# U2S192

## USB DIGITAL AUDIO INTERFACE

## OEM/EVALUATION BOARD DATASHEET



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U2S192- DS
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## Table of contents

# Preface

## I. About This Datasheet

This document provides the information needed to design and integrate the USB Digital Audio Interface 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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## 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 USB Digital Audio Interface (U2S192) is an easy-to-integrate OEM solution for high-end USB audio playback systems, supporting both USB Audio Class 1.0 and 2.0. Key features for the U2S192 include:

- Support for USB 2.0 High Speed compliant and USB Audio Class 1.0 or 2.0 (user selectable).
- 2-channel asynchronous endpoint for highest quality digital audio stereo playback.
- On-board 22.5792MHz and 24.576MHz oscillators.
- External master clock input.
- Resolution up to 32-bit, sampling rate up to 384kHz (96kHz for USB Audio Class 1.0).
- Support for DSD64 and DSD128 via DoP open standard.
- I2S and S/PDIF digital audio output.
- Full galvanic isolation.
- Based on XMOS XS1-L1 controller/DSP in 128TQFP package and SMSC USB3318 USB PHY.
- USB Audio Class 2.0 driver for MS Windows.

USB streaming is based on an asynchronous protocol, clocked by low-jitter on-board oscillators. Using this concept, the design benefits of a local high quality master clock to achieve highest quality, jitter-free digital audio playback.

External master clock synchronization is provided for enhanced flexibility and optimal clock distribution.

Full galvanic isolation avoids any interference issues between the audio device and the USB host. Critical components are powered by an external source to ensure optimal performances. The interface can also be configured to use bus power only, useful for using the board as a simple USB to S/PDIF mobile interface. Additionally, all connections on USB side are protected against short transient electrostatic discharges.

## 1.2 USB Considerations

### 1.2.1 Transmission Mode

There are several different methods for transferring audio data over an USB interface. These methods are:

- Synchronous Mode is a one-way digital connection for transferring data from the PC to the USB device. The computer acts as the clock master for playback and determines the playback timing. Computer and USB timing is not nearly accurate enough for high-fidelity playback.

- Adaptive Isochronous Mode is another communication method where the computer controls the audio transfer rate. Since the transfer rate is subject to variation, the device clock must adapt to this drifting signal by re-adjusting its own frequency. This approach usually involves a PLL (Phase Locked Loop) and leads to jitter in the derived clock, resulting in compromised sonic performance.

- Asynchronous Mode is a two-way communication method between the computer and the external device. In this case, the device is the clock master, and the PC is acting as a slave that delivers data only when requested by the device

The U2S192 interface is based on the asynchronous mode. Using high speed USB transmission, data are delivered much faster than the playback rate. The on-board DSP manages a memory buffer and controls the USB transmission to make sure that the buffer never gets empty during playback.

Because it eliminates the jitter caused by the PC hardware and software, this concept allows for superior playback performances when compared to other usual audio interfaces.

### 1.2.2 Compatibility Issues

USB audio devices have stronger requirements for USB hardware and software layers than other USB devices. A faulty hardware component (USB cable or USB port) may not have an impact on standard USB devices such as a Flash drive but can be catastrophic for a USB audio device.

Due to the real-time nature of USB audio streams there are also requirements for time characteristic of the operating system and third party software components installed on the system. Software components that make real-time behavior of the operating system worse are not compatible with audio streaming applications in general.

It is important to note that real-time requirements depend directly on audio latency requirements. If audio latency is not critical (in case of music playback) then timing requirements of the driver are relaxed which increases compatibility with other applications and drivers significantly.

Asynchronous transfer mode uses error checking but no retransmission in case of errors. Electrical noise on USB signals causes errors and thus data loss. This leads to audio signal distortions (clicks). This means that an USB audio device can work only if USB signal quality is good and no errors occur. Most other USB device types (Flash drive, printer) are based on bulk transfer mode which uses automatic retransmission in case of errors. These kind of devices are much more tolerant with respect to USB signal distortion.

Quite often the USB cable (or its connectors) is the cause for USB signal distortions. Some cables available on the market are not suited for USB 2.0 high-speed communication (480 Mbps). Also the maximum allowed cable length of 5 meters should not be exceeded.

On some PC main boards (or laptops) signal quality of some USB ports is insufficient for audio streaming. External USB ports (mounted on a front panel or elsewhere in the PC case) are a possible source of USB signal distortion. Quality of cables or connectors used to connect the external USB port with the main board could be insufficient, or internal cables are placed close to the power supply or other sources of electrical noise.

## 1.3 Functional Block Diagram

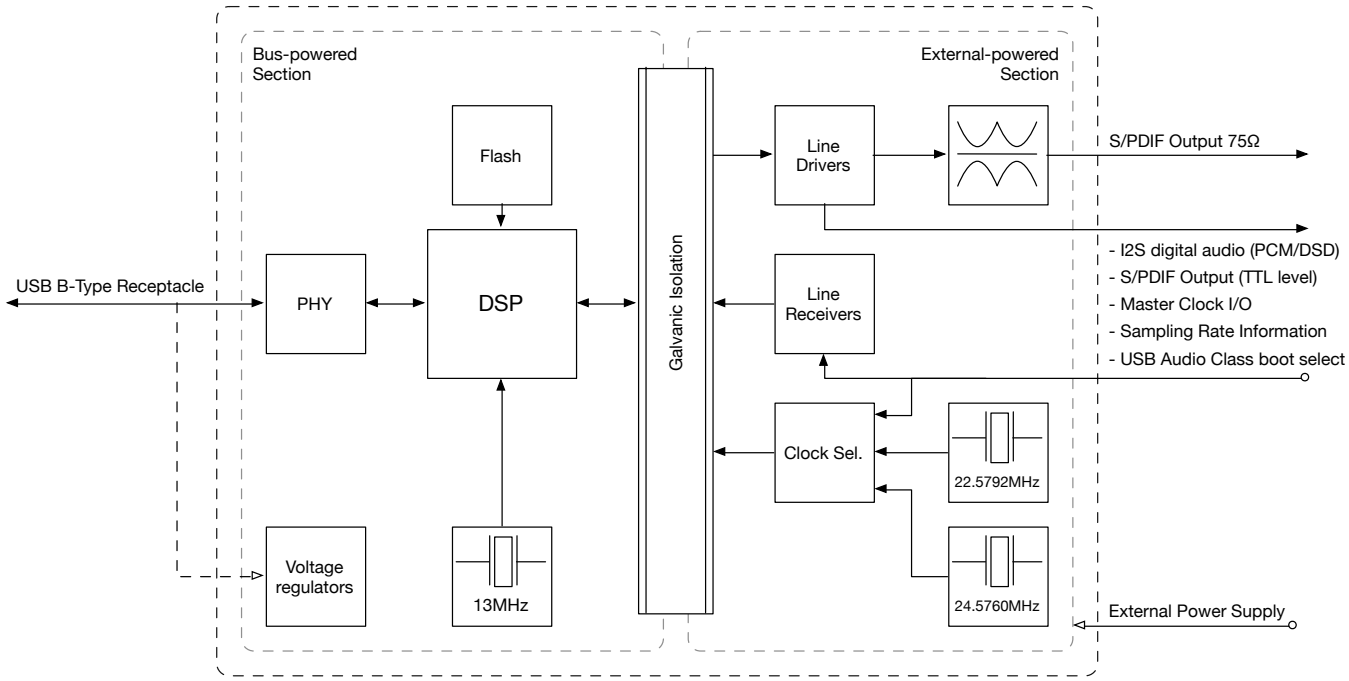


*Figure 1-1 – Functional block diagram*

# 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 / 3.6V |
| 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 U2S192 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. |
|---|---|---|---|
| External DC supply voltage | 3.10V | 3.30V | 3.45V |
| External DC supply current | | 100mA | |
| TTL output high level $V_{IH}$ | $V_{DD}$ - 0.4V | 3.10V | $V_{DD}$ |
| TTL output low level $V_{IL}$ | 0 | 0.2V | 0.4V |
| Differential S/PDIF output voltage | | 0.5V | |
| Differential S/PDIF output impedance | | 75Ω | |

*Table 2-3 – Electrical specifications*

## 2.5 Performance Specifications

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

*Table 2-4 – Performance specifications*

# 3 Connectors Description

## 3.1 Application 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 for I/O and clock management. |
| 2 | MCLK | Output | Master Clock Output – Master clock output at 22.5792MHz or 24.576MHz. Refer to Table 4-4. |
| 3 | GND | Ground | Ground for I/O and clock management. |
| 4 | BCLK | Output | Serial Audio Bit Clock Output – Serial bit clock for PCM and DSD audio data. |
| 5 | GND | Ground | Ground for I/O and clock management. |
| 6 | PCM_LRCLK | Output | Serial Audio Left/Right Clock Output – Frame sync clock for PCM audio data. |
| 7 | DSDR | Ground | Serial Audio Data Output – DSD audio right-channel data. |
| 8 | PCM_SDATA<br>DSDL | Output | Serial Audio Data Output – Stereo PCM audio data or DSD audio left-channel data. |
| 9 | GND | Ground | Ground for I/O and clock management. |
| 10 | SPDIF | Output | S/PDIF Output – Serial encoded audio data stream, TTL level. |
| 11 | GND | Ground | Ground for I/O and clock management. |
| 12 | MUTE# | Output | Mute signal<br>Low: the audio data stream is not valid and the DAC must be muted.<br>High: the audio data stream is valid. |
| 13 | 44K1_EN# | Output | Sampling Frequency<br>Low: the sampling frequency is a multiple of 44.1kHz.<br>High: the sampling frequency is a multiple of 48kHz. Refer to Table 4-3. |
| 14 | RATE0 | Output | Sampling Rate – Sampling rate information. Refer to Table 4-3. |
| 15 | RATE1 | Output | Sampling Rate – Sampling rate information. Refer to Table 4-3. |
| 16 | DSD_PCM# | Output | Audio Stream Format<br>Low: the digital audio output stream format is PCM<br>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 for I/O and clock management. |
| 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.<br>Low: external master clock synchronization is used.<br>High: internal master clock synchronization is used. Refer to Table 4-2. |
| 21 | AUDIOCLASS | Input | USB Audio Class – USB Audio Class mode selection.<br>Low: USB Audio Class 1.0 is selected.<br>High: USB Audio Class 2.0 is selected. Refer to Table 4-1 and Table 5-2. |
| 22 | GND | Ground | Ground for I/O and clock management. |
| 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 4-4. |
| 24 | GND | Ground | Ground for I/O and clock management. |

*Table 3-1 – Application Connector description*

## 3.2 S/PDIF 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

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 3-2 – S/PDIF connector description*

## 3.3 External 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 3-3 – External power supply connector description*

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

# 4 Application Information

## 4.1 USB Audio Class

The U2S192 provides USB 2.0 High Speed device and supports both USB Audio Class 1.0 and 2.0.

Audio Class 1.0 mode allows driver free playback of files up to 24-bit/96kHz under MS Windows and other operating systems natively supporting version 1.0 of the USB Audio Class.

For operating systems natively supporting USB Audio Class 2.0 specifications such as OS X, the U2S192 solution supports driver-free playback up to 32-bit/384kHz.

32-bit/384kHz support under MS Windows can be achieved with the help of a specific USB Audio Class 2.0 driver (available from the engineered Web site). USB Audio Class selection is done according to Table 4-1. AUDIOCLASS input is available on the Application Connector pin 21.

USB Audio Class 2.0 can be forced by placing a jumper on SW4 (refer to Table 5-2), thus overriding a control on the Application Connector dedicated signal.

USB Audio Class 2.0 mode is highly recommended as it is essential for supporting high definition PCM format as well as DSD/DoP.

| AUDIOCLASS | USB Audio Class Mode | Description |
|---|---|---|
| Low | USB Audio Class 1.0 | Native OS X and MS Windows support. |
| High | USB Audio Class 2.0 | Native OS X support; drivers needed for MS Windows. |

*Table 4-1 – USB Audio Class selection*

**Note:** Bit-perfect digital audio reproduction relies on a correct computer set-up. Audio performances and data integrity highly depends on the OS, media player software and USB audio drivers configuration.

## 4.2 Master Clock Synchronization

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

External master clock input is provided for enhanced flexibility. It is enabled by the EXT_MCLK_SEL# signal available on the Application Connector pin 20. External master clock must be either 22.5792MHz or 24.5760MHz according to the 44K_1EN# signal (refer to Table 4-3). Failure to do so will result in muted output or frame rate error. Clock synchronization is selected according to Table 4-2.

| EXT_MCLK_SEL# | Master Clock Source |
|---|---|
| Low | External |
| High | Internal |

*Table 4-2 – External master clock selection*

Figure 4-1 illustrates a possible U2S192 integration with a DAC board. This exemple implements a dual frequency master clock generator located close to the D/A conversion circuit. The clock is selected by the 44K_1EN# flag and sent to the USB interface.

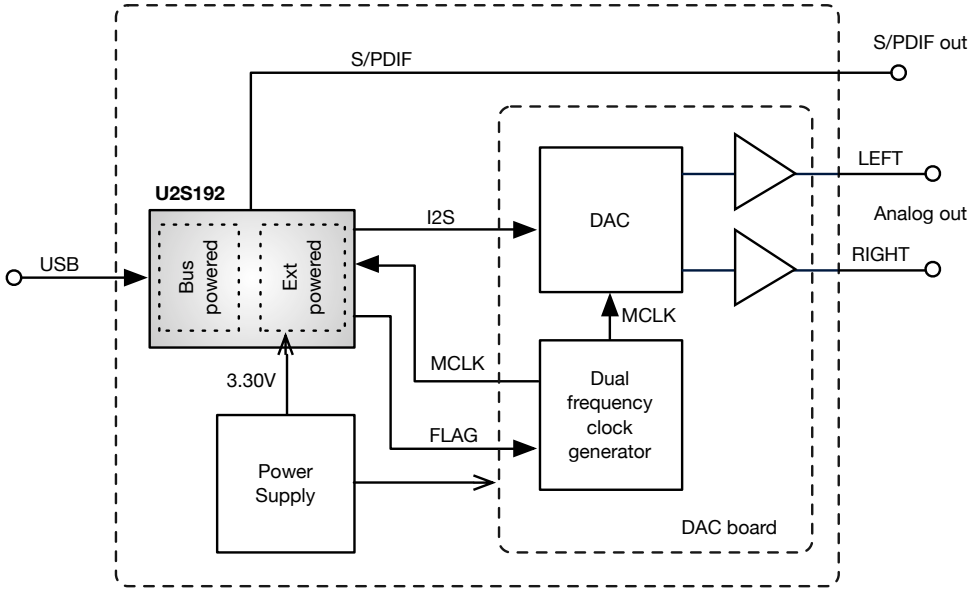


*Figure 4-1 - U2S192 integration with a DAC board*

## 4.3 Galvanic Isolation

Full galvanic isolation avoids any interference issues between the audio device and the USB host. Critical components are powered by an external source to ensure complete isolation from the host and optimal performances.
The interface can also be configured to use bus power only, useful for using the board as a simple USB to S/PDIF mobile interface. In this case, all signals on the Application Connector share the ground reference with the USB input. The S/PDIF dedicated 75Ω output implements an RF transformer thus remaining electrically floating in any case.

Refer to section “Bus-Powered Option” for more information about power supply set-up.

## 4.4 S/PDIF Output

An S/PDIF output is available on the Flex cable connector at standard TTL level. It provides a buffered and isolated output for direct coaxial cable connection. A fast driver coupled to a high quality RF transformer ensures signal quality and integrity with standard 75Ω coaxial cables.

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 cannot be transmitted over S/PDIF. The engineered standard USB firmware decodes DoP and extracts native DSD data for straight connexion to a DSD-compatible DAC via the Application Connector. However, undecoded DoP stream could be transmitted over an S/PDIF link. A specific Firmware which disables DoP decoding can be provided by engineered for this application.

## 4.5 I2S Digital Audio Bus

Both S/PDIF and I2S ports are configured in master mode. The sampling frequency is defined by the USB streaming itself and depends on the audio source file and computer configuration. The PCM sampling frequency is indicated by three flags available on the Application Connector pin 13 to 15.

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

*Table 4-3 – Relation between sampling frequency and hardware flags*

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

| 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 4-4 – Relation between left/right clock, master clock and bit clock*

## 4.6 DSD mode

Support for DSD64 and DSD128 is provided via DoP open standard in Audio Class 2.0 mode only. Native DSD playback is not possible with the provided MS Windows Audio Class 2.0 driver. 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 4-5 – Data stream type*

Table 4-6 shows how the DSD frequency is indicated by the hardware flags, and Table 4-7 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 4-6 – 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 4-7 – Relation between DoP sampling rate, bit clock and master clock*

In DSD mode, PCM_LRCLK (Application Connector pin 6) is unused. Right-channel DSD data are transmitted over DSDR (pin 7) and Left-channel DSD data are transmitted over PCM_SDATA/DSDL (pin 8).

# 5 Hardware Information

## 5.1 Connectors and Jumpers Location

The drawing below shows where the LED's, connectors and jumpers are located on the board.

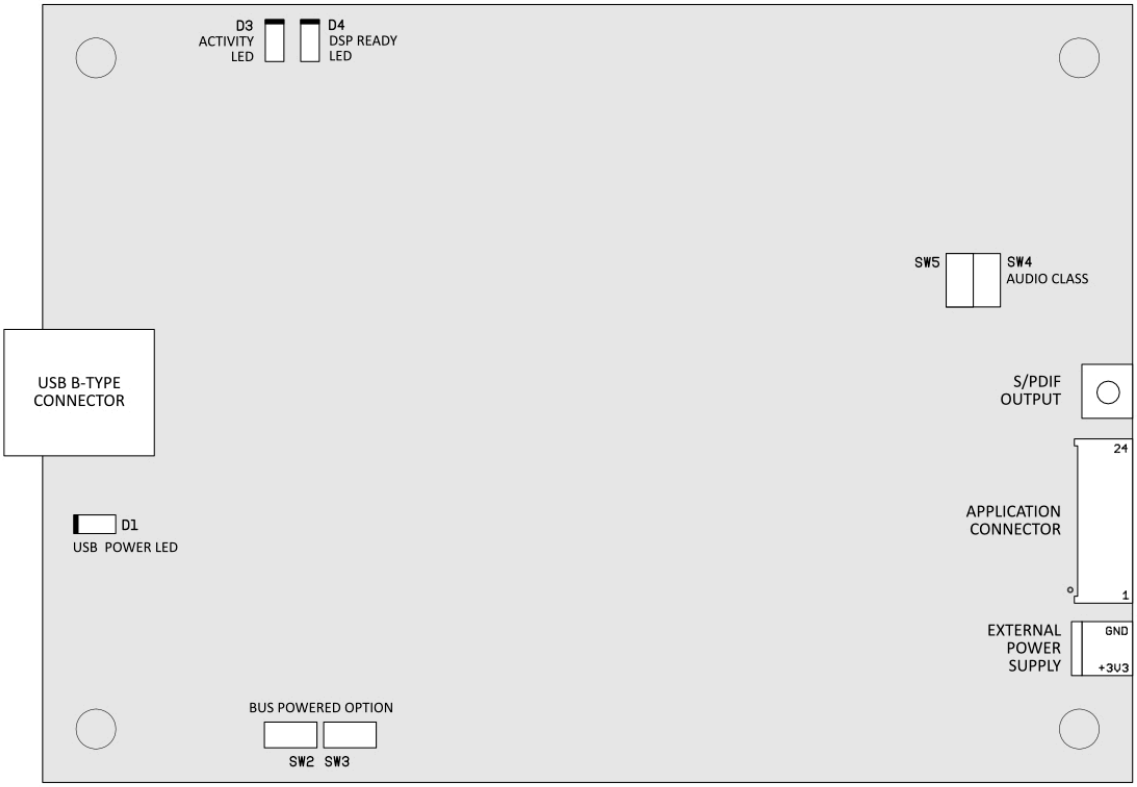


*Figure 5-1 – Connectors and jumpers location*

## 5.2 Bus-Powered Option

Bus-powered option is selected by closing jumpers SW2 and SW3. In this case, there is no galvanic isolation between the USB side and the user application side, all parts are powered by the bus. This set-up is useful for easy testing or using the board as a simple USB to S/PDIF mobile interface.

**Caution:** External power must never be applied when SW2 and SW3 are closed.

Leaving SW2 and SW3 open allows for the use of an external power supply. A low noise voltage regulated source is required to ensure optimal performances.

| SW2 | SW3 | Power Supply |
|---|---|---|
| Open | Open | External |
| Close | Close | Bus-powered |

*Table 5-1 – External power supply selection*

## 5.3 USB Audio Class

Audio Class support can be configured either by connecting the related signal on the Application Connector, or by using a jumper on SW4.

**Caution:** SW4 has to be left open in order to control this signal via the Application Connector.

| SW4 | USB Audio Class Mode |
|---|---|
| Close | USB Audio Class 1.0 |
| Open | USB Audio Class 2.0 |

*Table 5-2 – USB Audio Class on-board selection*

## 5.4 Board Dimensions

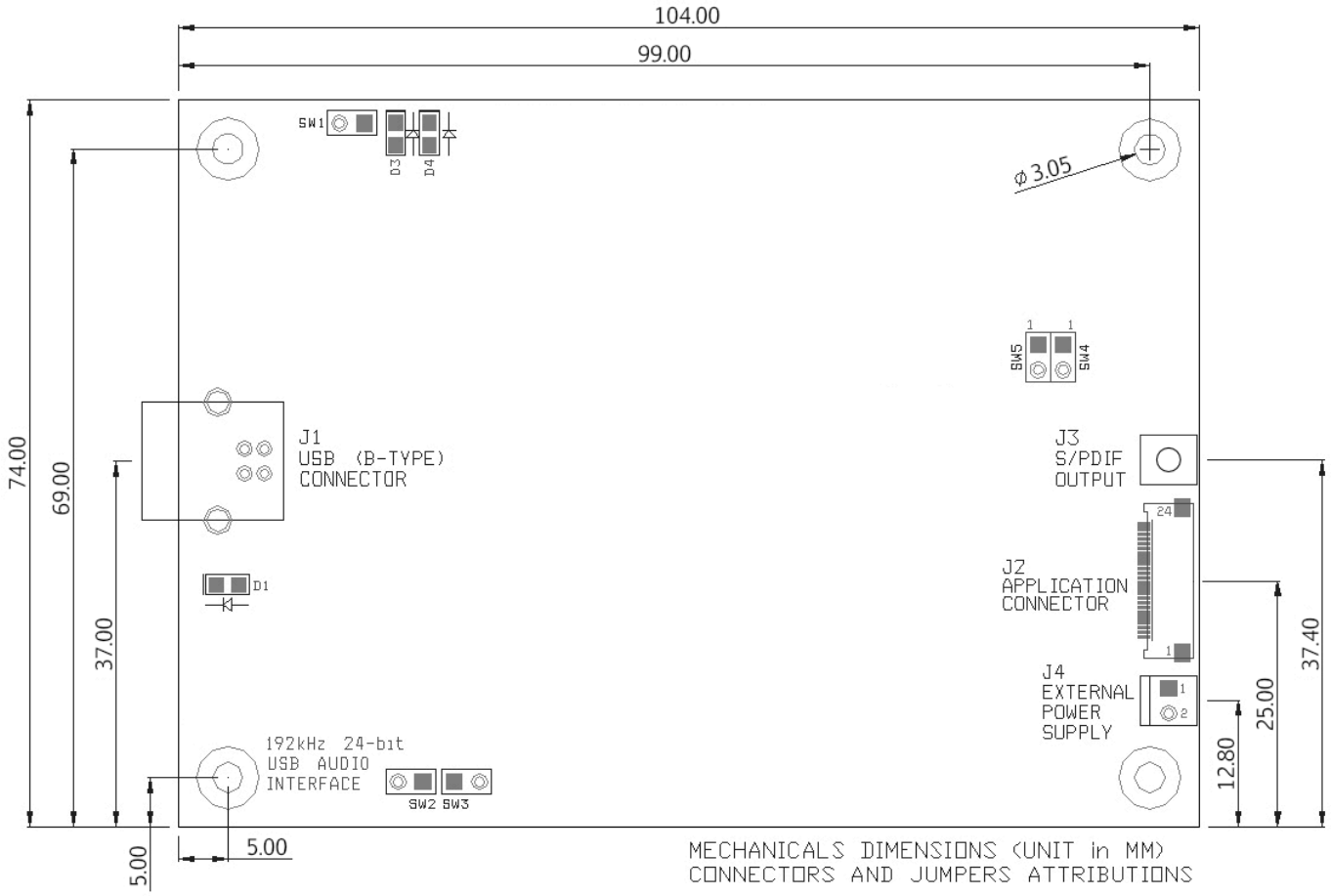


*Figure 5-2 – Mechanical dimensions*

# 6 Ordering Information

## 6.1 Part Number

| Part Number | Description |
|---|---|
| U2S192_OEM | U2S192 USB Digital Audio Interface |

## 6.2 Contact Information

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