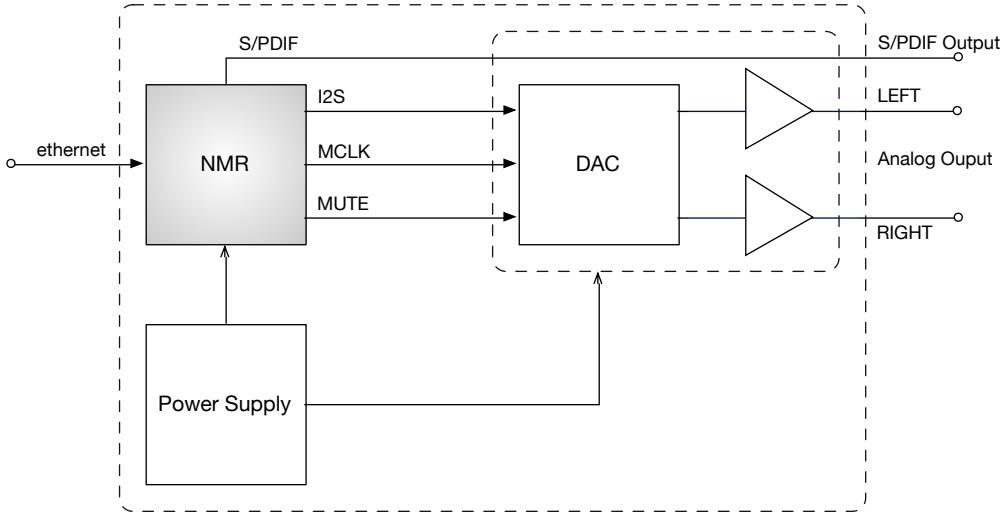

Figure 4-2 – Basic NMR implementation

Figure 4-3 illustrates another concept, defined by more flexibility and better performances. In this example, the audio Master Clock generators are located close to the DAC for optimal clock distribution. A micro-controller is used to configure the DAC chips and select the appropriate oscillator according to the audio stream sampling frequency. See section “Master Clock Synchronization“ for more information about external Master Clock.

The S/PDIF digital output is directly connected to the buffered and isolated 75Ω output of the NMR board in order to minimize the signal path. As for any high performance circuit, great care must be taken in designing the power supply, selecting critical components (DAC, oscillators, output buffers) and routing the DAC PCB.

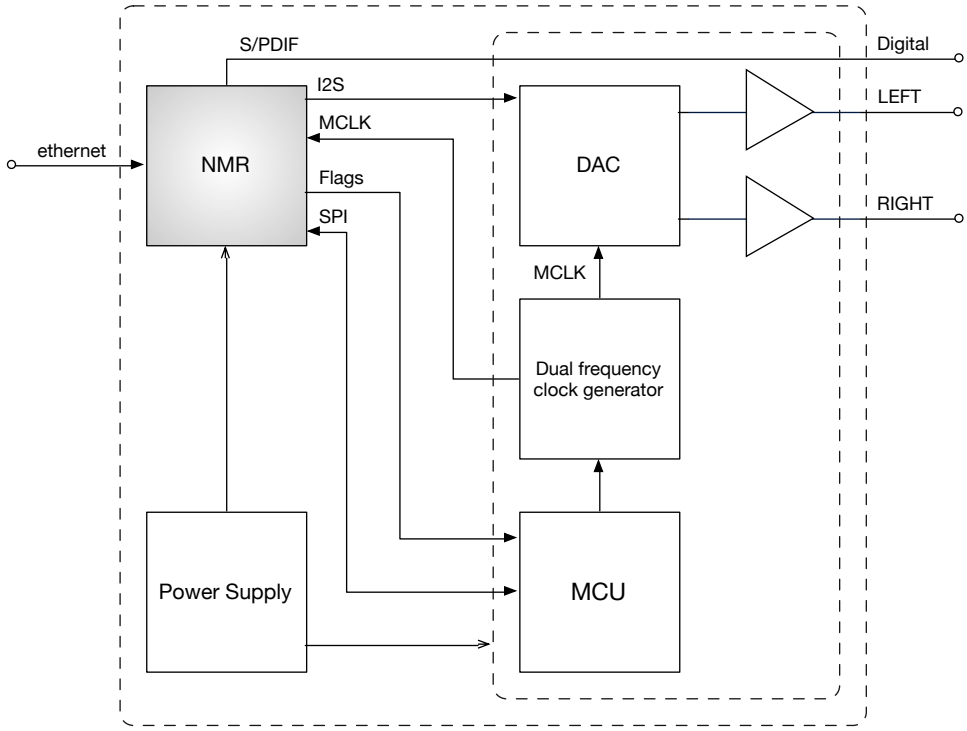

Figure 4-3 – Improved NMR implementation

4.4 Master Clock Synchronization

Asynchronous clocking allows for a full control of the Ethernet data transfer and audio master clock to minimize jitter and get the highest digital audio playback quality.

The on-board oscillators are high quality components with low jitter characteristics. However, depending on the DAC architecture or any possible post-processing, it can be wise to use one single master clock for everything.

Therefore, the internal master clock is available as an output on the Application connector, and an external master clock input is provided for enhanced flexibility. The master clock source can be selected by setting the EXT_MCLK_SEL# signal available on the Application connector.

External master clock must be either 22.5792MHz or 24.5760MHz according to the 44K1_EN# signal (refer to Table 4-3). Failure to do so will mute the output. Master clock selection is described in Table 4-1.

EXT_MCLK_SEL#	Master Clock Source
Low	External
High	Internal

Table 4-1 – Master clock selection

4.5 S/PDIF Output

An S/PDIF output is available on the Application connector at LVTTL level. Besides a dedicated SMB connector provides an isolated S/PDIF output for direct coaxial cable connection. A high quality RF transformer ensures the signal quality and integrity with standard 75Ω coaxial cables, according to the S/PDIF standard.

S/PDIF standard supports PCM up to 192kHz. Higher sampling rate such as 352.8kHz and 384kHz are not supported. For these formats, the I2S digital audio bus on the Application connector must be used. Native DSD stream isn't compatible S/PDIF and AES protocols, therefore such data cannot be transmitted over S/PDIF.

4.6 I2S Digital Audio Bus

The digital audio port is configured in I2S, master mode. The NMR supplies the data signals, left/right clock and bit clock. Refer to section "DSD Mode" for pin mapping in DSD mode.

The data signals are made of two lines: SDATA0 and SDATA1. Only SDATA0 is used in PCM audio.

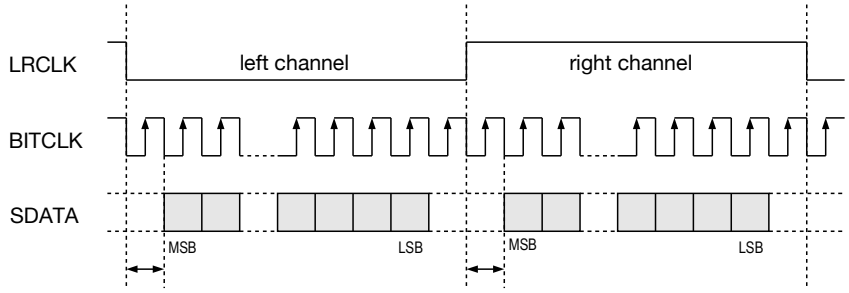

Figure 4-4 – I2S data format

The sampling frequency corresponding to the audio track currently playing can be retrieved with the help of the hardware flags RATE0, RATE1 and 44K1_EN#, available on the Application connector. Monitoring of these flags is useful to change the DAC or any post-processing settings whenever needed.

The MUTE signal indicates that the serial data are no longer valid and therefore should be discarded.

Table 4-2 shows how the clock mode signals must be decoded.

Left/Right Clock Frequency (Fs)	RATE0	RATE1	44K1_EN
44.1kHz	High	High	Low
48kHz	High	High	High
88.2kHz	Low	High	Low
96kHz	Low	High	High
176.4kHz	High	Low	Low
192kHz	High	Low	High
352.8kHz	Low	Low	Low
384kHz	Low	Low	High

Table 4-2 – Relation between sampling frequency and hardware flags

Table 4-3 shows how the audio sampling frequency (Fs), the bit clock frequency and the master clock frequency are related in PCM mode.

Left/Right Clock Frequency (Fs)	Bit Clock Ratio	Master Clock Ratio	Master Clock Frequency
44.1kHz	64 * Fs	512 * Fs	22.5792MHz
48kHz	64 * Fs	512 * Fs	24.576MHz
88.2kHz	64 * Fs	256 * Fs	22.5792MHz
96kHz	64 * Fs	256 * Fs	24.576MHz
176.4kHz	64 * Fs	128 * Fs	22.5792MHz
192kHz	64 * Fs	128 * Fs	24.576MHz
352.8kHz	64 * Fs	64 * Fs	22.5792MHz
384kHz	64 * Fs	64 * Fs	24.576MHz

Table 4-3 – Relation between left/right clock, master clock and bit clock

4.7 DSD Mode

Support for native DSD64 and DSD128 is provided by the NMR interface. DSD data format is indicated by the flag DSD_PCM# on Application Connector pin 16.

DSD_PCM#	Data Stream Type
Low	PCM
High	DSD

Table 4-4 – Data stream type

Table 4-5 shows how the DSD frequency is indicated by the hardware flags, and Table 4-6 illustrates the relation between DSD rate, corresponding sampling rate seen by the USB host in DoP mode, Bit Clock and Master Clock frequencies.

DSD Type	RATE0	RATE1	44K1_EN#
DSD 64	Low	High	Low
DSD 128	High	Low	Low

Table 4-5 – Relation between DSD rate and hardware flags

DSD Type	DoP Sampling Rate	Bit Clock Frequency	Master Clock Frequency
DSD 64	176.4kHz	2.8224MHz	22.5792MHz
DSD 128	352.8kHz	5.6448MHz	22.5792MHz

Table 4-6 – Relation between DoP sampling rate, bit clock and master clock

When playing DSD, the I2S digital audio bus is re-configured in order to output DSD data and clock. As there is no standard the NMR offer two mapping possibilities, selected by the micro-switch SW2.

Audio Output Connector Pin	PCM Signal	DSD Signal - SW2 OFF -	DSD Signal - SW2 ON -
4 - BCLK	BCLK	BCLK	BCLK
6 - LRCLK	LRCLK	n/a	DSD data left
7 - SDATA1	n/a	DSD data right	n/a
8 - SDATA0	PCM data L/R	DSD data left	DSD data right
10 - SPDIF	SPDIF	n/a	n/a
16 - DSD/PCM#	Low	High	High

Table 4-7 – Pin mapping options in DSD mode

4.8 Serial Peripheral Interface

The NMR features a full-duplex serial port based on the Serial Peripheral Interface standard.

The SPI port communicates in slave mode. It is used to access registers allowing the MR-MOD module to transmit information to the host device, referred as master, and to be configured for the desired operational mode. An interrupt line is provided to indicate a data change and avoid the need for the host to poll the MR-MOD continuously. The operation of the SPI port may be completely asynchronous with respect to the audio stream rates.

The SPI port is a five-wires serial interface where SPI_SS (active low) is the module chip select signal, SPI_SCK is the control port bit clock (input into the MR-MOD from the host device), SPI_MOSI is the input data line from master, SPI_MISO is the output data line to the master and SPI_INT is the interrupt line.

Refer to the Media Renderer Module (MR-MOD) data sheet (MR-MOD-DS-xxxE.PDF) for detailed description of the SPI and register interface.

4.9 Digital Volume Control

The volume is controlled by the Control Point and is transmitted to the NMR via the Ethernet connection. The corresponding attenuation is then computed inside the DSP and applied to the serial audio data output.

Most of basic digital volume controllers deteriorate the audio signal due to truncation or rounding errors, but thanks to a 32-bit calculation the signal integrity is preserved here.

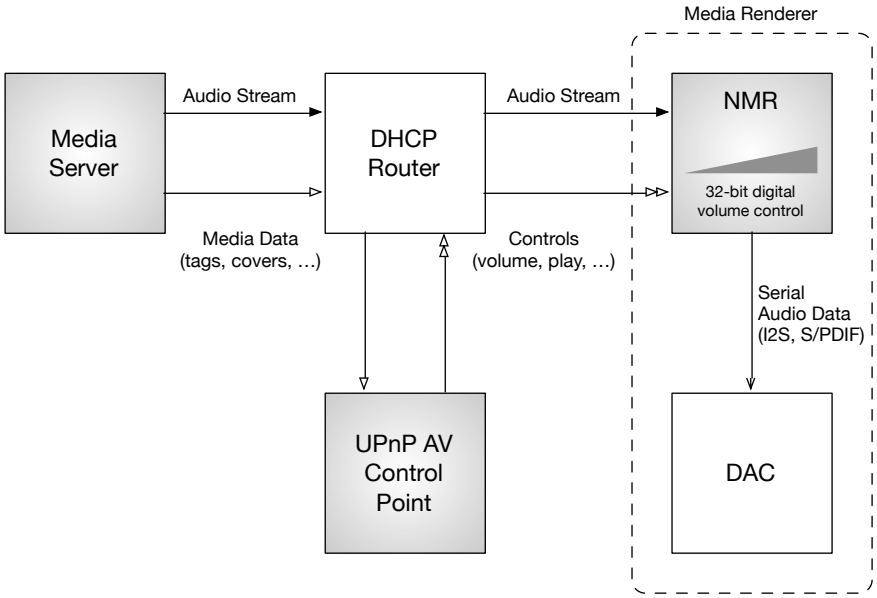

Figure 4-5 – Volume control description

5 Firmware and Boot Mode

The firmware update requires a computer connected on the same network as the NMR. Once the device has booted and is registered on the network, its information Web page can be accessed with an Internet browser. This page contains the firmware update interface.

On MS Windows-based computers, browsing the network gives easy access to the media renderer, displayed in the Network window under the label "Media Devices". A double-click on the "Audio Renderer-XX" icon shows the information Web page.

On other operating systems, it may be required to access the router's DHCP table to get the renderer's IP address. Then simply enter the IP address in your browser to access it.

The information page contains the firmware update interface.

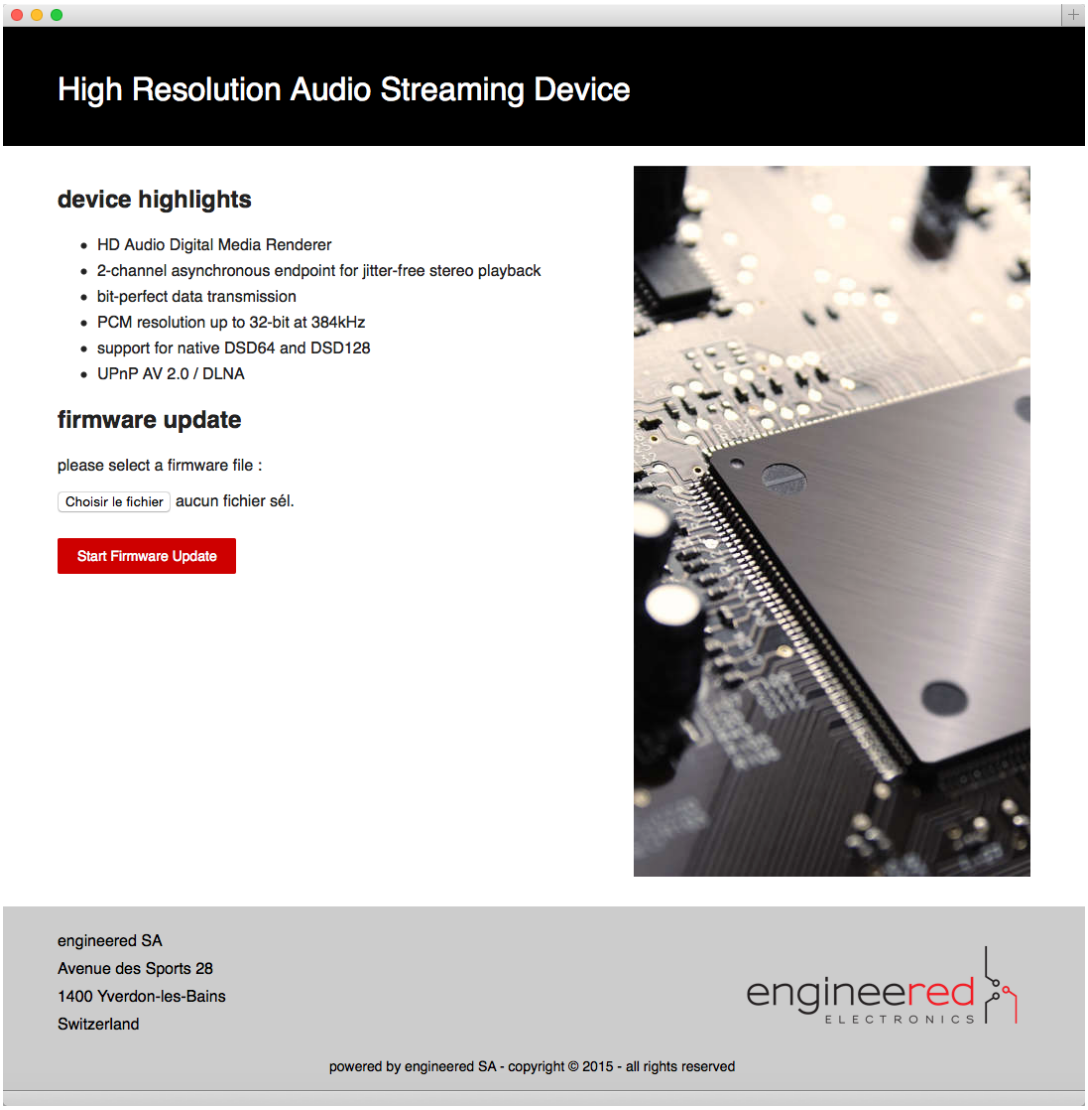

Figure 5-1 – Firmware update page

Download the latest firmware on our Web site and save the file on your computer, then extract the ZIP archive. Select the “nmr-__vX.XX-...bin” file and click on the “Start Firmware Update” button.

5.1 Network Setup

The NMR is compatible with the UPnP AV/DLNA specification. No configuration is needed. There must be a DHCP server in the network where the NMR operates. The NMR will fetch its configuration information directly from the DHCP server.

The two status LEDs give information about the boot status of the MR-MOD module, as described in the Table 5-1.

LED_S1	LED_S0	Description
1	1	Power up. Booting.
1	0	System booted
0	1	System booted. Network configured.
0	0	An error occurred

Table 5-1 – Status LED description

5.2 Network Identification

In your UPnP Control Point, the device will appear with the name “Audio Renderer-XXX” where XXX is the last digit of the acquired IP address.

6 Hardware Information

6.1 Connectors Location

The drawing below shows where the connectors are located on the board.

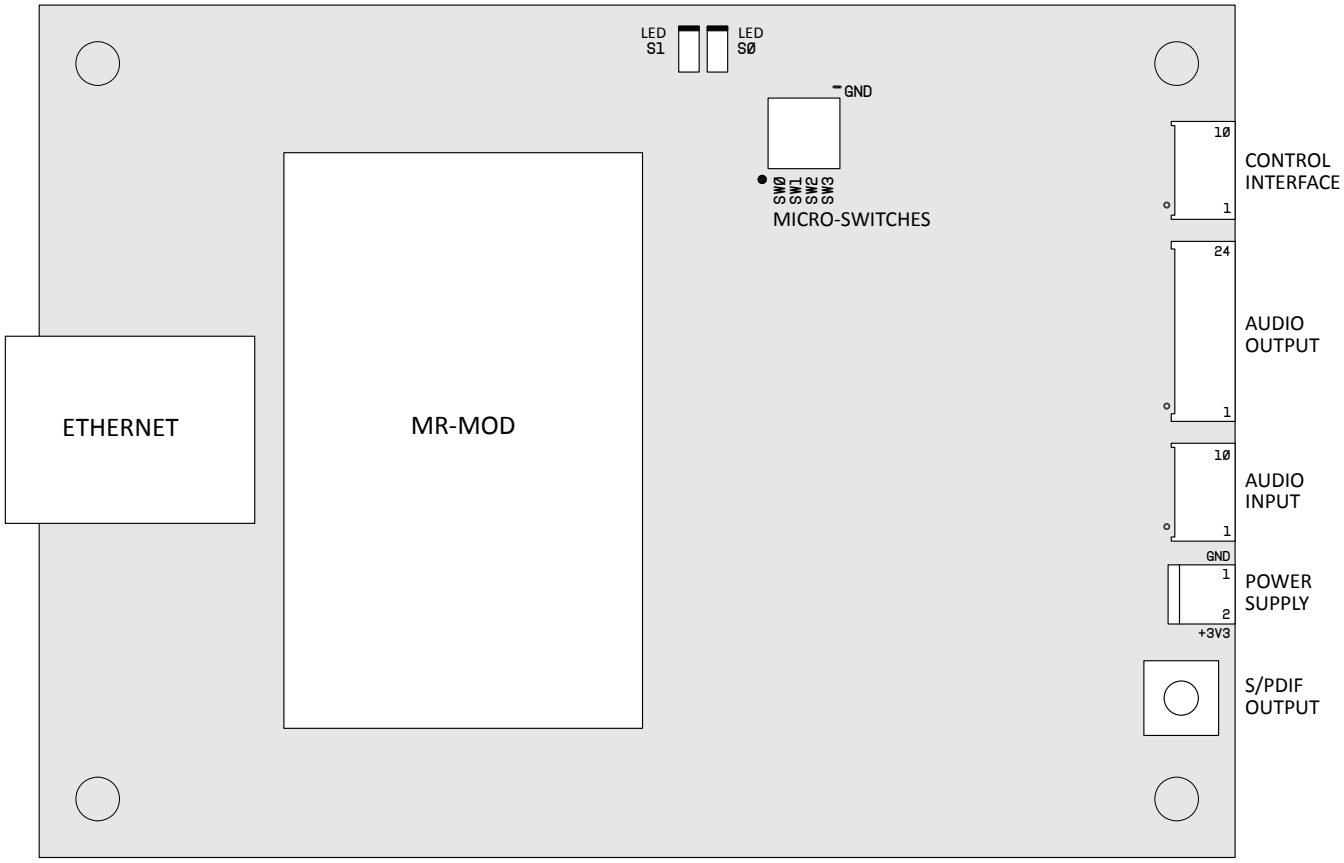

Figure 6-1 – Connectors location

6.2 Board Dimensions

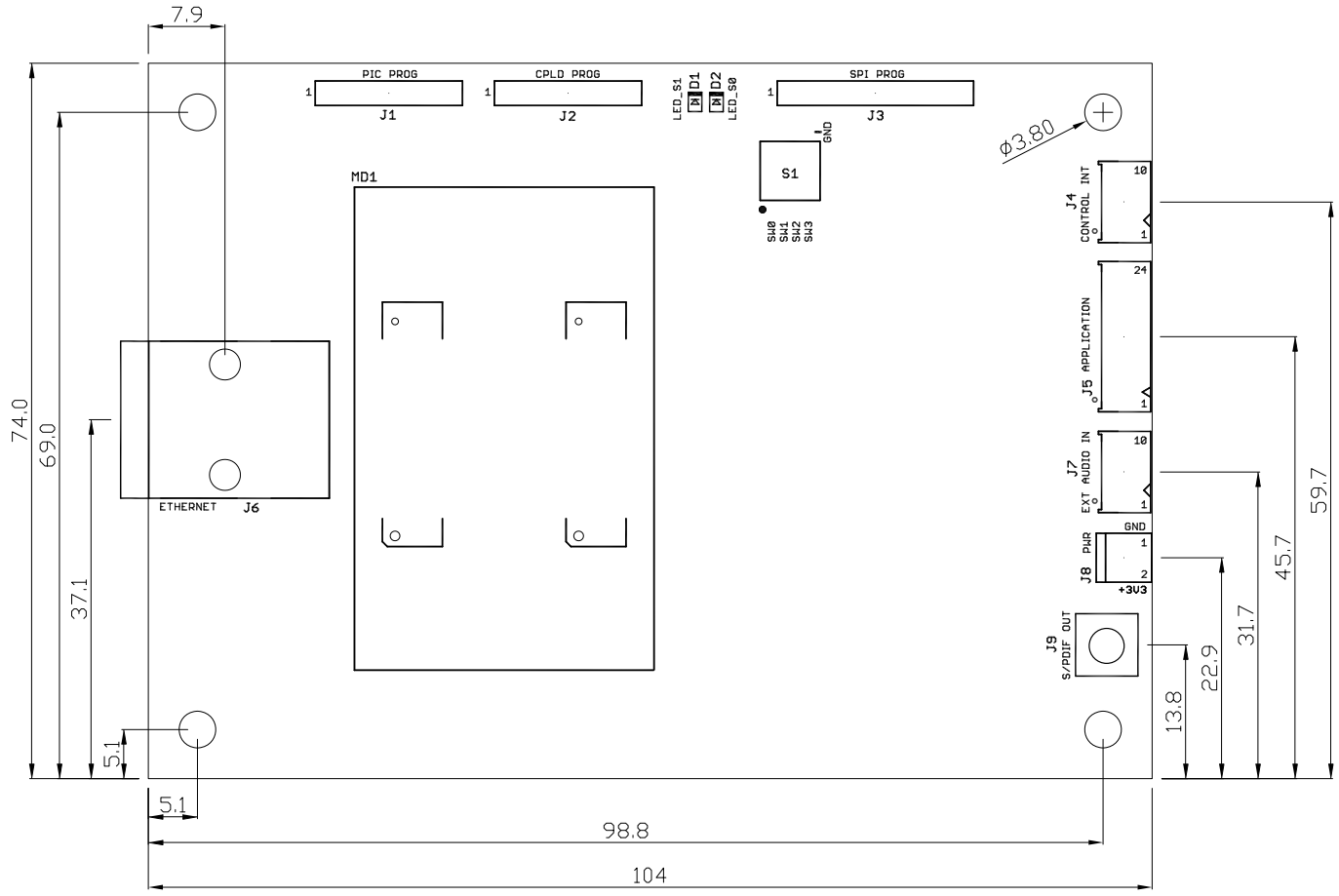

Figure 6-2 – Mechanical dimensions

7 Related Products

7.1 USB Audio Interface

The NMR board concept is very close to engineered's USB Audio interface ref. U2S192_OEM. These two products are mechanically compatible by keeping the same board dimensions and mounting holes' position. Connectors, digital audio flow and clocking concept are similar. Depending on the final application, these two boards can be interchanged. Some precautions have to be observed though, especially regarding the device power requirements.

7.2 S8 and Q8 Upsamplers

The S8 Module integrates four key technologies to deliver a highly integrated asynchronous upsampler and digital synchronizer with best low-level signal linearity and high performance multi-DAC differential output. The module features a single audio input port capable of supporting PCM data up to 384kHz or stereo DSD64 (2.8224MHz) and DSD128 (5.6448MHz). Two digital 8x FS upsampled output ports are available for interfacing to external D/A hardware. It provides highest quality Digital to Analog conversion using two DAC's per channel in differential mode and is a perfect match for the MR-MOD streaming technology in building a High End DAC compatible with latest high definition formats.

The Q8 Module shares the software and hardware technology with the S8 Module, but is optimized for projects requiring a down-sampled output. The first digital audio output port provides up-sampled data at 384kHz for driving a dual-DAC system. The second digital audio output port provides a direct down-sampled stream configurable for 1xFS (48kHz), 2xFS (96kHz) or 4xFS (192kHz) operation.

7.3 Custom Applications

The MR-MOD core is based on a modern DSP, which runs engineered's software framework for network-based digital audio playback. This software can be customized on demand for specific requirements.

The NMR hardware platform is mainly foreseen as an evaluation board for engineered's streaming technology. Please check our Web site for more information and contact us for development of custom hardware and software solutions that meets your product requirements.

8 Ordering Information

8.1 Part Number

Part Number	Description
NMR-OEM	NMR Network audio Media Renderer

8.2 Contact Information

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