Application Note: AN01004

ADAT - Replacing Wavefront AL1401/402 with xCORE

This application note describes the ADAT light-pipe protocol and an XMOS-based replacement for the Wavefront AL1401 ADAT encoder and AL1402 ADAT decoder IC's, both of which are End-of-Life products.

Prerequisites

- This document assumes familiarity with the XMOS xCORE architecture[1] and the ADAT protocol[2]. Documentation related to these aspects which are not specific to this application note are linked to in the references appendix.
- For descriptions of XMOS related terms found in this document please see the XMOS Glossary[3].

[1] http://www.xmos.com/published/xcore-architecture
[2] http://ackspace.nl/wiki/ADAT_project
[3] http://www.xmos.com/published/glossary

1 Overview

The physical interface of the ADAT protocol consists of a unidirectional connection in which the ADAT data bit-stream is transferred via Toshiba TOSlink connectors. This optical connection, along with a PTFE based carrier link, can transmit ADAT data up to a distance of about 10 meters.

Each unidirectional ADAT light-pipe consists of either 8 channels of 48kHz 24-bit audio data or 4 channels of 96kHz 24-bit audio. In addition to audio sample data the ADAT bit-stream carries synchronization information and user data. The resulting 12.288 MHz bit-stream is NRZI encoded allowing for both clock and data information to be conveyed in a single one bit-stream.

The ADAT receiver is then responsible for recovering the 12.288 MHz bit-clock and the audio data streams from the NRZI encoded ADAT bit-stream.

1.1 Wavefront AL1401/AL1402 ADAT encoder/decoder

The Wavefront AL1401AG OptoGen interface IC encodes four stereo pairs (8 audio channels) of digital audio, presented as 4 I2S/PCM data channels, and produces a single ADAT data-stream. With an internal PLL to generate all needed clock signals, the AL1401AG requires only word-clock (Fs) for proper operation.

The Wavefront AL1402G OptoRec interface IC decodes a single ADAT bit-stream and produces four stereo pairs (8 audio channels) of digital audio presented as 4 I2S/PCM data channels. With an internal PLL to generate all needed clock signals, the AL1402G requires no external clocks in master mode, and only word-clock (Fs) for proper operation in slave mode.

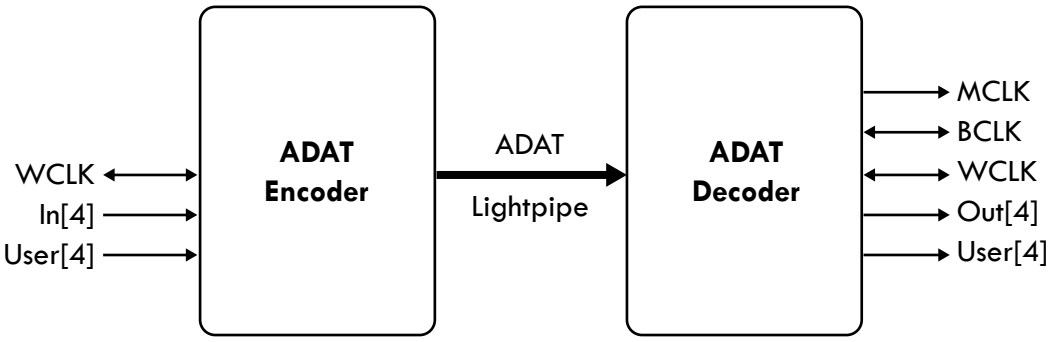

Figure 1: Simplified diagram of the AL1401 and AL1402 based ADAT encoder and receiver

1.2 XMOS Multicore Microcontrollers

The xCORE family of 32-bit multicore microcontrollers are programmed in a C/C++ environment and provide 400-1000MIPS of low latency, timing-deterministic behavior.

This architecture makes them ideally suited to implementing embedded hardware-like functionality, such as an ADAT transmitter and/or receiver.

2 XMOS ADAT encoder and decoder

The ADAT transmitter receives 4 separate synchronised 48kHz I2S streams (or 2 96kHz I2S streams) and encodes them together with master audio clock to create the 12.288 Mbit NRZI encoded ADAT bit-stream.

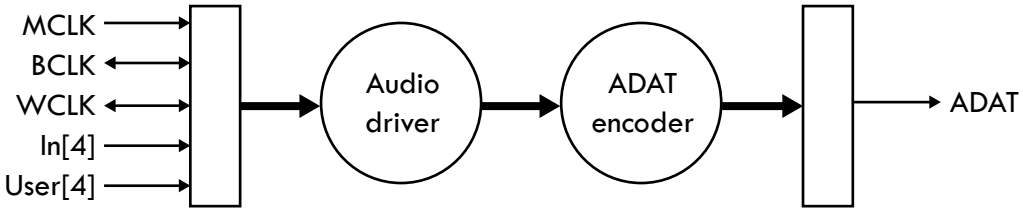

Figure 2: XMOS based ADAT encoder (I2S/TDM to ADAT conversion)

The ADAT receiver is responsible for recovering the 12.288 MHz bit-clock and the 48 kHz (or 96 kHz) word-clock from the 12.288 Mbit NRZI encoded ADAT bit-stream. The data is buffered and converted to the correct output rate, while the PLL is adjusted on a separate core and output across an I2C interface.

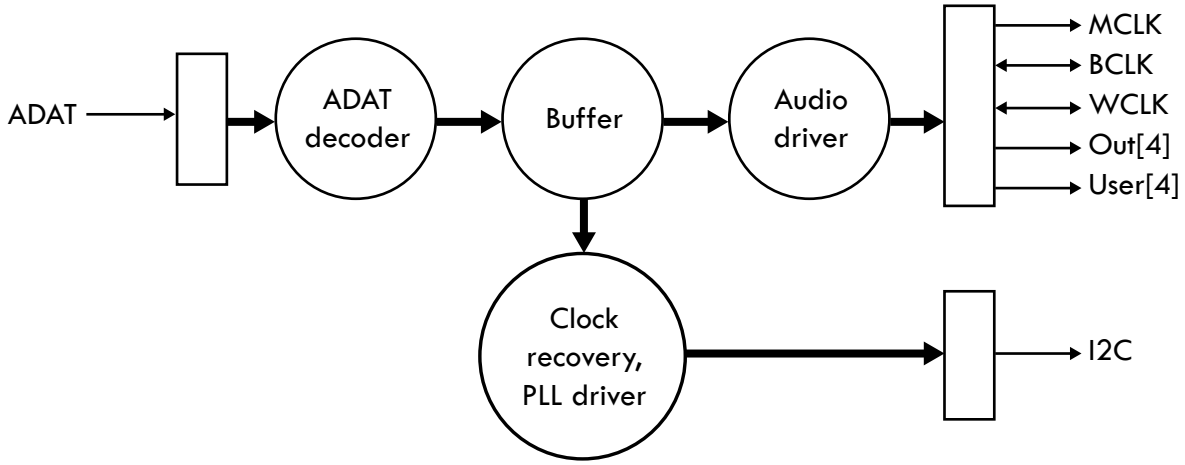

Figure 3: XMOS based ADAT decoder (ADAT to I2S/TDM)

3 Microcontroller resources

The following are estimations of the hardware resources required for implementing the ADAT transmitter and/or ADAT receiver on an xCORE multicore microcontroller:

Component	Function	Cores	RAM	MIPS	Input pins	Output pins
Transmitter	Audio Driver	1	4 KB	20	4[1] to 7[2]	0
Transmitter	ADAT Encoder	1	2 KB	20	4	1
Receiver	ADAT Decoder	1	2 KB	20	1	4
Receiver	Audio Driver	1	4 KB	20	4[1] to 7[2]	0
Receiver	Clock Recovery / PLL driver	1	<1 KB	6	0	2

[1] 5 pins for a single l I2S/TDM bus: MCLK, BCLK, LRCLK and one SDIN or one SDOUT wire.

[2] 7 pins for up to four I2S busses: MCLK, BCLK, LRCLK and four SDIN or four SDOUT wires.

Note that it is possible, due to the processing headroom in the xCORE microcontroller, to implement both the ADAT transmitter and the ADAT receiver using a single XMOS device. This can be accomplished in two ways; by using five cores to host the functions in the table above or by combining the ADAT bit-stream encoder and decoder functions into one core and also by implementing bidirectional I2S/TDM on another core resulting in a demand for four cores. Suitable devices are shown in the table below:

Part number	Cores	RAM	GPIO pins	MIPS
XS1-L4A-64	4	64 KBytes	28	400
XS1-L6A-64	6	64 KBytes	64	500
XS1-L8A-64	8	64 KBytes	64	500

3.1 More possibilities

XS1-USB multicore microcontrollers integrate a USB 2.0 PHY. These devices, in conjunction with USB Audio 2.0 firmware (available free of charge as royalty free source-code from www.xmos.com) can be used to host ADAT transmitter/receiver functionality, I2S/TDM interfaces, DSP processing, and multi-channel USB Audio 2.0 functionality. Suitable devices include:

Part number	Cores	RAM	GPIO pins	MIPS
XS1-U6A-64	6	64 KBytes	38	500
XS1-U8A-64	8	64 KBytes	38	500

4 References

ADAT project - *Danny Witberg*, Hackerspace ACKspace

http://ackspace.nl/wiki/ADAT_project

xCORE Architecture Introduction

http://www.xmos.com/published/xcore-architecture

XMOS Glossary

http://www.xmos.com/published/glossary