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# Digital Audio Solution

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## Features

Following are the features of digital audio solution:

- SPDIF or I2S digital audio
- DSP EQ functionality
- Volume control with fader
- Anti-clipping limiter
- Over-current detection
- Offset calibration
- H-Bridge output device

## Applications

Following are the applications of digital audio solution:

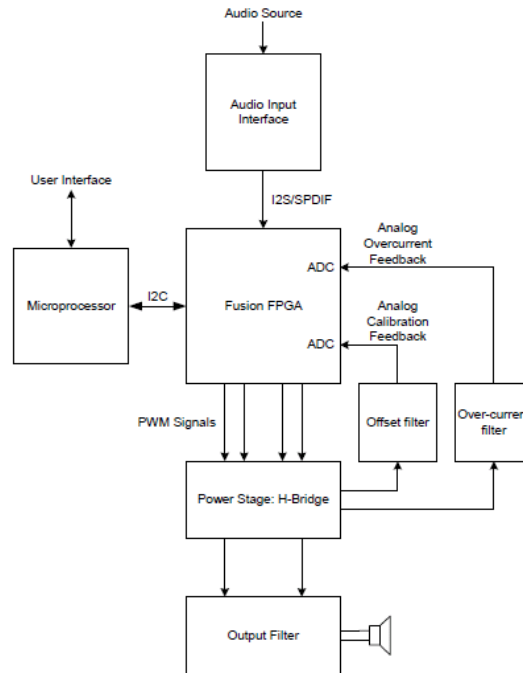
- D-class audio
- Low power audio
- Embedded audio

## Digital Audio Solution

The digital audio system provides an audio processing and amplification solution based on the Microsemi Fusion® field programmable gate array (FPGA). The solution accepts any standard digital audio format including I2S, optical SPDIF, coax SPDIF, or any of the widely used serial formats that represent variants of the standard I2S format. The audio interface converts the audio stream into logic-level signals appropriate for the digital inputs of the Fusion FPGA.

A microprocessor is used to configure the FPGA through a standard I2C interface. The microprocessor also provide the communication bridge between the FPGA and the user interface which may be implemented anything from push-button switches to a graphical Windows control interface.

The FPGA drives a standard H-Bridge which provides the power to the output speaker load. The level of the output is dependent on the PWM signals controlling the H-Bridge, which are modulated inside the FPGA. An output filter is necessary to remove the high-frequency switching elements of the output signal. The switching frequency must be set in such a way that the switching components can be adequately filtered without distorting the audio itself.



**Figure 1 • Digital Audio Solution**

The offset filter circuit measures the offset of the H-Bridge during the calibration sequence and adjusts the dynamic range as appropriate for the ADC of the Fusion FPGA. Similarly, the over-current filter measures the  $V_{ds}$  of the output FET devices to detect error conditions. The thresholds for error detection and offset compensation are set digitally inside the FPGA.

## Performance

The digital audio solution can be implemented for audio sampling rates between 48 kHz to 192 kHz, and switching frequencies up to 100 kHz. The FPGA is synchronized to the audio stream and run at 256 x the audio sampling rate, or the system clock runs asynchronously up to 100 MHz.

## FPGA Functional Description

The Fusion FPGA supports the standard audio formats including SPDIF, I2S, and other synchronous serial modes. The design provides volume control, fading, and limiting as well as a graphic equalizer for tuning poor speakers and amplifiers. The PWM output can drive an H-bridge directly, thus providing a single chip front end to an audio power stage.

The digital audio solution utilizes the ADC functionality on the Microsemi Fusion device for over-current detection and calibration. The over-current detection circuit triggers, when the analog feedback (filtered V<sub>ds</sub> of the output FET) crosses a pre-defined threshold indicating excessive source/sink current or a short to a power rail. The output is disabled in order to protect the power devices from a catastrophic failure. In a similar fashion, the analog input for the calibration circuit detects offsets in the output bridge and compensates for this in the PWM modulation.

The FPGA in the digital audio solution is highly configurable and can be dynamically configured through the I2C communication bus. Parameters such as the limiting attack and release thresholds, graphic equalizer coefficients, fading rates, over current threshold, and so on can be configured by a host microprocessor allowing for a very versatile FPGA implementation.

## About Spectrum Design Solutions

Spectrum Design Solutions is highly specialized in FPGA design and has successfully completed designs for fortune 100 companies down to small start-ups. Our engineers have many years of experience making performance trade-offs for FPGA designs targeting high speed, area reduction, and low power

Spectrum Design Solutions is an engineering consulting and product development firm headquartered at 420 North 5th Street, Suite950, Minneapolis, MN 55401. Telephone: 612-435-0789.

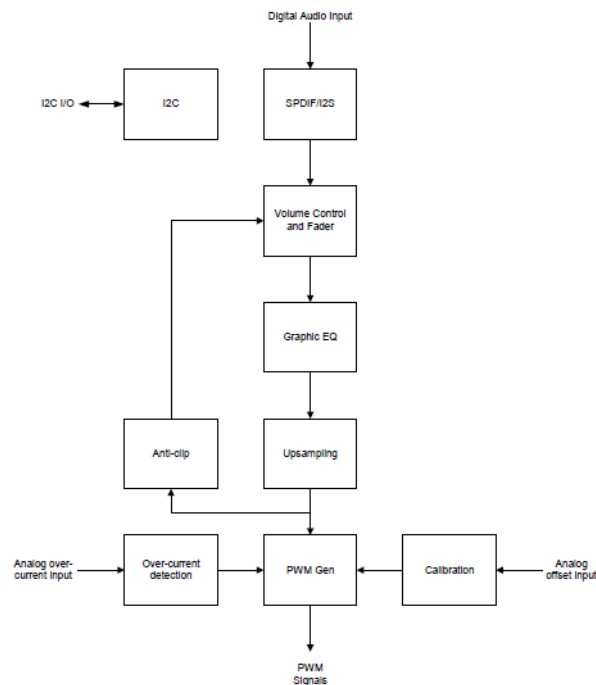


Figure 2 • Fusion FPGA Design

## List of Changes

The following shows important changes made in this document for each revision.

<b>Revision</b>	<b>Changes</b>	<b>Page</b>
Revision 1 (July 2016)	Non-technical updates.	N/A
Revision 0 (December 2005)	Initial release.	N/A



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