QF3DFX Profound Sound Audio Processor

High performance, easy to use audio processing

APPLICATIONS

- Docking Stations
- Sound Bars
- Radios
- Home Theatre
- Televisions
- Stereo Headsets (both wired and wireless)
- Automotive Audio Systems
- Any Powered Speaker Product

KEY FEATURES

- Zero software required
  - Device controls volume up, down, mute and profile switches
  - Self booting from external EEPROM
- Optionally, a microcontroller can dynamically reconfigure device via I2C or SPI
- Input
  - I2S, 2-channel stereo
  - TDM, up to 8 slots
- Output
  - I2S, up to 6 channels
  - TDM, up to 6 channels of an 8-slot system operated on. Remaining channels pass thru untouched
- Automatic Gain Control
- Dynamics Processing
  - Dynamic Bass and Treble
  - Soft compression
- Psychoacoustics
  - Virtual Bass
  - Spatialization
  - High Frequency Recovery
- Equalization
  - Both Parametric and Graphic EQ
  - User controlled with up to 8 profiles
- Subsonic filtering
- Digital Volume Control with mute
- Crossovers
- Low power, can run from 1.8V supply only
- 1.8V/3.3V I/O, 5V level compatible

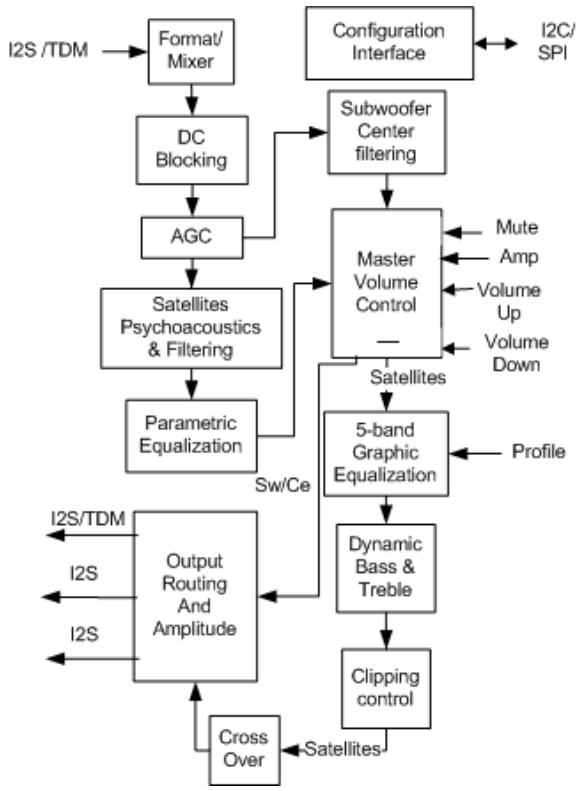
OVERVIEW

The QF3DFX Profound Sound audio processor provides high performance, royalty free algorithms utilizing Quickfilter's Profound Sound™ technology. These algorithms are fully user tunable. The QF3DFX delivers deep, powerful bass, crisp high frequency notes with pleasing volume, and enhanced stereo separation even when using low cost speakers placed close together.

The QF3DFX can operate without a microcontroller present in the system. It will boot directly from EEPROM. The QF3DFX provides pin control for volume up, volume down, mute and equalization profile buttons without any other micro or software required. The device can be configured to easily interface with I2S or TDM based audio systems. The QF3DFX automatically powers down when audio data is not present.

Using Quickfilter's QFPro™ PC-based development tool, the complete chip can be configured with zero software being written. The developer can select options from basic menus to configure and tune the chip's audio parameters to the needs of his specific application in minutes.

The chip can also be fully controlled by a micro, if desired, using either an I2C or SPI interface. All QF3DFX registers can be individually controlled by the micro.



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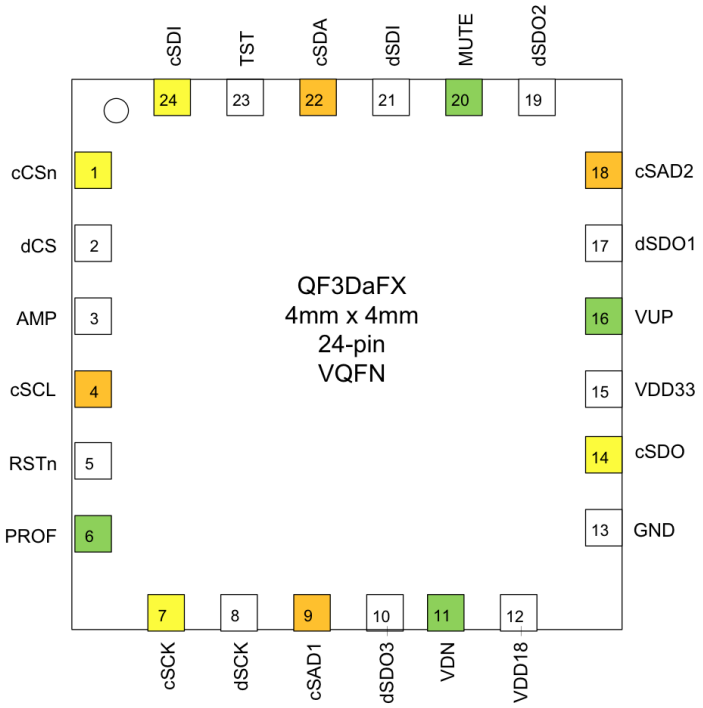
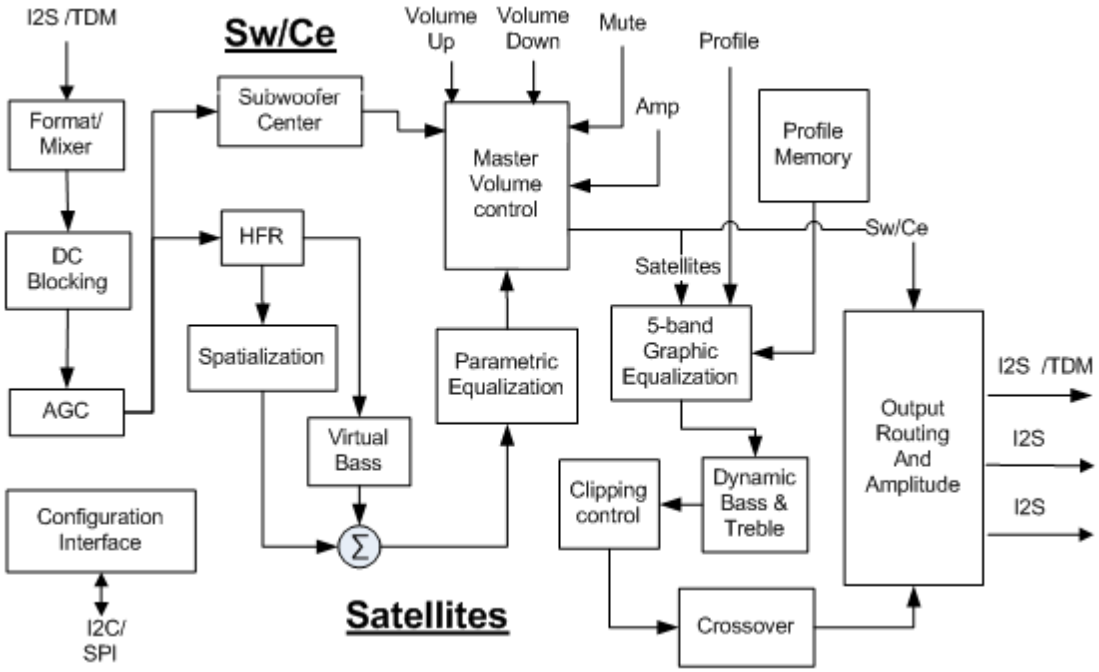
1.0 PIN OUT AND PIN DESCRIPTIONS



Pin	Signal Name	I/O	Type	Description
1	cCSn	I	Digital	SPI configuration chip select; active low; default internal pull-up
2	dCS	I	Digital	I2S / TDM chip select; configurable as active low or high
3	AMP	I	Digital	will reduce overall amp gain be programmed value if asserted
4	cSCL	I/O	Digital	I2C configuration clock
5	RSTn	I	Digital	chip reset; active low; default internal pull-up
6	PROF	I	Digital	round robin cycles thru profiles
7	cSCK	I	Digital	SPI configuration input clock; rising capture edge
8	dSCK	I	Digital	I2S/TDM data input clock; either rising or falling capture edge
9	cSAD1	I	Digital	I2C configuration address 1
10	dSDO3	O	Digital	I2S data output
11	VDN	I	Digital	volume down
12	VDD18	N/A	Power	digital core voltage; 1.8V fixed
13	GND	N/A	Return	digital power supply return pin
14	cSDO	O	Digital	SPI configuration serial data output
15	VDD33	N/A	Power	digital I/O voltage; 1.8V - 3.3V
16	VUP	I	Digital	volume up
17	dSDO1	O	Digital	I2S / TDM data output
18	cSAD2	I	Digital	I2C configuration address 2
19	dSDO2	O	Digital	I2C data output
20	MUTE	I	Digital	mute
21	dSD1	I	Digital	I2S / TDM serial data output
22	cSDA	I/O	Digital	I2C configuration data

23	TST	I	Digital	production test
24	cSDI	I	Digital	SPI configuration data input

2.0 GENERAL DESCRIPTION



2.1 General

The QF3DFX is an internal 3-channel audio processor with psychoacoustics, dynamics processing, volume control and filtering. The serial data interface can accept up to 2-channels of I2S or up to 8 slots of TDM source data which can be mixed to 1, 2 or 3 internal channels.

All 3 internal channels receive subsonic filtering and automatic gain control. The mono channel is directed to a series of filters for band limiting and parametric equalization. The satellite channels pass through psychoacoustic effects, parametric and graphic equalization.

All 3 channels converge at the master volume control. The volume can be controlled externally via 3 pins which allow for slew rate controlled volume up, volume down, and mute. There is an additional pin which can take feedback from an external amplifier for thermal issues.

The graphic equalizer can be externally controlled via another pin. One switch can be used to change profiles with an optional tone acknowledgement.

All audio features of the chip can take on more elaborate forms of presentation in systems which use a microcontroller.

Dynamic bass, dynamic treble, soft signal management, and crossovers are available for the satellite channels. The output is capable of weighted routing of any internal channel to any output channel or slot position.

All filters are IIR based and utilize full noise shaping for the highest audio performance. There are no periodic attributes added to the audio content from the filter processing.

Multiple QF3DFX devices can be used in series to process all the channels of a TDM stream or in parallel utilizing the I2S outputs.

2.2 Format/Mixer

Serial audio streams of 24 or 16-bit data of I2S (up to 2 channels), Left Justified, Right Justified, or TDM (up to 8 slots) are supported. The input source data (channels or slots) can be mixed and reduced to any of the 3 internal channels (2-satellite channels and 1-subwoofer/center channel).

The QF3DFX utilizes the incoming bit clock and framing signal to exit power down mode and process the incoming serial audio data stream. The QF3DFX returns to power down mode when these signals are not active. If desired, the QF3DFX can be bypassed. The bypass function simply routes the input to one channel of the output.

2.3 DC Blocking

This block provides filtering for classic audio DC blocking as well as providing subsonic filtering to remove low frequencies which are below the traditional 20Hz range of human hearing.

2.4 Automatic Gain Control, AGC

The function of the AGC is to keep the input signal energy between the high and low threshold values; each is highly programmable. The satellite channels share common configuration settings and the Sw/Ce channel has independent settings.

The AGC has programmable attack, release, high threshold, low threshold, noise threshold and averaging. The AGC is fully capable of supporting dynamic range compression. The RMS averaging time is developer programmable to support special modes such as “Night Mode” and “Commercial Mode**.”**

Night mode reduces relatively loud audio content and raises soft audio content when a more constant audio level is desired.

The AGC can also be setup to quickly reduce loud content only and not increase lower level content. Commercial content has a higher average value than the program content and is perceived as having increased volume. The AGC can be setup to quickly lower the commercial volume without affecting normal program volume.

2.5 Subwoofer/Center, Sw/Ce

The Sw/Ce block is a mono channel for subwoofer or center channel processing. It is comprised of 7 2nd-order biquad filters for band limiting and parametric equalization. The Sw/Ce block output gain is independently adjustable for balancing with the satellite channel gain.

QFPro's parametric equalization design tool can be used to dynamically view overall results while selecting filter types and adjusting corresponding parameters.

2.6 High Frequency Restoration, HFR

Most audio data compression algorithms, such as MP3 encoding, limit the high frequency content. The High Frequency Restoration (HFR) block estimates and restores high frequency content that has been lost due to audio data compression or other processing.

The HFR block can also be used with full-band audio to emphasize high frequency content or to compensate for speaker performance. Common coefficients are utilized for both satellite channels. The HFR function is highly programmable and includes gain control for mixing the resulting effect back with the source audio data.

2.7 Spatialization, SP

The SP block uses a proprietary algorithm to enhance the sense of stereo separation in the audio signal. Many audio platforms have speakers that are in close proximity, and therefore do not have the desired stereo separation or sense of spaciousness. The SP block enhances the stereo separation that is present in audio data to increase the apparent speaker separation.

The Spatialization function is highly configurable with fully independent common and side processing with a spatialization enhancement option. The common and side signals can be independently colored (filtered) and amplitude adjusted.

2.8 Virtual Bass, VB

Smaller enclosures use smaller speakers that do not typically reproduce bass frequencies well. By using Quickfilter's virtual bass effects block, more apparent bass can be added to the satellite channels. The VB function is highly programmable and provides the necessary band limiting, effects algorithm, and gain necessary for virtualization of source bass content, including gain control for mixing the resulting effect back with the source audio data. Both satellite channels share common settings.

2.9 Parametric Equalization, PEQ

The Parametric Equalizer is used for system requirements (e.g., band limiting, coloring, etc.) and speaker related performance attributes and is comprised of 10 2nd-order biquad filters with common

coefficients for both satellite channels. QFPro's parametric equalization design tool can be used to dynamically view composite results while selecting filter types and adjusting corresponding parameters.

2.10 Master Volume Control, MVC

The MVC comprises volume, mute, loudness, and amplifier protection features for both the satellite and Sw/Ce channels.

Each of the three internal channels share a common setting which can be varied from -96dB to +24dB (including mute) with a granularity of 1 dB, The volume level sequencing can be a unique, non-linear volume sequence setup up through a user programmable 100-step table. A SPI or I2C bus master can also directly control the volume.

The MVC block also includes a user programmable slew rate to manage volume changes.

Volume up, down, and mute can be controlled from QF3DFX pins. This method of controlling volume is useful in applications where there is no external microcontroller in the system.

Each of these pins is configured with an internal pull-up resistor. The only external hardware required is a momentary switch. When the switch is closed, it should drive the pin level to ground. Internal logic provides a de-bounce function. There is no need for external debouncing circuitry.

An amplifier protection pin is provided to aid in the protection of amplifiers from thermal issues. If the pin is held low for at least 30 nsec, the volume is decreased by a user programmable level. The reduced volume will remain until the pin is released. This feature utilizes the volume slew feature and, therefore, the volume change will not be abrupt.

2.11 5-Band Graphic Equalizer, GEQ

The GEQ is a 5-band graphic equalizer that can be controlled by the end user. Each of the parallel bands is composed of a 2^{nd}-order filter and can be independently varied from -12dB to +12dB by the profile pin or directly by a SPI or I2C bus master.

The end user can control the GEQ by choosing one of several profiles. The profiles are a set of coefficients for the filters that produce a certain shape in the frequency response of the GEQ.

This method of controlling volume is useful if there is no external microcontroller in the system. Each time the profile pin is momentarily toggled low, the profile advances in a round-robin fashion. The profile pin is configured similar to the volume pins described above.

There is an option for a tone to be generated for each profile thereby providing the end user with a low cost indication of the profile selected. The tone for the first profile can be set independent of the other profiles. Both tones have frequency and amplitude programmability.

2.12 Profile Memory, PM

This is an internal memory structure utilized for coefficient storage of up to 8 profiles. This is for profile pin use only.

2.13 Dynamic Bass and Treble, DBT

Dynamic bass compensates for the difficulty in hearing bass as the volume is decreased. The DBT block compensates for this by boosting lower frequencies as their energy level decreases.

Dynamic treble compensates for higher frequency content that drops below a relative reference. The BDT block will boost the higher frequencies.

Dynamic bass and dynamic treble can be independently enabled and are highly programmable with respect to operating frequency range and corresponding amplitudes.

2.14 Clipping Control

A programmable standard cubic compressor soft clipper is available in the QF3DFX.

2.15 Crossover

The crossover block will split each input channel into two audio frequency bands by use of a high-pass filter and a low-pass filter. This allows the user to better match the low and high frequencies to the speakers (i.e. woofers and tweeters). The filters will be in the form of a crossover filter in which each will share the same corner frequency. The block is comprised of 8 2^{nd}-order filters capable of many types of crossover structures including the classic Linkwitz-Riley filter.

2.16 Output Routing and Amplitude, ORA

For the I2S or TDM outputs, any of 5 internal channels (satellites crossed plus Sw/Ce) may be directed to any of the available 6 output I2S channels or TDM slots, including directing a single channel to all available channels or slots.

The amplitude of each the output channels can be independently adjusted. This amplitude can be negative allowing for the creation of digital differential outputs if required in the target system.

2.17 Configuration Interface, CI

The Configuration interface is used to read and write the control registers and program the coefficient memory space. It supports both I2C and SPI protocols. I2C can be a master and a slave while SPI operates only in slave mode. There are two I2C address pins available for I2C system requirements.

The configuration interface supports self-booting (configure and run) from an external I2C EEPROM. The EEPROM is also utilized to save the previous values for volume level and profiles selected. These can be optionally restored at the next power up.

The external I2C EEPROM is a16-bit format device.

The SPI Interface is capable of operating at speeds of up to 20MHz. The I2C interface can run at speeds of up to 400 kHz. Both interfaces can run at much slower speeds if required by other system components.

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