

Application Note: AN01009

# Optimizing USB Audio for stereo output, battery powered devices

This application note characterizes the expected power usage of the Xmos USB Audio reference design running on the XS1-U6 device, configured for stereo out applications. The second part of this document outlines optional changes to the hardware and firmware, with the goal of reducing power consumption and extending battery life.

The USB Audio reference design is optimized for performance, configurability and low resource usage. The standard reference design running on the XS1-U6 comfortably fits within the USB bus power envelope with plenty of power available for support components and audio CODECs.

When powering systems from a battery, a fixed amount of energy is available. Reduction of power dissipation allows the designer to increase battery life or keep the same battery life for a smaller battery, bringing cost and form factor savings. By making different design choices and constraining the original Xmos USB Audio reference design, various power optimizations can be applied to help achieve these goals.

This application note assumes that the reader is familiar with the Xmos architecture<sup>1</sup> and the Xmos USB Audio reference design<sup>2</sup>

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<sup>1</sup><http://www.xmos.com/published/xcore-architecture?version=latest>

<sup>2</sup><http://www.xmos.com/products/reference-designs/dj>

# 1 Overview

The power measurements have been made using the following test harness:

- USB Audio 2.0 DJ Kit hardware. This board was modified to allow measurement of the current and voltage of the VSUP (XS1-U6 core) pin. In addition, the VDDIO (3v3 for I/O) supply pins were isolated from the rest of the board to allow the I/O power consumed by the XS1-U6 device to be measured. Two kits were modified to allow correlation of two different systems.
- USB Audio firmware, *sw\_usb\_audio*. The version used was 6.1.0 which was modified to support lower power operation. These code modifications will be rolled into later versions of the stereo configurations. Consequently, the baseline numbers shown here will also apply to future versions of this reference design.
- Host Macbook Air machine running OSX version 10.8.3 (Mountain Lion) with integrated USB Audio Class 2 driver.
- Host Windows machine running Windows 7 SP1 with v1.61 Thesycon USB Audio Class 2 driver.
- Gold-tree test harness Windows 7 SP1 desktop system including EHCI controller, 5 HS hubs and various USB devices sharing the USB bus.

A diagram of the chip power measurement method is shown below. There are multiple power domains within the XS1-U6 device. In this application, all of the power is drawn through the VSUP (core and PHY supply) and VDDIO (I/O supply) pins. By multiplying the current and voltage on these rails and summing both supplies, the total chip power is determined.

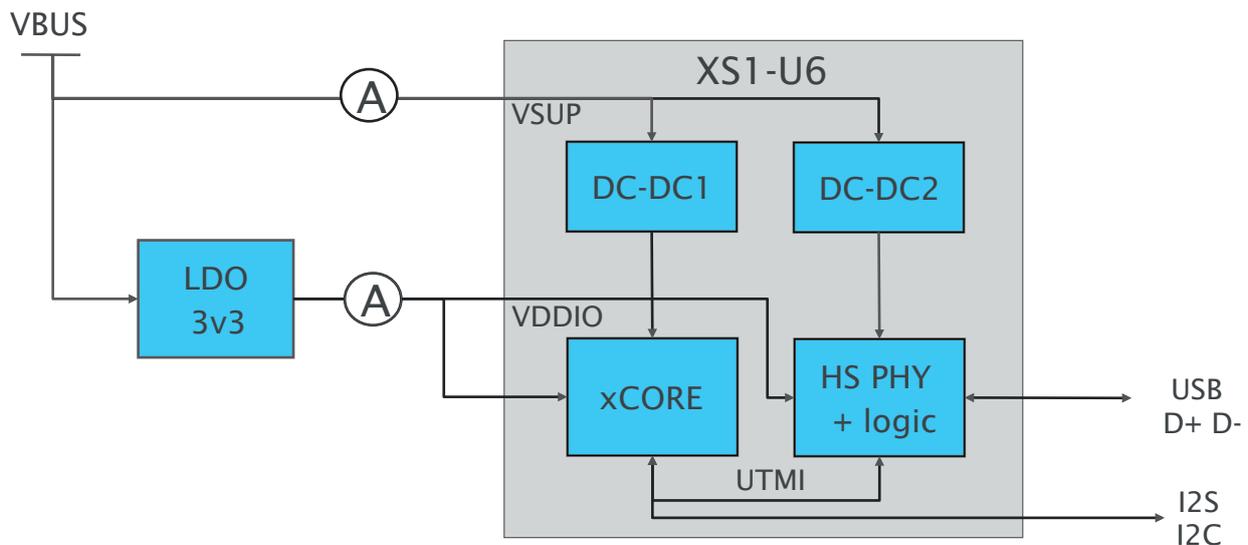


Figure 1: Test Harness

For each configuration, basic enumeration and playback was tested on both OSX and Windows 7 hosts, and power when playing audio was measured. For the final, lowest power system listed, a hub test was performed to test for the presence of audio glitches (lost samples) over a period several hours. This is a subset of the XMOS USB Audio test plan. No audio glitches were present on the stream during the testing performed and hence the lowest power configuration successfully passed the test subset.

For further information about USB testing and compatibility of XMOS USB Audio reference designs, please refer to the USB Audio System Requirements Guide<sup>3</sup>

<sup>3</sup><http://www.xmos.com/published/xmos-usb-and-usb-audio-system-requirements-guide>

## 2 Power measurement and optimizations

A number of different optimizations were applied to the reference design and their impact was measured. These optimizations can be grouped into categories.

- Reference design software architecture optimizations and configuration for stereo output only feature set. Multiple power optimization were already applied, and will be part of future releases. The result of these optimizations are characterized in the baseline power figure below.
- Hardware modification including supply voltage scaling and use of high quality inductor.
- Reference design feature reduction. Reduction of power by lowering the audio sample frequency to 48kHz and use of full speed USB Audio Class 1 and full speed USB.

The table below shows the measured power consumption of XS1-U6 USB Audio reference design, configured to stereo output, USB Audio Class 2, 192kHz which is typical for DAC type applications.

Configuration	VSUP Power	3v3 I/O Power	Total
2 out UAC2 192KHz baseline	286.3mW	56.2mW	342.5mW

Table 1: Power saving from reference design feature reduction

Next, external hardware changes were considered to help reduce power consumption. The XS1-U6 VSUP pin supplies two internal buck DC-DC converters and supports an input supply voltage of between 3V0 and 5V5. The regulators are more efficient when managing a smaller voltage drop, so the power saving was measured for a VSUP of 3V3 instead of 5V0 typical VBUS used for USB. The standard inductor (200mR ESR) for DC-DC1 that supplies the xCORE tile was replaced with a high quality, low ESR (65mR) version to minimize power loss.

Configuration	VSUP Power	3v3 I/O Power	Total
Reduced VSUP & HiQ inductor	269.9mW	56.1mW	326.0mW

Table 2: Power saving from powering down unused features

Reduction of VSUP and use of a higher quality inductor, in this case, yielded a power saving of 16.5mW.

Finally, feature reduction were applied to further save power. In many cases, it is possible to reduce audio sample frequency from 192kHz to 48kHz, which also then allows the use of full speed USB (12Mbps) and USB Audio Class 1 instead of high speed USB (480Mbps) and USB Audio Class 2. Note that the samples are still bit-perfect 24-bit and the clocking is asynchronous, so the system still delivers very high audio quality.

Configuration	VSUP Power	3v3 I/O Power	Total
48kHz sample frequency, UAC2	268.6mW	53.1mW	321.8mW
48kHz sample frequency, UAC1	261.1mW	41.4mW	302.5mW

Table 3: Power saving from feature reduction

### 3 Conclusion

This application note shows how some simple design optimizations can be made to reduce overall power consumption by up to 12%, compared with the baseline reference design. Even though the XS1-U6 provides 500MIPS of highly deterministic performance, flexible interfacing and a high level of analog integration, the device combined with our USB Audio firmware provides the highest quality USB Audio interface while drawing as little as 300mW.