



# Soundbars:

## A MARKET OVERVIEW AND DESIGN CONSIDERATIONS

By David Grant, Sr. Product Marketing Manager, DSP Business Unit, Cirrus Logic, Inc.

Is it possible to get a decent-quality audio experience from a flat-panel HDTV chassis? Most of the time, the answer is a clear 'no.'

Cramming high-quality audio components—good sounding speakers, high-quality amplification and low-resonance cabinet—into the confines of a flat-panel HDTV simply isn't a feasible solution. The trends of the HDTV market are constantly working against the designer. As a result, most flat-panel HDTVs provide at best a below-average audio experience, characterized by tepid output power through tiny speakers that, more often than not, are incapable of meeting consumer's expectations when compared to the video experience.

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## ENTER THE SOUNDBAR

No, it's not a place where singles go to drink and listen to music on headphones. It's a sleek, thin, modern-styled powered speaker that is located directly below your brand new flat-panel TV which significantly improves the audio experience without the complexity of an entire home theater set up that involves hanging surround speakers, running wires, etc.

Like DVD receivers and iPod® docking stations before them—which emerged many years ago and now are considered a standard product category within the consumer electronics universe—soundbars are at the beginning of a new growth wave that will become a solid market segment.

Soundbars have broken into the home theater scene by offering an intriguing value proposition. They bridge the gap between the complete audio shortcomings of the HDTV and high-end home theater systems featuring an A/V receiver and a full complement of surround-sound speakers.

One of the hottest products in consumer electronics today, soundbars are expected to have a world-wide CAGR of 70.3% (2007–2012 source: IMS).

Early entrants into the “active” or “amplified soundbar” market, including Yamaha, Philips, Sony, Samsung (see figure, below) and Vizio have rightly recognized that for soundbars to gain acceptance by consumers they too must adhere to the principles that made flat-panel TVs so successful: sleek, minimalist designs that deliver a step up in performance compared to the integrated TV audio system.

Other traditional passive speaker manufacturers such as Polk Audio, Boston Acoustics and Atlantic Technology have also thrown their hat into the ring, but one might question whether these products (which are sans amplification and audio processing capabilities) are truly soundbars or simply traditional speaker systems appealing to those who would prefer to run all of the speaker wires to a single location. It can be argued that “true soundbars” are amplified systems with integrated audio decoding and processing, because these are the products that are capable of solving customer problems beyond the desire for aesthetics.

In the HDTV space, LCDs and plasmas were a significant step forward in technology, quality, size, weight and appearance compared to their CRT and projection system brethren. Likewise, soundbars are finding their niche because they are a significant step-up in sound quality compared to integrated HDTV speakers. Most importantly, they don't require the chunk of change or sacrifices in visual aesthetics as in home theater systems.

Many consumers also shy away from surround-sound systems (HTiBs or AVRs with passive speakers) because of the complicated design, wiring and installation headaches that often come with the commitment to achieve the complete “home theater experience.” To contrast, more and

more soundbars are incorporating a wireless subwoofer allowing for freedom of placement within the room.

Soundbars are delivering a solid audio experience in a way that makes it easy, attractive and cost effective—plus they're delivering on the not-to-be-overlooked factor of spousal approval. The industry has recognized that many households simply don't want—or don't have the physical structures or budget—to support a complex home theater system, especially in secondary or tertiary installations. To this audience, soundbars are finding a strong market.

## SOUNDBARS AS A HDTV & MONITOR ACCESSORY

You can't unlink the soundbar from the flat-panel buying experience. The soundbar should best be viewed as an accessory to the HDTV purchase experience, much like HDMI™ cables.

The current line up of soundbars range from products offering minimal audio features at about \$99 all the way up to more advanced systems that marry the soundbar into a full-blown home theater in a box (HTiB) system replete with DVD playback. But common varieties of soundbars today have a few defining characteristics: two to five speakers, one or more audio inputs, some level of audio post-processing capability with a virtual surround-sound or sound beam steering feature in order to “place” the audio around the listener. Most importantly, they are all designed to sit underneath the TV itself, blending seamlessly to both appear and function as a single device.

At the OEM level, what's interesting is that this market has no current incumbent majority market leader today. The game is wide open for success, and the field of players is not limited to just the traditional speaker manufacturers.

Even HDTV manufacturers are looking very hard at soundbars, believing they have a unique advantage compared to other manufacturers because they can develop soundbars that are an extension of their branded TVs, with an integrated remote control and more seamless operation. Other market players include premium electronics brand manufacturers and companies who have made their name in peripheral products, such as docking stations.



**VSB210WS 2.1-CHANNEL SOUNDBAR BY VIZIO®**

This product gets its audio processing power from Cirrus Logic's CS48520 audio DSP, the digital audio input from S/PDIF sources are handled by the Cirrus Logic CS8416, while the analog inputs are converted to the digital domain by the Cirrus Logic CS5341.



**Figure:** Samsung's HT-X810 is a full-featured soundbar that boasts 300 W of total power. Designed to complement most flat-panel TVs, it also features a wireless subwoofer.

It gets its audio processing power from the Cirrus Logic [CS48540](#) audio DSP, while the Cirrus Logic [CS5345](#) A/D converter handles audio conversion tasks.

It makes a lot of sense that soundbars will be successful too. Big box CE retailers have recently given considerable shelf space to soundbars. To these retailers, soundbars offer an excellent sales opportunity—especially as measured by the benchmark revenue per square foot—with strong margins for all the players. The OEM/ODM, the TV brand and the retailer are all excited at the idea of being able to tack on a \$99–\$499 up sale at the point of sale when selling any HDTV or Entertainment PC product.

## DESIGN CONSIDERATIONS

If you're in the game already, or thinking about jumping in while the water's still warm, there are a few design and engineering guidelines to first understand.

For soundbars to prove their worthiness, they have to give consumers a perceived measure of performance improvement compared to the TV audio itself (hence the very reason for their existence), and product designers and marketers would do well to remember that in retail outlets competitive products will often sit side-by-side and be judged by consumers—much like after-market automotive audio systems.

First, if you're making a basic product, such as a two speaker system, at minimum you're looking at having a stereo analog interface and possibly some other audio input such as S/PDIF. Remember that this product is all about blending seamlessly with the sleek and slim TV design, and so going with Class-D amplifier technology is a foregone conclusion. Class A/B amplifiers just won't cut it when it comes to conforming to slim form factors while meeting the power requirements of even the lowest cost soundbar designs on the market today due to heat generation issues from this inefficient amplifier technology.

Fifteen watts/channel output for stereo or 2.1 channel configurations is a minimum in order to compete with HDTVs that are already offering ten watts/channel, albeit the drivers and cabinet will go a long way to improving the audio along.

From there, mid-range models with at least three speakers will require Class-D solutions offering at least 45 to 90 W of total output power. Typically, mid-range models also offer a separate wireless powered subwoofer option, which can have output power ranging from 50 W up to 250 W.

Aside from just improving TV sound incrementally compared to the TV's speakers, most soundbars seek to add additional value by incorporating other audio features that require post-processing capability, such as Audistry™ by Dolby,® Dolby Pro Logic® IIx, Dolby Virtual Speaker,® Dolby Headphone,® DTS Surround Sensation Speaker MaxxBass, SRS TruSurround XT®/HD/HD4, Bass Management, multiband parametric equalization for speaker/cabinet tuning as well as the brand new audio-leveling/modeling technologies that include either Dolby Volume,® SRS TruVolume™ or Audyssey Dynamic Volume™ technologies.

More advanced soundbars will start to incorporate more speakers, both for improved sound quality as well as to incorporate surround-sound decoding functionality. They'll need to incorporate HDMI™ 1.3A (or later) in order to support high bit-rate bitstream outputs from the latest Blu-ray Disc® players, offer wireless subwoofer connectivity and perhaps be ready for peripherals such as iPod and Sirius®/XM® satellite radio. Some high-end products today are even incorporating Blu-ray Disc playback directly. Truly, these systems are not your father's Home Theater in a Box!

## BASIC IC REQUIREMENTS

- Class-D Amplification
- Analog, S/PDIF and/or HDMI™ 1.3A (or later) audio inputs
- Audio DSP (for decoding and/or audio processing)

And while the market is wide open for manufacturers, at a quick glance it may appear that the branded TV manufacturers themselves might hold an advantage, due to their ability to give consumers a product that works seamlessly with the TV's operation. In this scenario, the assumption is that the consumer would prefer, and perhaps even pay a little extra for, a soundbar whose operation could be controlled directly through a single TV remote or the TV's onscreen display menus.

But because the market is still so fresh and new, there's not one particular approach to soundbar design and development that has established itself as a clear-cut leader with consumers. The playing field is still wide open. And most importantly to manufacturers, it's still a fast-growing market segment that will likely become a solid niche area of consumer electronics for years to come.

## SOUNDBAR DESIGN OPTION EXAMPLES

### ENTRY-LEVEL MODEL

- S/PDIF and/or analog input
- 2.1 channels of output (external powered subwoofer optional)
- At least 15 W/channel
- Spatialization/Virtualization/Audio Enhancements (Dolby Virtual Speaker, Dolby Headphone, Audistry by Dolby, DTS Surround Sensation,<sup>®</sup> SRS TruSurround XT/HD/HD4, SRS Headphone 360<sup>™</sup>)
- Audio Leveling & Modeling (Dolby Volume,<sup>®</sup> SRS TruVolume,<sup>™</sup> Audyssey Dynamic Volume & Audyssey Dynamic EQ<sup>™</sup>)

### MID-RANGE MODEL

- HDMI<sup>™</sup>, S/PDIF and analog inputs
- At least 3.1 channels of output (with wireless powered subwoofer)
- At least 15 W/channel
- Legacy Compressed Audio Decoder Support (Dolby Digital,<sup>®</sup> DTS Digital Surround<sup>™</sup>, MPEG, Multichannel, AAC<sup>™</sup>)
- Matrix Decoding (Dolby<sup>®</sup> Pro Logic<sup>®</sup> IIx, DTS Neo:6,<sup>®</sup> Logic7,<sup>™</sup> DTS Neural Surround<sup>™</sup>)
- Spatialization/Virtualization/Audio Enhancements (Dolby Virtual Speaker, Dolby Headphone, Audistry by Dolby, DTS Surround Sensation, SRS TruSurround XT/HD/HD4, SRS Headphone 360<sup>™</sup>)
- Audio Leveling & Modeling (Dolby Volume, SRS TruVolume, Audyssey Dynamic Volume & Dynamic EQ )

### HDTV CONNECTED HD AUDIO SOUNDBAR

- Single HDMI<sup>™</sup> v1.3 or v1.4 input (when used in conjunction with an HDTV that offers HDMI v1.3 or v1.4 output)
- Up 5.1 channels of output (with wireless powered subwoofer)
- Up to 30 W/channel
- HD Audio Decoder (DTS-HD<sup>®</sup> Master Audio, DTS-HD High Resolution Audio, Dolby TrueHD, Dolby Digital Plus)
- Legacy Compressed Audio Decoder Support (Dolby Digital, DTS Digital Surround, MPEG Multichannel, AAC)
- Matrix Decoding (Dolby Pro Logic IIx, DTS Neo:6, Logic7, DTS Neural Surround)
- Spatialization/Virtualization/Audio Enhancements (Dolby Virtual Speaker, Dolby Headphone, Audistry by Dolby, DTS Surround Sensation, SRS TruSurround XT/HD/HD4, SRS Headphone 360)
- Audio Leveling & Modeling (Dolby Volume, SRS TruVolume, Audyssey Dynamic Volume & Audyssey Dynamic EQ)
- iPod/Sirius/XM connectivity & HD/FM/Internet Radio

### TWO-WAY COMMUNICATION WITH HDTV VIA SINGLE HDMI CONNECTION

HDTV splits audio from video signal from HDMI and routes all digital audio signals to internal HDMI Tx—audio is then received by the HDMI Rx inside the Soundbar—Automatically configures A/V sync settings depending on both audio and video mode

- Covers legacy video inputs
- Single remote control functionality
- On Screen Display of soundbar stream type/decoding/processing/volume level status via TV integrated OSD

## CIRRUS LOGIC SOUNDBAR REFERENCE DESIGN SOLUTIONS

Cirrus Logic has developed proven, turnkey soundbar reference designs with all the required components — DSP, digital amplifier, DAC, S/PDIF receiver — to get customers into production fast. These reference designs are FCC Class B certified, RoHS compliant and come equipped with complete design files such as schematics, bill of materials, system-level microcontroller source code and Gerber files.

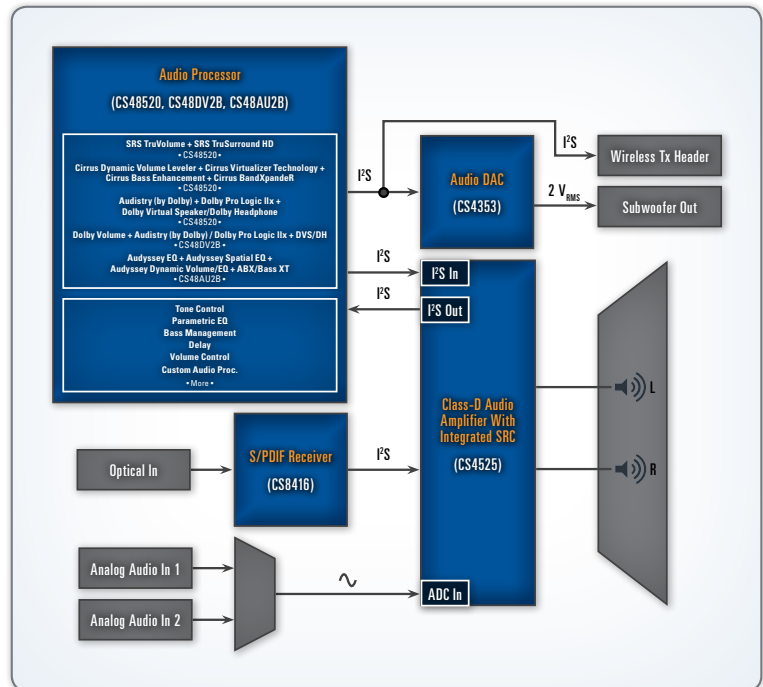
## CIRRUS LOGIC SOUNDBAR REFERENCE DESIGN EXAMPLES

CRD-SB15Wx2 15W x 2 Channel Soundbar with 2  $V_{RMS}$  Subwoofer Line Out (see diagram at right)

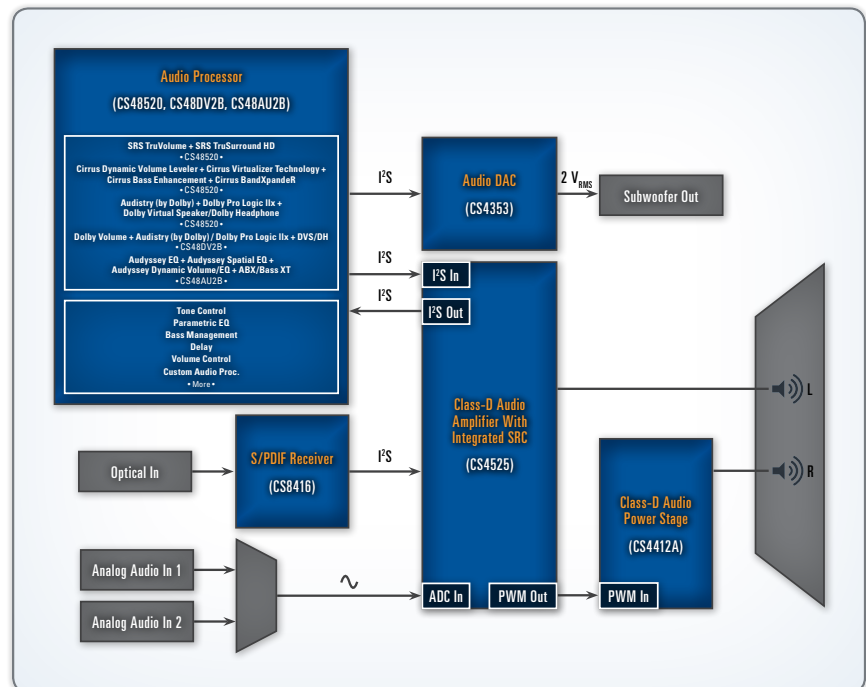
CRD-SB30Wx2 30W x 2 Channel Soundbar with 2  $V_{RMS}$  Subwoofer Line Out (see diagram below)

### FEATURED CIRRUS LOGIC ICs

- CS48520 32-bit audio DSP
- CS4525 30W digital amplifier with stereo A/D converter
- CS4412A 30W Class D audio power stage (CRD-SB30Wx2 only)
- CS4353 Stereo D/A converter with 2  $V_{RMS}$  line out
- CS8416 S/PDIF receiver



CRD-SB15Wx2 15W x 2 Channel Soundbar with 2  $V_{RMS}$  Subwoofer Line Out



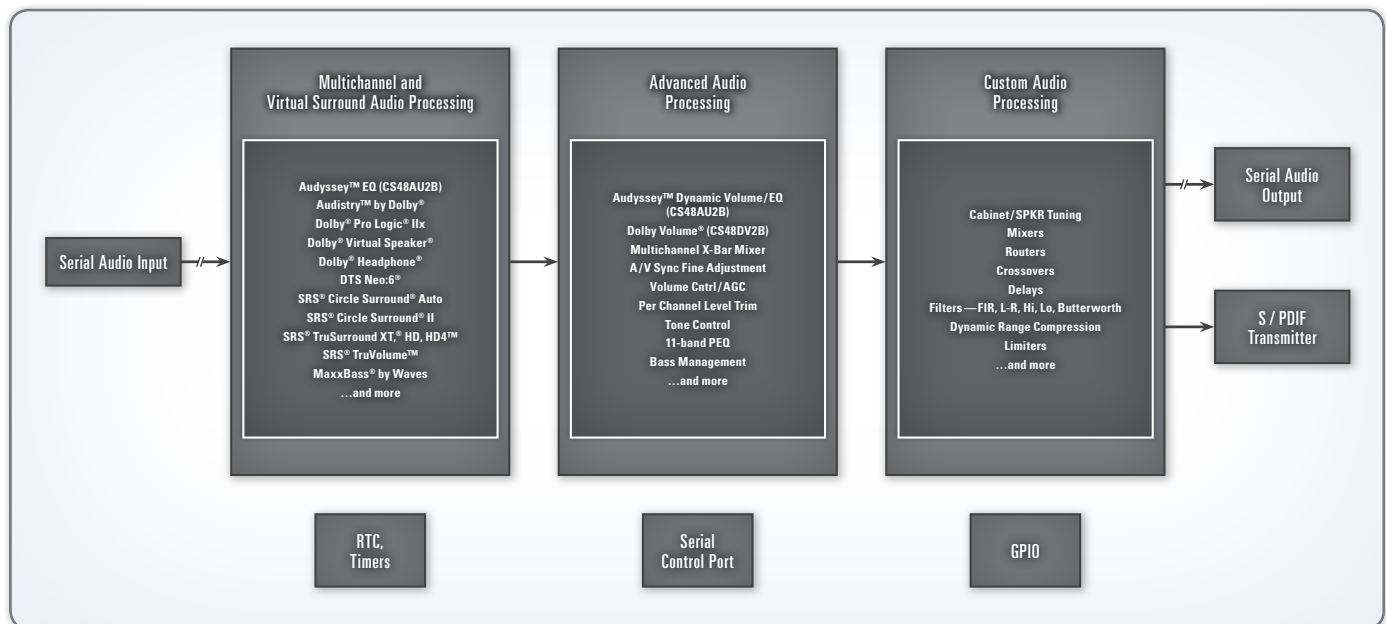
CRD-SB30Wx2 30W x 2 Channel Soundbar with 2  $V_{RMS}$  Subwoofer Line Out

## SOUNDBAR REFERENCE DESIGNS — FEATURED ICs

## CS485X0 / CS48DV2B / CS48AU2B AUDIO DSPS

## Features

- Multichannel 32-bit audio post processing at 150 MHz with dual MACs (300 M MACs/Sec)
- CS48520 supports 4 channel 32-bit PCM I/O
- CS48540 supports 8 channel 32-bit PCM I/O
- CS48560 supports 12 channel 32-bit PCM I/O
- CS48DV2B supports 2 channel Dolby Volume processing including concurrent support for: Audyssey by Dolby or Dolby Pro Logic IIx or Dolby Virtual Speaker
- CS48AU2B supports 2 channel Audyssey processing including: Audyssey EQ, Audyssey Dynamic Volume/EQ, Audyssey Bass XT/ Audyssey Adaptive Bass eXtension (ABX)
- 192 kHz S/PDIF Tx
- SPI™/I<sup>2</sup>C® serial control port
- Low-power standby: 260µW
- Large on-chip RAM & ROM
- DSP Composer programmable GUI software tool
- The very latest licensed third party audio processing algorithms from SRS Labs, Dolby Laboratories, DTS Inc., EmbracingSound, Expamedia, Waves, and Audyssey Laboratories.
- An extensive library of Cirrus proprietary downloadable and customizable firmware



CS485x0 / CS48AU2B / CS48DV2B

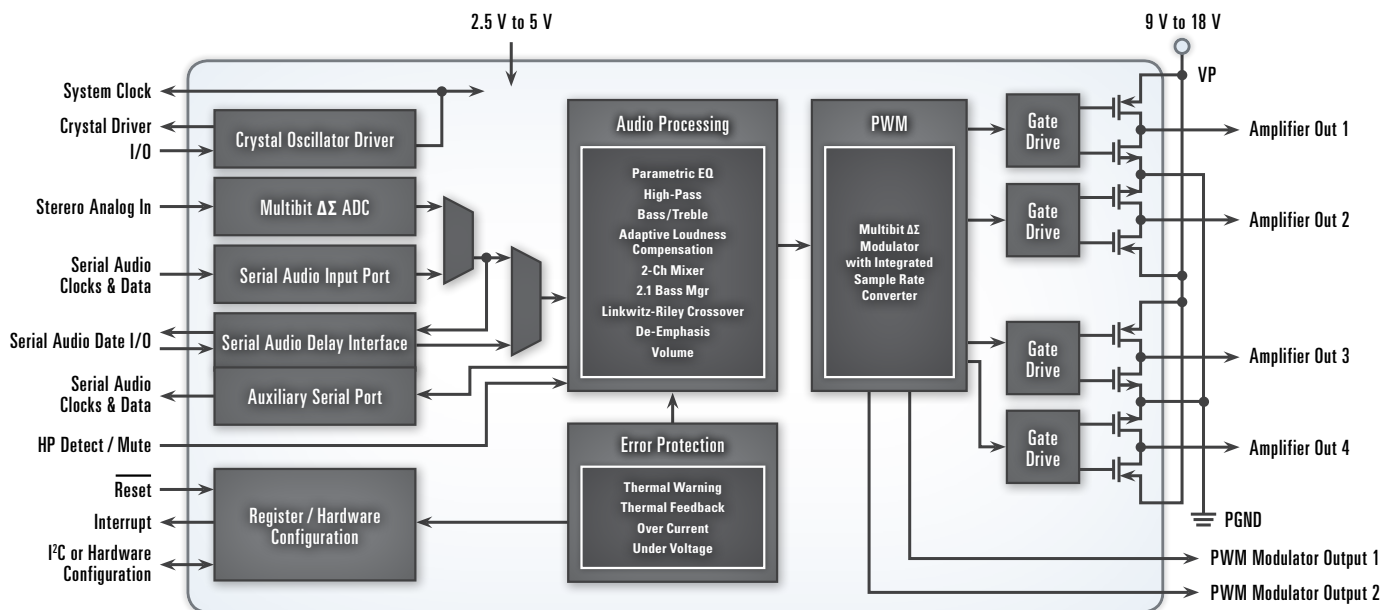


## SOUNDBAR REFERENCE DESIGNS — FEATURED ICS (CONTINUED)

## CS4525 30 W DIGITAL AUDIO AMPLIFIER WITH INTEGRATED STEREO A/D CONVERTER

## Features

- Fully integrated power amplifier
- Integrated stereo A/D converter, sample-rate converter, digital audio processor, PWM controller, power MOSFETs
- High efficiency
- No heatsink required
- Programmable power foldback on thermal warning
- > 100 dB dynamic range and < 0.1% THD+N @ 1 W
- Configurable outputs (10% THD+N)
- 1 x 30 W into 4  $\Omega$ , parallel full-bridge
- 2 x 15 W into 8  $\Omega$ , full-bridge
- 2 x 7 W into 4  $\Omega$ , half-bridge + 1 x 15 W into 8  $\Omega$ , full-bridge
- 24-bit stereo A/D converter with 95 dB dynamic range and -88 dB THD+N
- Thermally enhanced QFN package, lead-free assembly



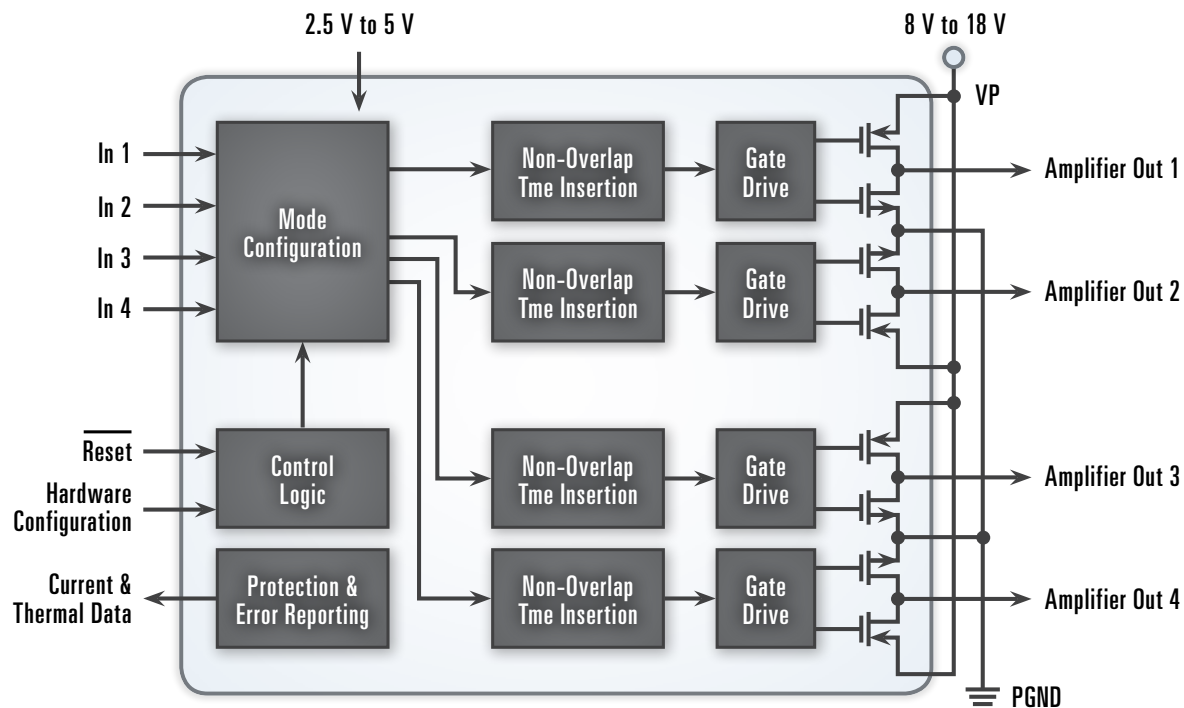


## SOUNDBAR REFERENCE DESIGNS — FEATURED ICS (CONTINUED)

## CS4412A 30W QUAD HALF-BRIDGE DIGITAL AMPLIFIER POWER STAGE

## Features

- Configurable outputs
  - 2 x 15 W into 8  $\Omega$ , full-bridge
  - 1 x 30 W into 4  $\Omega$ , parallel full-bridge
  - 4 x 7 W into 4  $\Omega$ , half-bridge
  - 2 x 7 W into 4  $\Omega$ , half-bridge + 1 x 15 W into 8  $\Omega$ , full-bridge
- Space-efficient thermally-enhanced QFN
  - No external heat sink required
- 100 dB dynamic range — system level
- < 0.1% THD+N @ 1 W — system level
- Built-In protection with error reporting
  - Over-current
  - Thermal warning and overload
  - Under-voltage
- +8 V to +18 V high voltage supply
- PWM Popguard® for quiet startup
- No bootstrap required
- Low quiescent current
- Low power standby mode



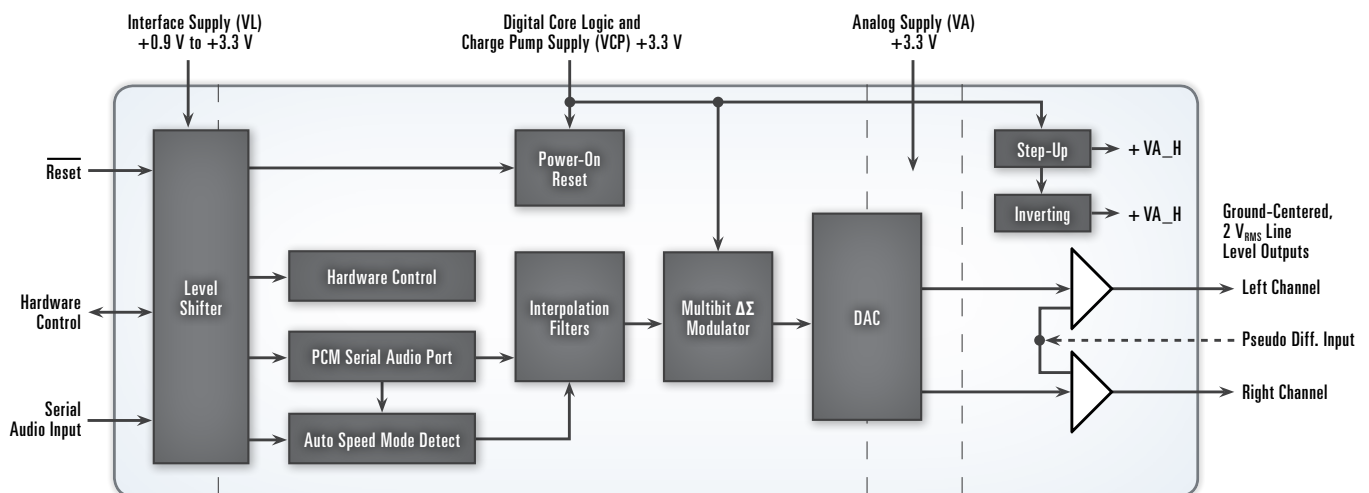


## SOUNDBAR REFERENCE DESIGNS — FEATURED ICs (CONTINUED)

CS4353 3.3 V STEREO AUDIO DAC WITH 2 V<sub>RMS</sub> LINE OUTPUT

## Features

- Multi-bit Delta-Sigma Modulator
- 106 dB A-wt dynamic range
- -93 dB THD+N
- Single-ended ground centered analog architecture
  - No DC-blocking capacitors required
  - Integrated step-up/Inverting charge pump
  - Filtered line-level outputs
  - Selectable 1 or 2 V<sub>RMS</sub> full-scale output
- Low clock-jitter sensitivity
- Low-latency digital filtering
- Supports sample rates up to 192 kHz
- 24-bit resolution
- Power supplies
  - +3.3 V charge pump and core logic
  - +3.3 V analog
  - +0.9 to 3.3 V Interface
- 24-pin QFN, Lead-free assembly

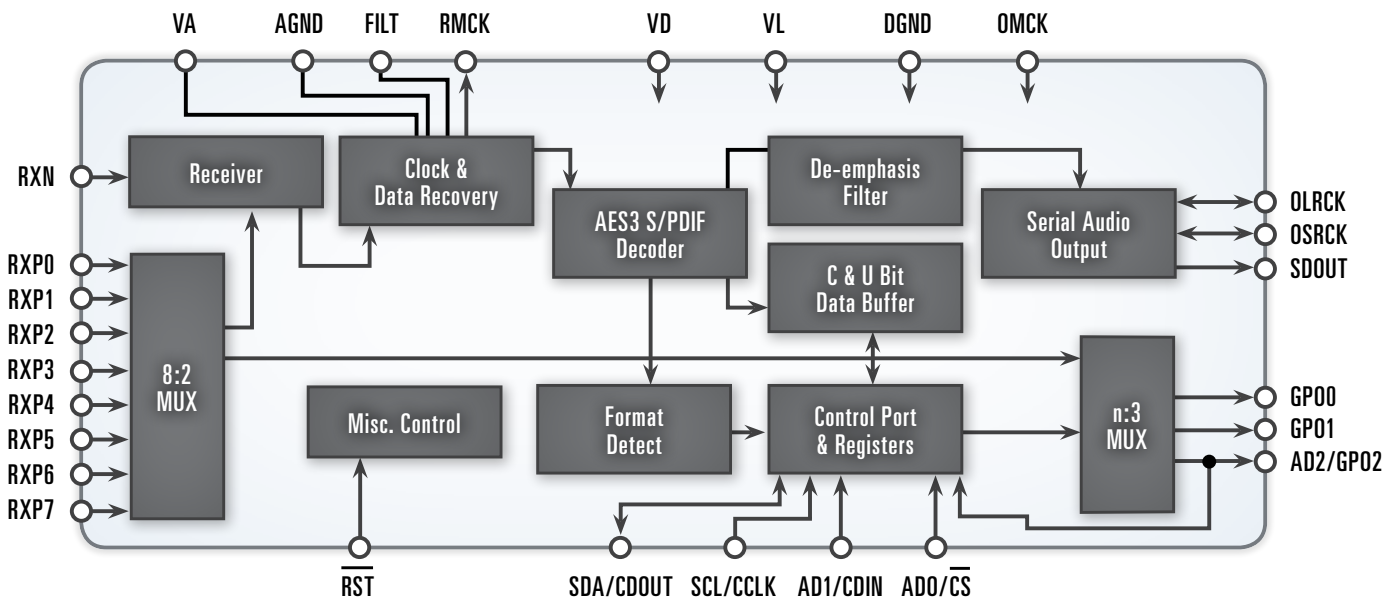


## SOUNDBAR REFERENCE DESIGNS — FEATURED ICS (CONTINUED)

## CS8416 192 KHZ DIGITAL AUDIO RECEIVER

## Features

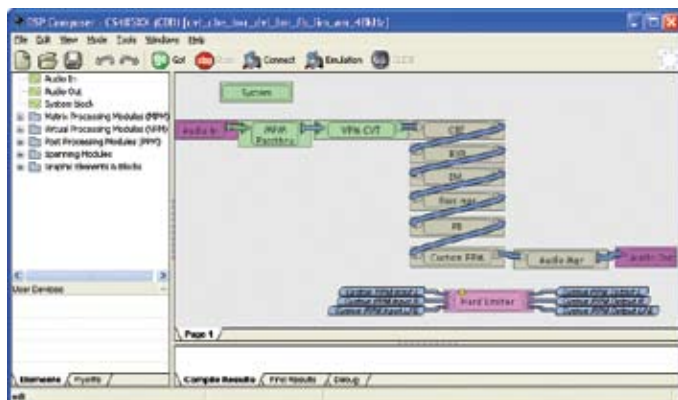
- Compatible with EIAJ CP1201, IEC-60958 and AES3 standards
- 8:2 S/PDIF input MUX
- Selectable signal routing to three general-purpose output pins
- S/PDIF to Tx inputs
- Flexible 3-wire serial digital output port
- 32 kHz to 192 kHz sample frequency range
- Low-jitter clock-recovery
- Pin and microcontroller read access to channel status and user data
- SPI™ or I<sup>2</sup>C software mode and standalone hardware mode
- Differential cable receiver
- On-chip channel status data buffer memories
- Auto-detection of compressed audio input streams
- OMCK system clock mode
- 3.3 V analog supply (VA), 3.3 V digital supply (VD) and 3.3 V to 5 V digital interface supply (VL)
- Package: 28-pin SOIC, 28-pin TSSOP, 28-pin QFN; lead-free assembly



## DESIGN RESOURCES

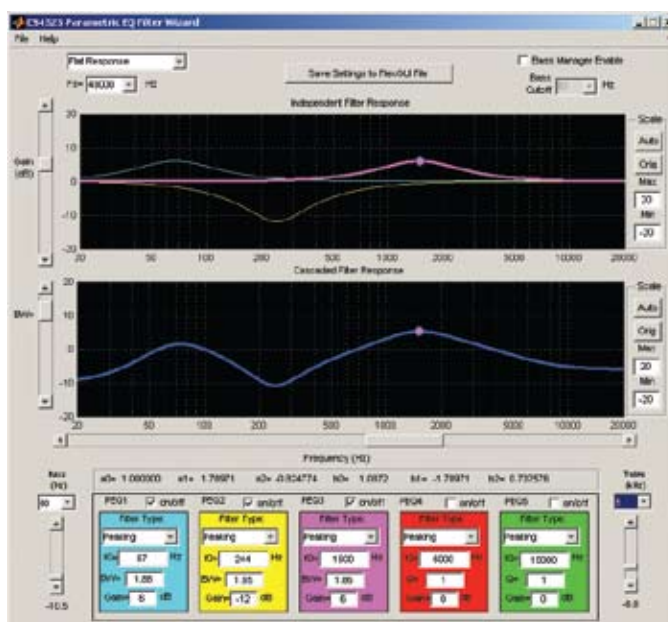
### DSP COMPOSER™ — GRAPHICAL DSP PROGRAMMING TOOL

- Visual programming of audio processing
- User friendly and easy to design
- DSP experts can use it to improve time-to-market
- Non-DSP experts can use it and create efficient implementations
- Very efficient code generation
- All basic prototypes hand-optimized and pre-stored
- Easy design using schematic-like wiring of modules
- Self documenting design flow
- Allows hierarchical blocks and custom library creation
- Perfect for algorithm design and tweaking
- Allows run-time design/parameter modification while listening/taking measurements
- Implementation is ready after algorithm tweaking



### CS4525 PARAMETRIC EQ FILTER WIZARD

The CS4525 Parametric EQ Filter Wizard provides a graphical interface to the Parametric Equalization, Bass Manager, and Tone Control Features of the CS4525. The CS4525 Parametric EQ Filter Wizard application note includes the necessary information so that a user can quickly and easily configure any or all of the five on-chip biquad filters, the Bass Manager crossover frequency, and the bass/treble shelving filters available in the CS4525 via the application's Graphical User Interface (GUI).



Please visit <http://www.cirrus.com/sb> for more information on the CRD-SB30Wx2:

- Product Brief
- Registration for Reference Design Installer
- DSP Composer and Micro Condenser, Application Notes, Firmware, and Users Guide Installer

Cirrus Logic offers a wide selection of free tools and resources to help system designers implement audio products fast and efficiently.

Please visit <http://www.cirrus.com/en/support/> for more information on the following:

- Product Data Sheets
- Reference Designs and Evaluation Boards
- User Manuals
- Tools and Software
- Application Notes
- Product Bulletins

