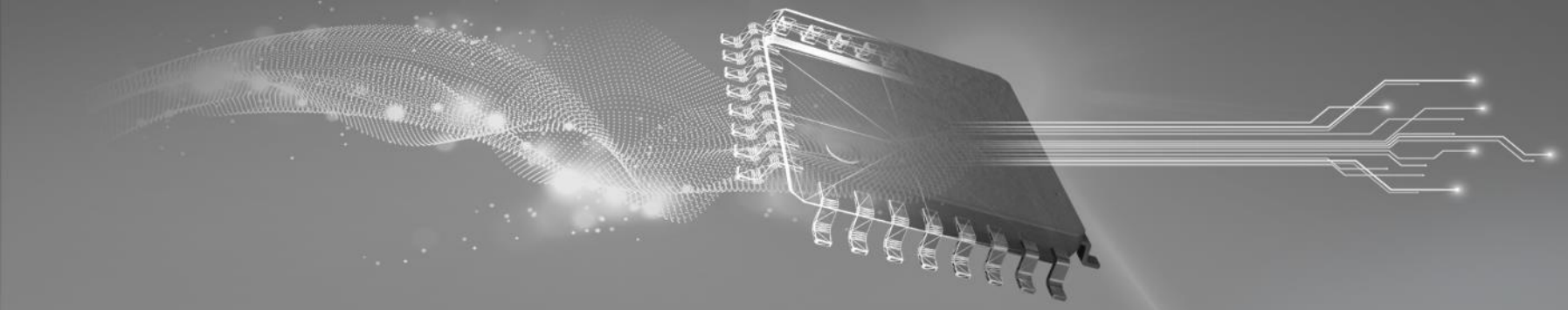
TI TECH DAYS



How TI Smart Amp technology enables high quality audio with optimized subsystem design and built-in advanced speaker protection

Chuck Smyth

Low Power Audio

Texas Instruments

Smart Amp Overview

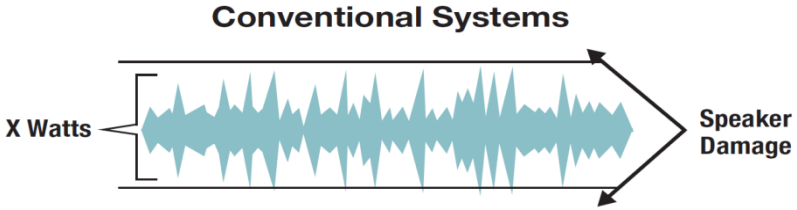
- Introduction
- Market Trends
- Device Portfolio
- Device Features
- EVM
- PPC3
- Algorithm

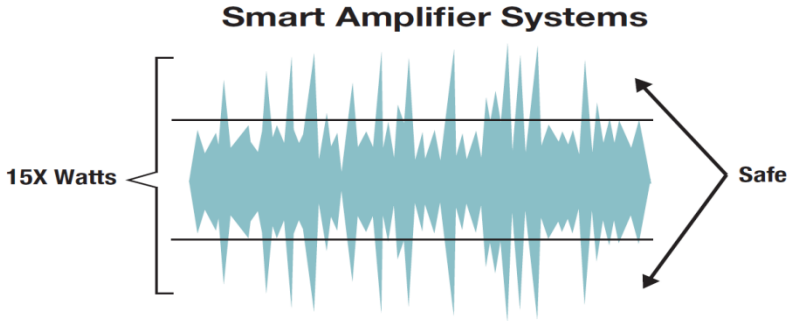
Abstract

Audio system designers need to continuously optimize the overall performance of audio subsystems for loudness, voice clarity, reliability and power efficiency. As the form factor of the end equipment keeps shrinking, the mechanical design requires the use of smaller speakers, PCB and batteries which normally will reduce the system's performance. This design challenge creates a great opportunity for the broad adoption of TI's smart amp technology, which has proven successful to optimize for smart home and personal electronics applications.

This session will introduce the latest TI Smart Amp technology and device features such as the speaker protection algorithm, integrated IV sense, audio processing, algorithm controlled look ahead class-H boost, thermal fold back, brownout protection and integrated PDM mic interface.

Amplifier Design Methodology

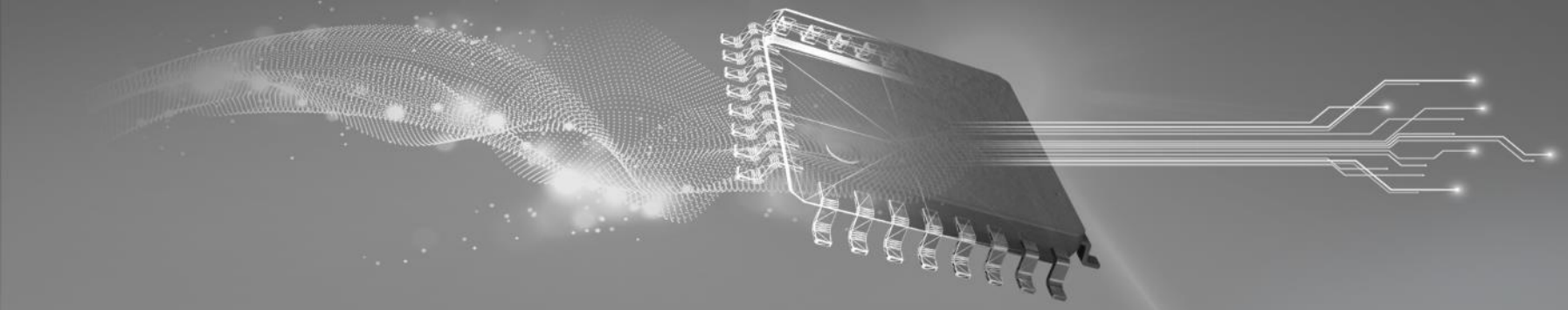




- Limits are set for worst case.
- Does not perform continuous speaker modeling.
- Results may be too conservative since loudspeaker excursion and thermal are not monitored.

- Smart Amp continuous speaker modeling keeps excursion and temperature under control.
- Output power and excursion constantly optimized for maximum power and reliability.
- Allows extending the bass.
- Improvement as much as physics allows.

TI TECH DAYS



Market Trends

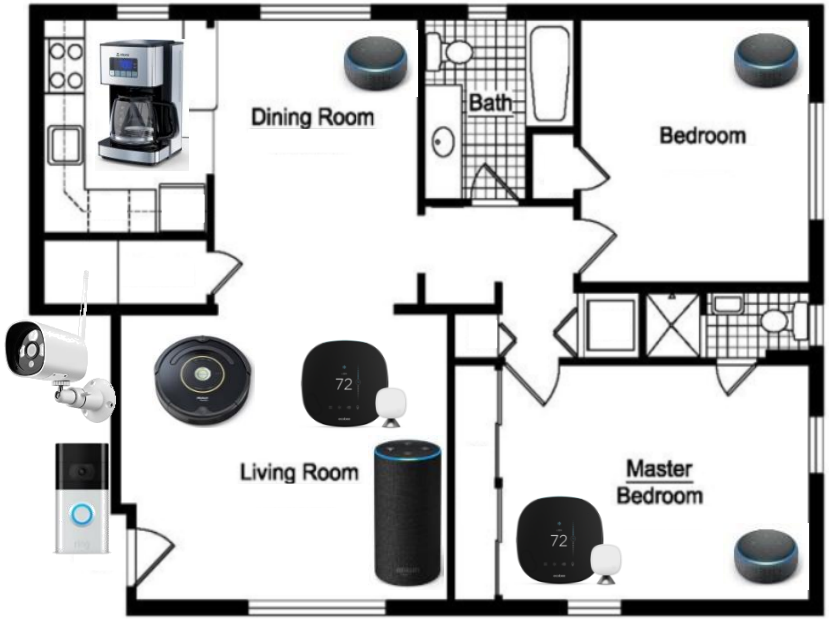
Market Trends | Connected Home

- 100M households worldwide have a smart speaker at home

- Wide adoption of smart speakers has paved the way to adding audio in other home electronics

  - Smart speaker
  - Video doorbell
  - Security camera
  - Network cameras
  - Appliances
  - Thermostats
  - Set-top boxes
  - Streaming devices
  - Light Switches
  - Security Keypad
  - Smart Displays
  - Mirrors

- The value of voice assistants comes from ecosystem and connectivity with other home devices



Market Trends | Connected Home

Audio Trends

- Market for high quality audio output in home growing
  - Discrete -> Class AB -> Class D -> Boosted/Smart Amp
  - Analog Input -> Digital Input
- Loud, intelligible voice output from assistant needed in all areas of home
- Product form factors continue to shrink in size
- Battery-powered devices growing and replacing line-powered devices

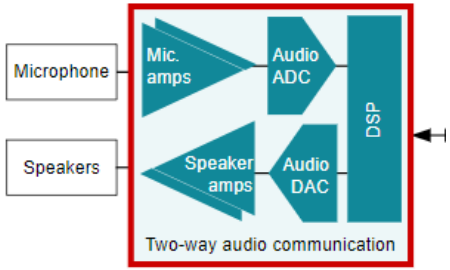
Design Problems

- Limited PCB space and sleek design requires small footprint for speaker
- Noisy, chaotic households make audio difficult to hear
- Devices must be power efficient

Smart Amp | Video Surveillance

System Description

- Video doorbells have become increasingly popular with consumers
- These allow homeowners to see who is at their door via smartphone app
- Homeowners communicate with visitors via microphones speaker in the doorbell housing



TI Applications diagram – Video doorbell

Smart Amp

Key system benefits:

- Speaker protection doubles SPL from small speakers
- Low idle channel noise
- Small size WCSP
- 2.5-5.5V & 16V supply options
- High efficiency

Related application:

- Smart thermostat
- IP camera
- Electronic smart lock

Relevant Devices

- TAS2563 – 6W Smart Amp
- TPA2011D1 – 3W A-IN Class-D
- TAS2770 – 20W D-IN Smart Amp

More Information:

- TIDA-01589: Two-way audio reference design (ref design)
- Smart home market trends (blog)
- How to achieve loud sound from a small speaker (blog)
- Purepath Console 3 software (software)
- TAS2563 quick start guide (user guide)
- Post-filter feedback design considerations (app note)
- Smart Amp training (video series)

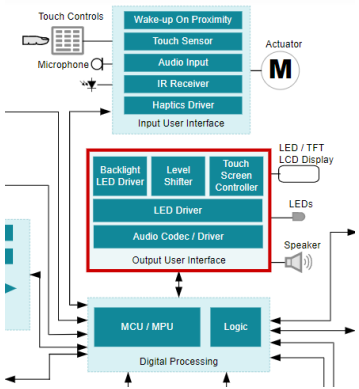
Texas Instruments

Smart Amp | Appliances

Vacuum robot

System Description

- Many common appliances have integrated AI-powered audio features
- Users can control vacuum robots with voice commands, with the robot responding via prerecorded voice or chimes.



TI Applications diagram – Vacuum robot

Smart Amp

Key system benefits:

- Speaker protection doubles SPL from small speakers
- EQ features to tune audio
- WCSP & QFN package options
- 2.5-5.5V supply

Related application:

- Robotic lawn mower
- Appliances user interface
- Smart coffee machine/blender

Relevant Devices

- TAS2563 – 6W Smart Amp
- TAS2505 – 2W D-IN Class-D
- TPA2011D1 – 3W A-IN Class-D

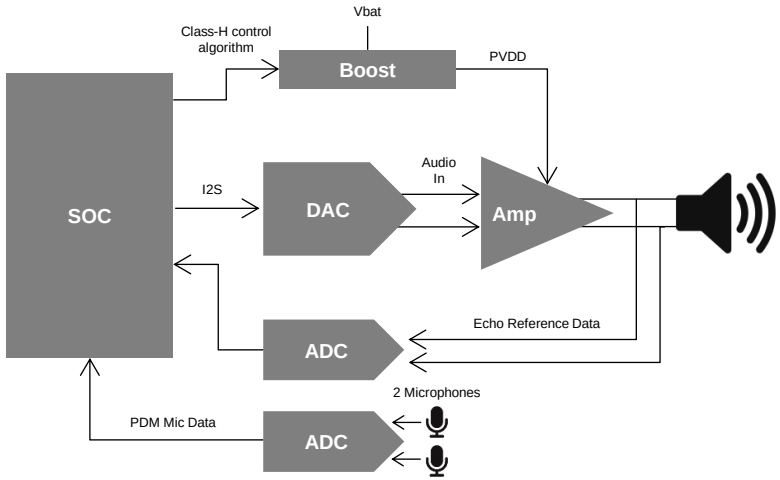
More Information:

- TIDA-01589: Two-way audio reference design (ref design)
- Smart home market trends (blog)
- How to achieve loud sound from a small speaker (blog)
- Purepath Console 3 software (software)
- TAS2563 quick start guide (user guide)
- Post-filter feedback design considerations (app note)
- Smart Amp training (video series)

9

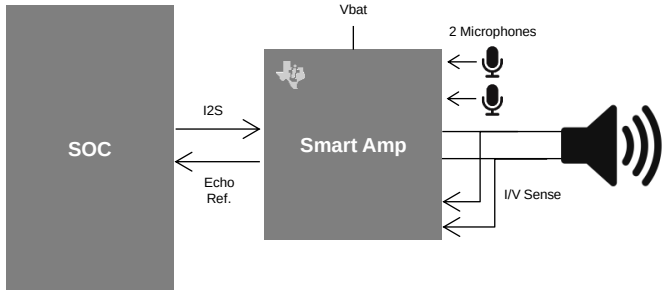
Smart Amp | System block diagrams

Traditional Two-Way Audio System



- Two-way audio requires:
  - Class-D amplifier + DAC
  - Boost from Vbat in battery-powered systems
  - ADC for analog microphone inputs
  - ADC for echo cancellation readings

Smart Amp Audio System



- Smart amp integrates all of those features and adds:
  - Integrated speaker protection
  - Integrated Class-H boost algorithm
  - Integrated DSP for audio processing (EQ, DRC, etc.)
  - Integrated interface for digital microphones
  - Integrated reference for echo cancellation

Audio amplifier in PC & Bluetooth Speakers

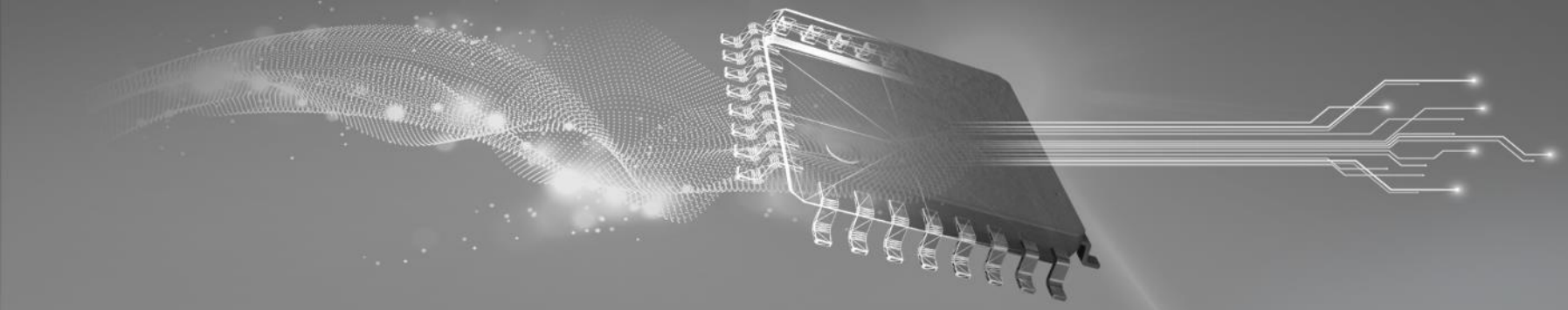
- Key difference from the Phone to PC & Bluetooth speakers are
  - Most of the systems don't need integrated Boost as external high voltage/high Power rail available.
    - Wide variation in the input PVDD voltage support required from system to system. Wide input voltage support like 3.0V to 23V enables capturing more market share.
  - Max P_{OUT} of these speakers higher than Phone speakers
  - Requirements on Idle channel noise less stringent
  - Thermal management of Board a bigger concern here as more output power is delivered
  - Conductive EMI a bigger concern on wall powered speakers due to longer power line length.

Audio amplifier in PC & Bluetooth Speakers, Supply voltages

End System	Tablets	Laptop	Bluetooth speakers	Door bells etc
Typical Input Power supply	1S / 2S Lithium Ion battery	2S/3S Lithium Ion battery / Battery charger	1S/2S Lithium Ion battery Wall power	Wall power: 12VDC ± 10% Backup battery: 1S Lithium Ion battery
Power Supply voltage available	• 2.3V to 4.5V • 4.6V to 9V	• 4.6V to 9V • 6.9V to 13.5V • 19.5V +/- 10%	• 2.3V to 4.5V • 4.6V to 9V • 5V / 12V / 18V / 24V	• 12V/5V/3.3V as an intermediate common rail
Other voltage available	VDD/IOVDD: 3.3V/2.8V/1.8V/1.5V/1.2V Core: 0.96V/1V/1.05V/1.1V Memory: 0.75V/0.9V/1.2V/1.25V/1.35V	VDD/IOVDD: 3.3V/2.8V/1.8V/1.5V/1.2V Core: 0.96V/1V/1.05V/1.1V Memory: 0.75V/0.9V/1.2V/1.25V/1.35V	Fan, HDD, USB, HDMI: 5V VDD/IOVDD: 3.3V/2.8V/1.8V/1.5V/1.2V Core: 0.96V/1V/1.05V/1.1V Memory: 0.75V/0.9V/1.2V/1.25V/1.35V	VDD/IOVDD: 3.3V/1.8V

- The supply voltage mentioned here are the generally available voltages in the end systems.
- Any specific end system would have a subset of these supply voltages.

TI TECH DAYS



Device/System Overview

TAS2563 | 11.5V Boosted Class-D w/ IV Sense + DSP

Features

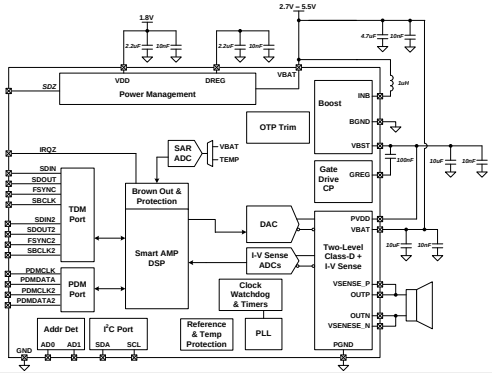
- High Performance Class-D 11.5V Boosted Amplifier
  - 5.2W output power into 8Ω at 4.2V (1% THD+N)
  - 6W output power into 4Ω at 4.2V (1% THD+N)
- Integrated speaker voltage and current sense for real time monitoring
- High efficiency: 85% at 0.5W @ 3.6V
- Flexible Digital Interface: I2S/TDM 8 channels
- 15uV Idle Channel noise w/ 1uV in Noise-Gate
- VBAT tracking peak voltage limiter with brown out detection
- VBAT 2.7V to 5.5V; AVDD 1.8V; IOVDD 1.8V
- Small 2.5 x 3.0mm, 0.4mm, 42-ball WCSP
- 2nd ASI BUS to Enable TAS2563+TAS2563 Dual Mono operation

Applications

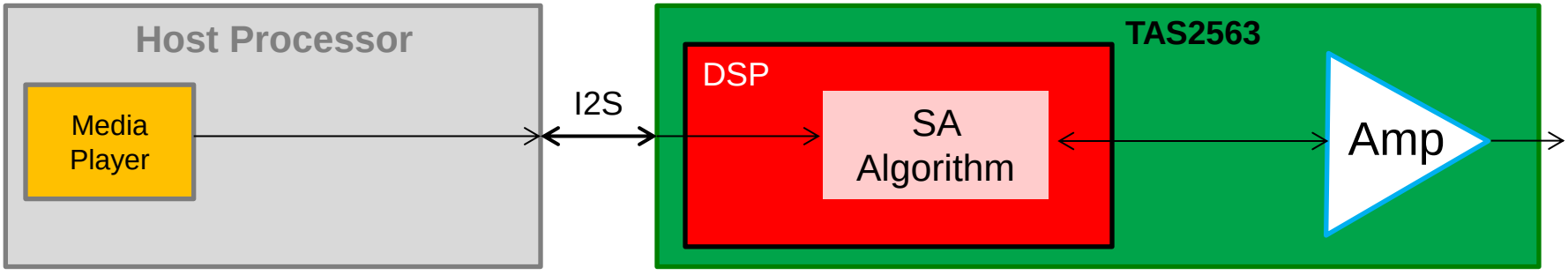
- Cellphone
- Tablets
- Speakerphones
- Power over Ethernet Applications
- DoorBells and Thermostats

Benefits

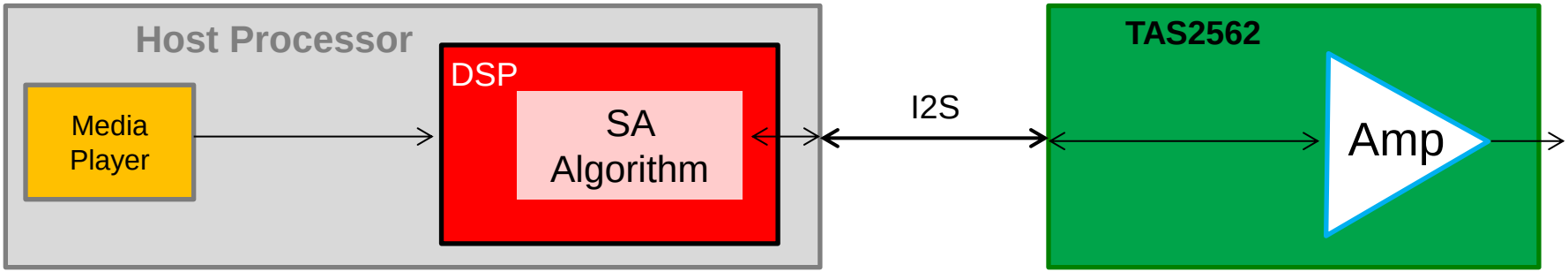
- Louder and clearer audio in 1S battery systems
- Improved efficiency and algorithms over TAS2557
- Auto Power up-down using audio clocks
- Advanced Brownout for peak SPL while Minimizing clipping events, prevents system shut downs
- Increased Boost voltage for 32 Ω receiver and peak SPL
- Wide voltage range for battery operation
- Improved tools for broad market adoption
- Allows 2x PDM Mic applications



Integrated vs. Non-Integrated



Integrated



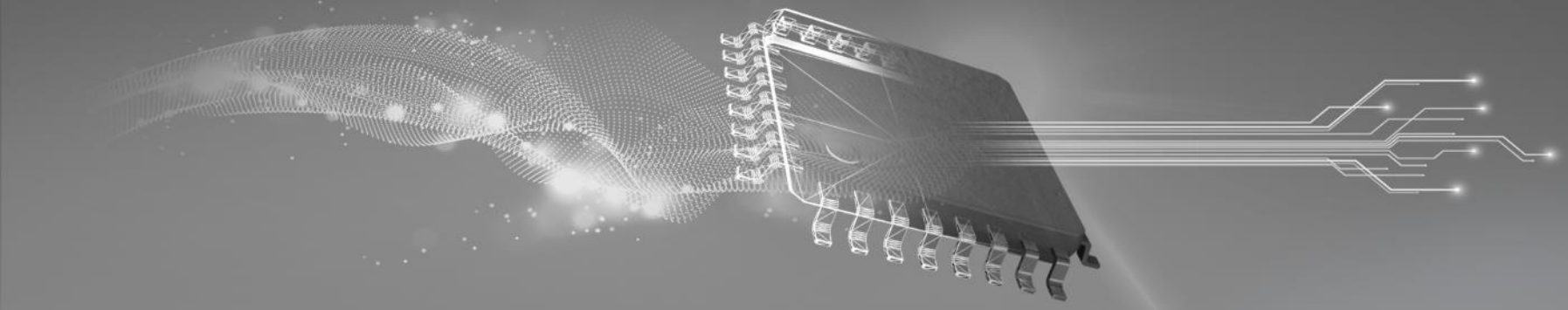
Non- integrated

LPAA | Boosted Class-D Amplifier

Status: Production

Device Specifications	TAS2562	TAS2563
Boost	11.5V	11.5V
Class-H	12 Level	12 Level
Idle Channel Noise Speaker Mode	14.8V	14.8V
Idle Channel Noise Gate Enable	<1uV	<1uV
Max Power in 8 Ohms	5.2W	5.2W
THDN @ 1W	-80dB	-80dB
Idle Channel Power	37mW	37mW
EMI Control	SSM	SSM
Package	WCSP	WCSP
Pin to pin compatible	Yes	Yes
Speaker Protection Algorithm and Audio Processing	Host Processor	Integrated DSP

TI TECH DAYS

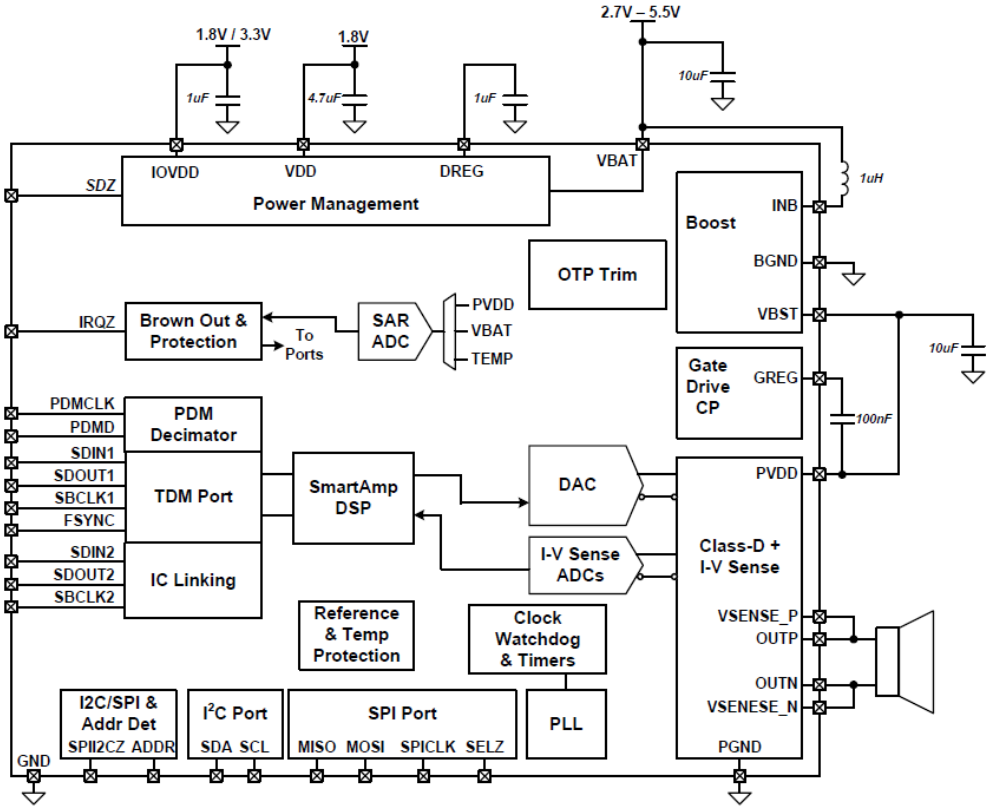


Device Hardware Features

Hardware Features List

- Multi-Level Boost (11.5V)
  - Boost current phase control
  - Class H with 12 steps
- Battery tracking
  - Brown out Protection
  - Voltage Limiter
- Temperature Tracking
  - Thermal fold-back AGC
- Programmable HPF
  - DC blocker
- Current and Voltage Sensing
- TDM
- Tone Generator
- Configurable Interrupt
- Idle Channel Detect
  - Noise Gate Mode
- SPI or I2C control
- Spread Spectrum low EMI mode
- Input current limiter
- Overcurrent protection
- Ultrasound Support
- Auto wakeup on I2S
- Inter chip communication for stereo solutions
- Hardware noise gate
- Device VBAT and temperature information through I2S and I2C

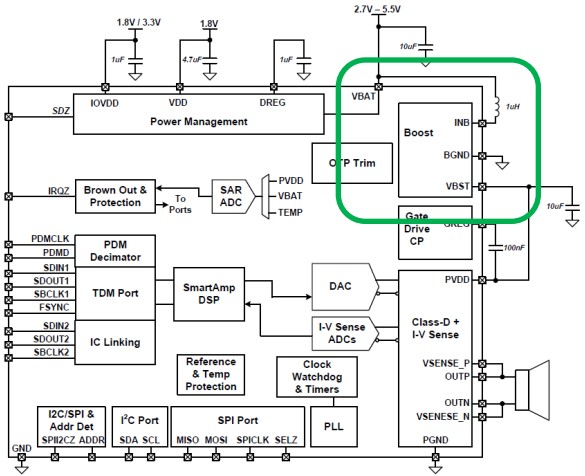
TAS2563 Block Diagram

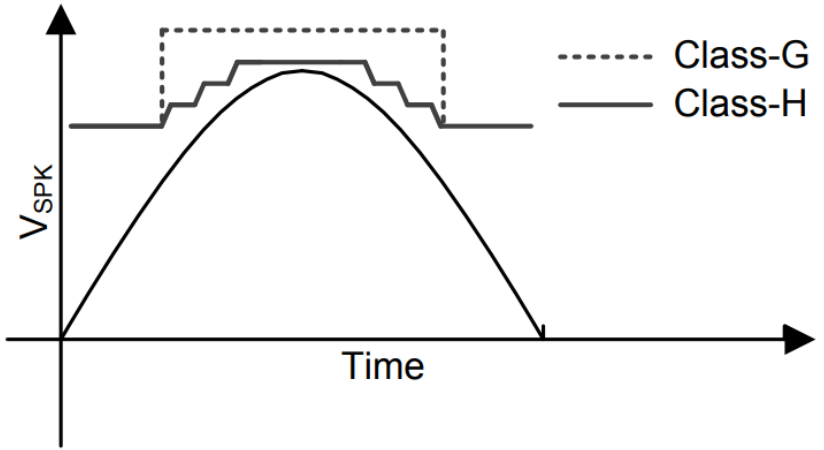


Multi-Level Boost

Multi-Level Boost App Note

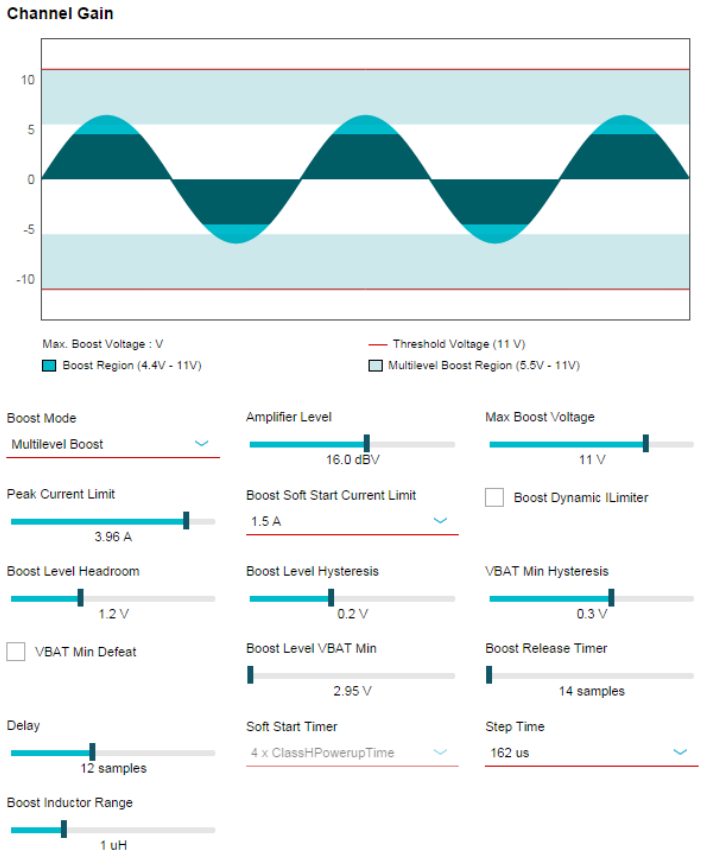
- Supports Class – G and Class – H operation
  - Look ahead algorithm monitors VBAT and input signal to determine whether additional headroom is needed to produce the desired output
  - Boost is enabled dynamically to maximize output efficiency at all output





Multi-Level Boost

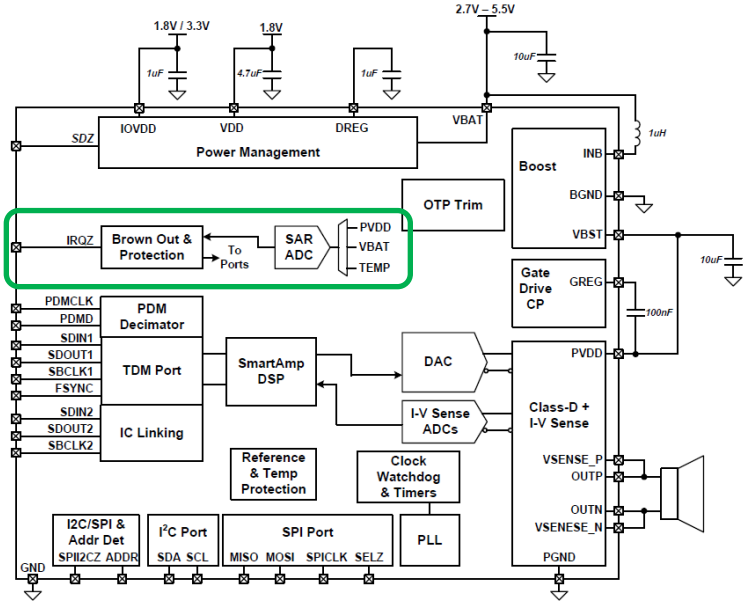
- Boost Configuration options
  - Mode (Class – G, Class – H, Always On, Disabled)
  - Active Mode Lower Frequency Limit
  - Soft-Start Current Limit
  - Soft-Start Timer
  - Boost Inductor Range
  - Load Regulation
  - Boost Maximum Voltage (6.5 V – 12.5 V)
  - Boost Sync
  - Boost Phase (0° or 180°)



Battery Tracking

Battery Tracking App Note

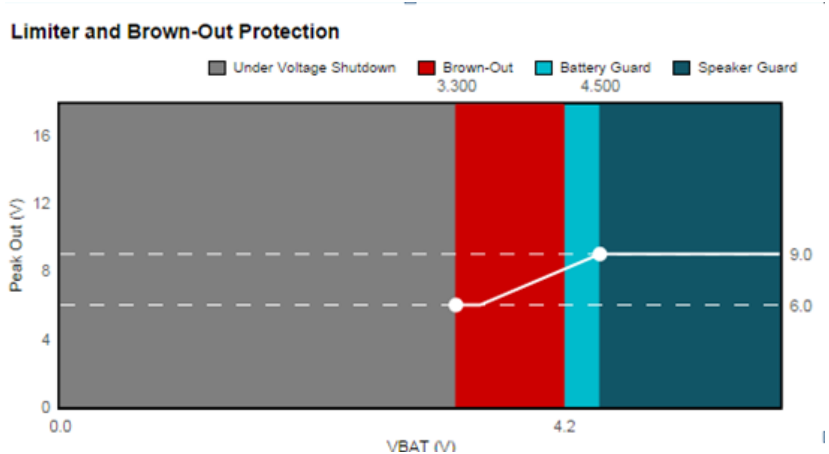
Monitoring VBAT allows the dynamic AGC to adjust peak output levels and extend battery life. In the event of low battery voltage, Brownout Protection can be enabled to prevent excessive current draw in the audio subsystem. This may help to keep the system operational without causing battery droop that would brown out the entire system.



Battery Tracking

Highly configurable user control:

- Attack
  - step size
  - Rate
- Release
  - Step size
  - Rate
- Hysteresis
- Hold time
- Brown Out Protection
  - Threshold
  - Action (Mute or Max Attenuation)
- Output Level Control
  - Maximum
  - Minimum
  - Inflection Point



Benefits:

Prevent system level brown out events caused by audio

Limit peak output power gradually based on remaining battery charge

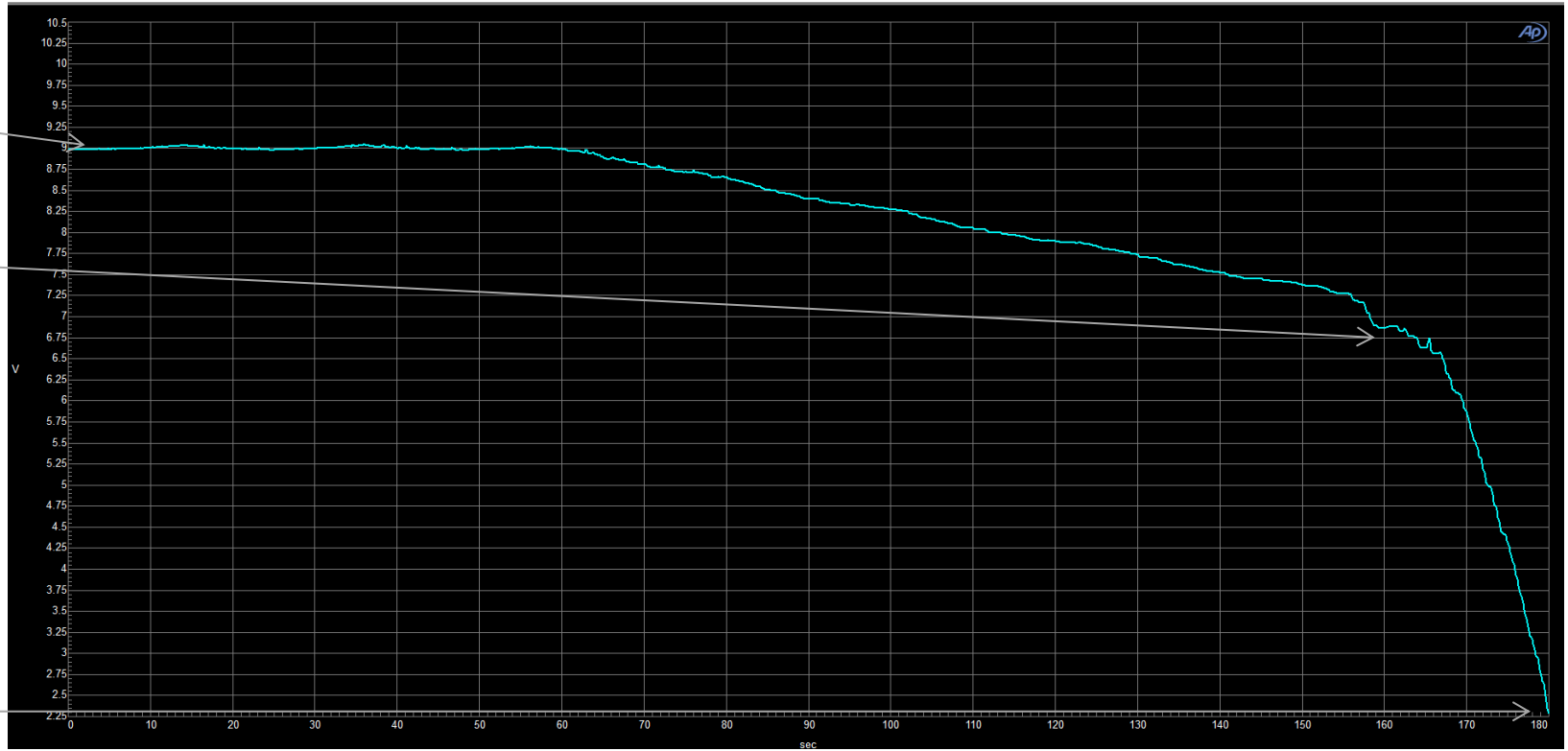
Limiter Verification

VBAT = 5 V

VBAT = 3.6 V

Brown Out Active Flag Set – ramps at new attack rate until BOP threshold

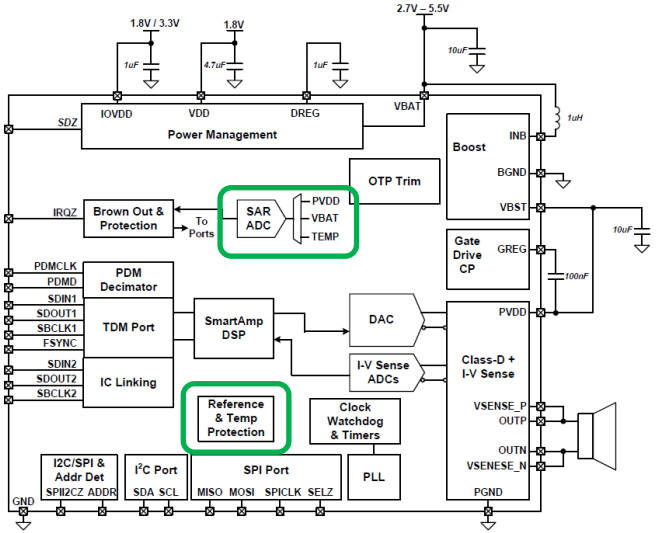
VBAT = 3.3 V



Temperature Tracking

- TAS2563 monitors die temperature using a built-in temperature sensor. This allows for Over Temp protection and the Thermal fold back AGC
- Prevent amplifier from self-damage due to over-heating
- Prevent amplifier temperature from exceeding custom threshold by limiting output gain
- Real-time feed back to host regarding amplifier state. No need for remote temperature sensor.

Thermal Foldback App Note



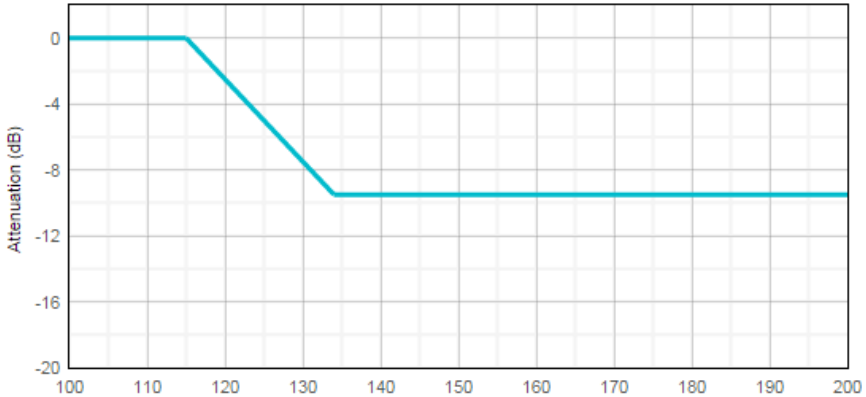
Temperature Tracking

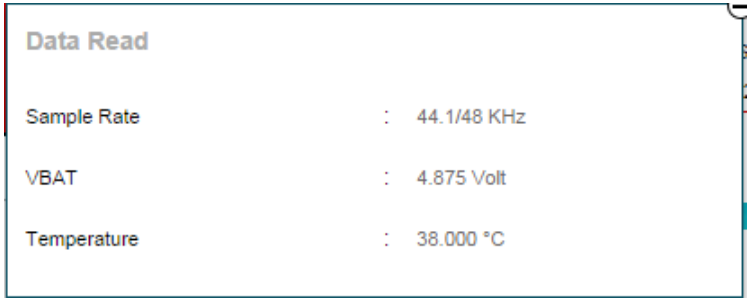
- Over Temp protection:

  If unsafe die temperature is detected the device will enter software shutdown for self protection

- Thermal Fold back AGC:

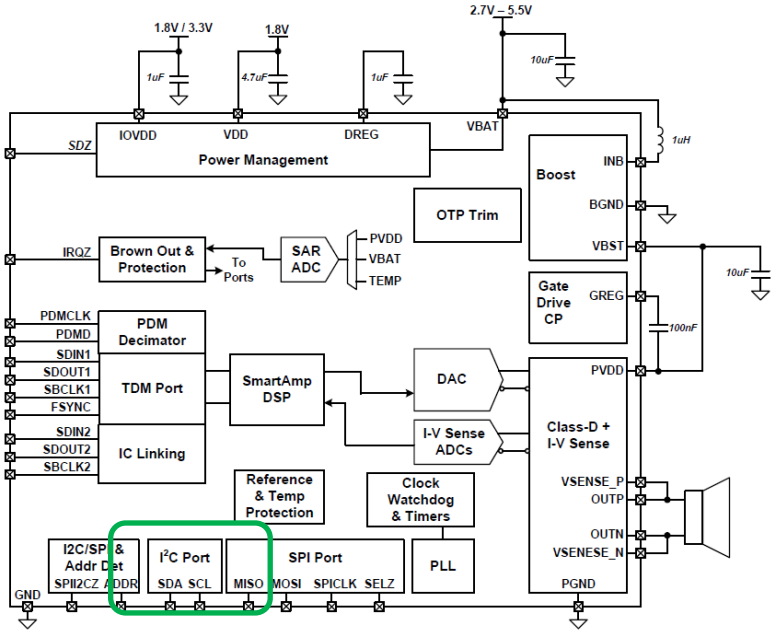
  Thermal fold back allows the device to dynamically adjust output gain in order to limit temperature to meet user defined operating conditions





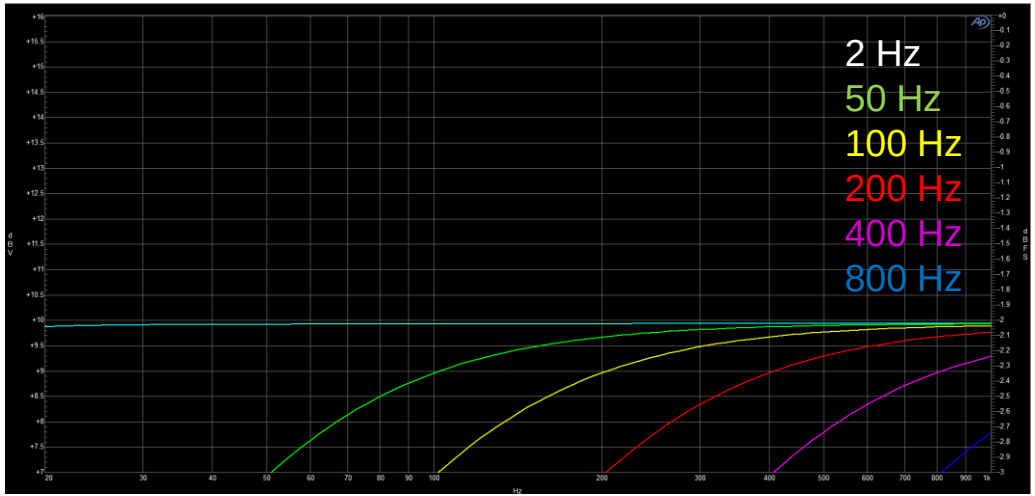
Programmable HPF

- TAS2563 includes a configurable HPF to prevent DC and excessive low frequency content.
- Excessive DC or low frequency content can damage speakers
- Speaker frequency response limitations may prevent the speaker from accurately reproducing low frequency audio. Efficiency can be improved by filtering out content at frequencies below the speaker capabilities.



Programmable HPF

- Benefits:
  - Prevents excessive low frequency or DC content from damaging the speaker
  - Improves efficiency by allowing user to limit non-reproducible low frequency content



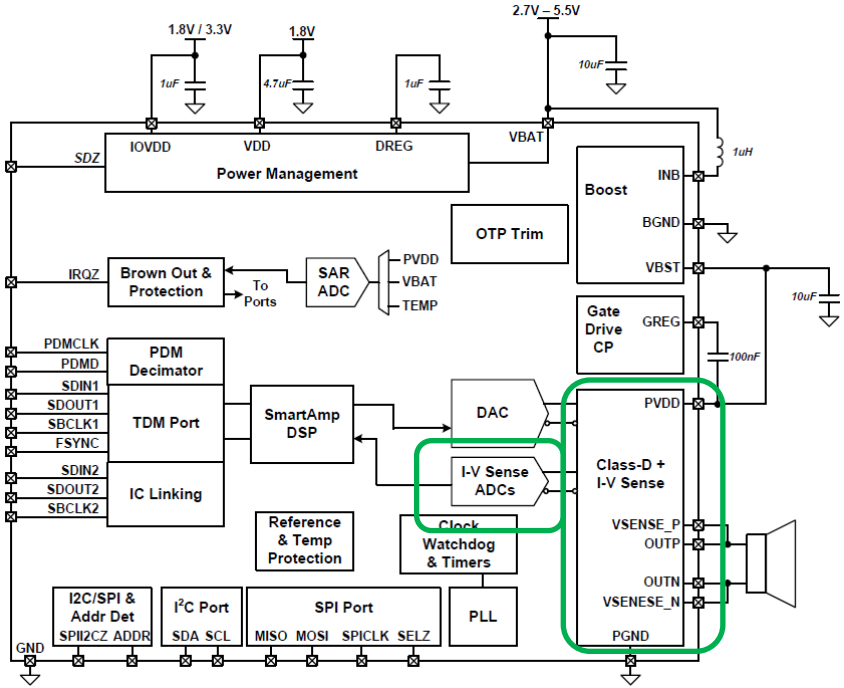
Current and Voltage Sensing

- Real time Voltage and Current sensing allow for dynamic speaker protection algorithm and load characterization.
- Common sources of speaker damage include over-excursion events and over-temperature events.
- Changes in coil temperature and cone movement can be tracked using voltage and current data when driving a known load.
- Texas Instruments Smart Amp algorithm allows user to store speaker characteristics and tuning profile to achieve maximum output power while preventing speaker damage.

Current and Voltage Sensing

Benefits:

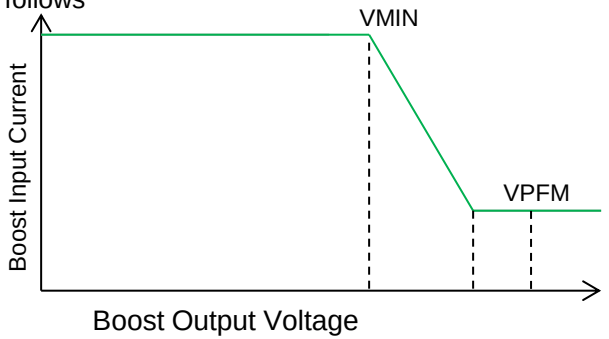
- Allows real time tracking of Speaker coil temperature and excursion
- Allows for load calibration and diagnostics
- Used in conjunction with TI SmartAmp algorithm, can maximize speaker performance while preventing speaker damage



Impact of Boost Current Limit

- Boost Input Current Limit impacts the max input power.
  - Input Power can be calculated by VBAT* Input Average Current
  - Input Average Current
    = Boost Current Limit – Current Ripple/2
- Voltage is required @ Class-D Output to deliver Power without Clipping
  - For any given Pout, Vpeak Required for no clipping can be calculated as
  - Vpeak=sqrt(2*Pout*Rload).
  - Supply Required can be calculated as
  - Vsup=Vpeak/Efficiency + Vmargin
  - Vpeak is signal Peak calculated as shown, Efficiency is chip efficiency and Vmargin is Margin for high frequency components.
- Based on these parameters, Supply Required can be figured for any input signal

- Supply @ the boost output remains fixed till Input Power>Output Power.
  - Boost Output Voltage vs. Input Current waveform looks as follows



  - For Output Power< Input Power, Output Voltage will settle between VPFM and VMIN
  - Once input Power<Output Power, Extra Power is drawn from Boost Cap and Voltage on Boost Starts to dip below VMIN.
  - If Supply Voltage dips below Vsup required by Class-D, Clipping occurs in Class-D.

Boost Power Delivery

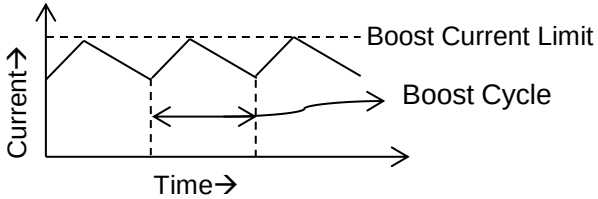
- Based on previous slide, higher Voltage with Same Current Limit helps in improving output power delivery.
  - Extra Power is extracted out of capacitor.
  - Boost Voltage will still dip but is enough to support load peaks.

- For 11V, There is very little efficiency impact
  - Boost Efficiency is limited by Input Current which is same between two settings.
  - Class-D has resistive losses as dominant and they do not change(reduces by small amount with higher voltage)
  - Class-D Switching losses increase a little by are compensated mostly by improvement in resistive losses.

- It can be shown with calculations based on previous slide that
  - With 2A Boost Peak Current Setting @3.6V VBAT, Average Input Current is expected to be ~1.8A.
  - This limits input power to 6.5W.
  - For -1.96dBFS Input, Power delivered @ Class-D Output is 3.2W(With 83% efficiency, Input Power=3.85W)
  - This would mean power required to deliver peak without clipping is 7.7W
- As input power < Output Power, Boost Cap will start draining.
  - Once Boost drops below 7.55V, Class-D will start clipping.
  - For 11V Boost, this gives a headroom of 3.45V as compared to 1.45V for 9V boost.
  - This prevents clipping with 11V Boost as Cap can deliver these peaks.

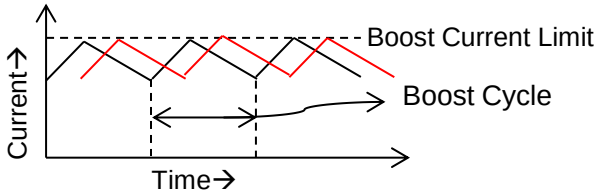
Boost Phase Control

- For Multi Device System, TI proposal is to synchronize loading across devices
  - Boost clocks can be synchronized to ensure overall supply current remains constant while increasing device input current.
  - This helps in increasing power output while protecting the battery against overload conditions.
- Boost Current Profile w.r.t. time looks like:-



- Presently, Boost Current Limit is set to 2A
  - This is done to prevent overall loading with multiple devices to cross 8A.
  - This helps in protecting the battery

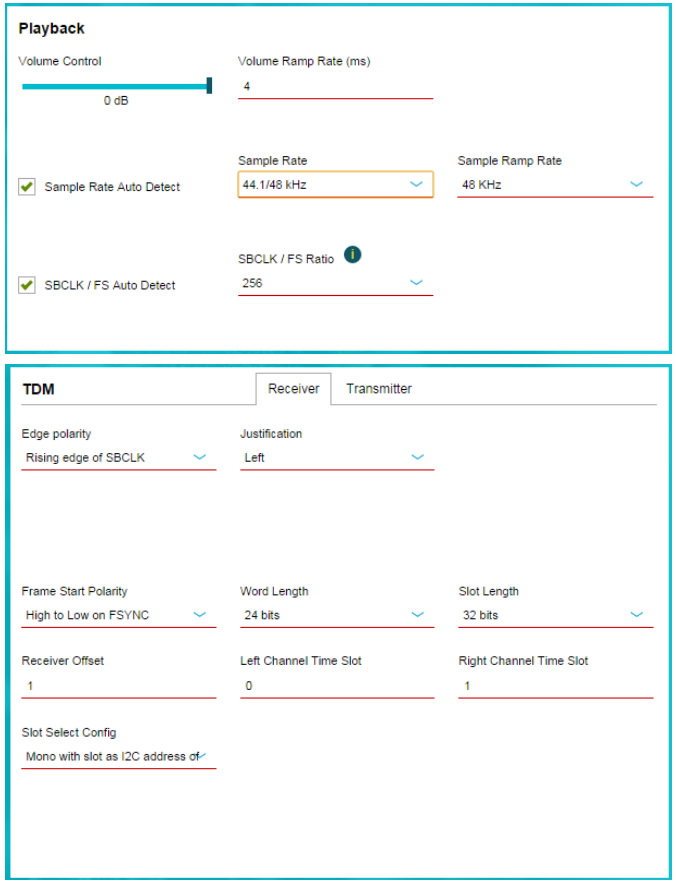
- TI Solution for next generation is to synchronize multiple devices
  - Different Devices will be running on phase shifted clocks.
  - This will ensure when one device is ramping up, other is ramping down.
  - This will help in reducing overall loading on battery.
- Boost Current Profile for 2 devices w.r.t. time will look like:-



- With this architecture, Boost Current Limit can be set to around 2.3A
  - Overall Current for 2 devices will never cross 4A.
  - This helps in improving input power by 15% and can improve output signal by ~7%

TDM Inputs

- Benefits:
  - Highly customizable inputs allow the device to be interpret I2S and TDM input streams at a variety of word sizes, sample rates, and justification formats.
  - TAS2563 is designed to share SDOUT with other devices, which allows multiple devices to communicate back to the host on a single bus.



TDM Inputs

- TDM inputs are configurable to accept a variety of formats

Table 22. TDM RX Time Slot Length

RX_SLEN[1:0]	Time Slot Length
00	16-bits
01	24-bits
10	32-bits (default)
11	reserved

Table 23. TDM RX Sample Word Length

RX_WLEN[1:0]	Length
00	16-bits
01	20-bits
10	24-bits (default)
11	32-bits

Table 24. TDM RX Sample Justification

RX_JUSTIFY	Justification
0	Left (default)
1	Right

Table 25. TDM RX Time Slot Select Configuration

RX_SCFG[1:0]	Config Origin
00	Mono with Time Slot equal to I^2C Address Offset (default)
01	Mono Left Channel
10	Mono Right Channel
10	Stereo Down Mix [L+R]/2

Table 26. TDM RX Left Channel Time Slot

RX_SLOT_L[3:0]	Time Slot
0x0	0 (default)
0x1	1
. . .	...
0xE	14
0xF	15

Table 27. TDM RX Right Channel Time Slot

RX_SLOT_R[3:0]	Time Slot
0x0	0
0x1	1 (default)
. . .	...
0xE	14
0xF	15

Table 28. TDM TX Transmit Polarity

TX_EDGE	SDOUT Transmit Edge
0	Rising edge of SBCLK
1	Falling edge of SBCLK (default)

Table 29. TDM TX Start of Frame to Time Slot 0 Offset

TX_OFFSET[2:0]	SBCLK Cycles
0x0	0
0x1	1 (default)
0x2	2
. . .	...
0x6	6
0x7	7

Table 30. TDM TX Unused Bit Field Fill

TX_FILL	SDOUT Unused Bit Fields
0	Transmit 0
1	Transmit Hi-Z (default)

Table 31. TDM TX SDOUT Bus Keeper Enable

TX_KEEPEN	SDOUT Bus Keeper
0	Disable bus keeper
1	Enable bus keeper (default)

Table 32. TDM TX SDOUT Bus Keeper Length

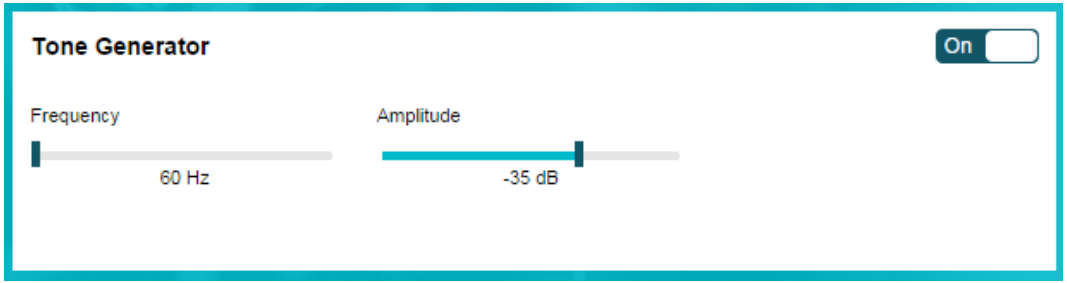
TX_KEEPLN	SDOUT Bus Keeper enabled for
0	1 LSB cycle (default)
1	Always

Table 33. TDM TX SDOUT Bus Keeper LSB Cycle

TX_KEEPCY	SDOUT Bus Keeper driven
0	full-cycle (default)
1	half-cycle

Tone Generator

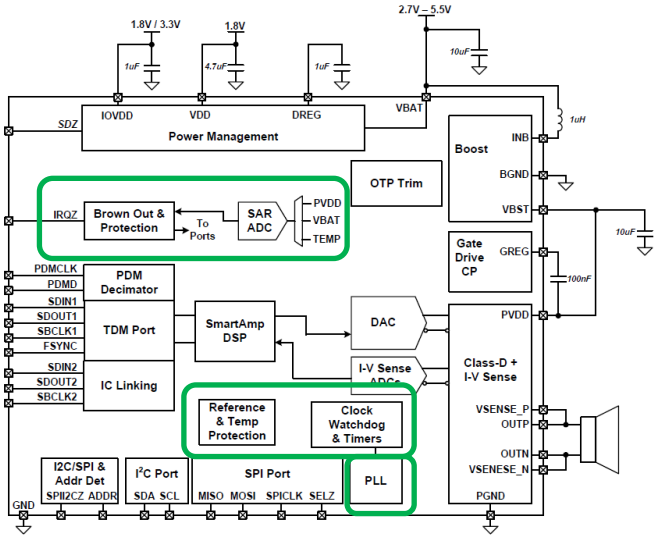
- TAS2563 includes a tone generator function that can produce a fixed output tone when triggered
- Device can be triggered through external GPIO source or when SDIN is active



- Benefits:
  - Enables load diagnostics
  - Enables user to generate a fixed tone triggered from via GPIO

Configurable Interrupt

- TAS2563 will transmit interrupt status using the IRQZ pin back to the host.
- Each flag can be independently read back for accurate fault status.
- Read back is available on both a latched and a live register
- Flags can also be masked from influencing the IRQZ state
- Gives feedback to host when fault conditions are present

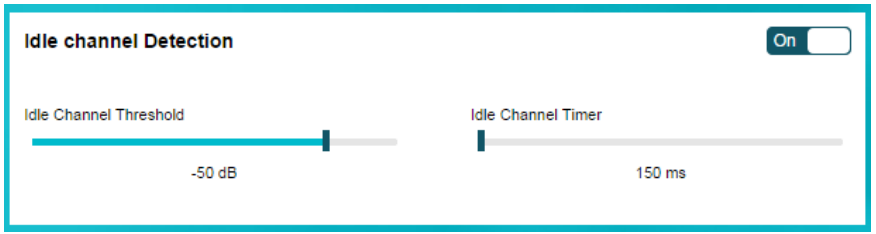


IRQ

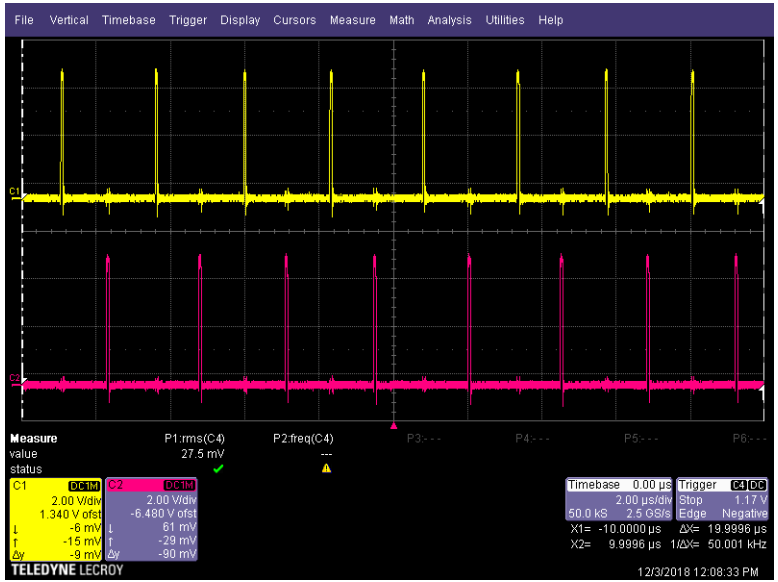
	Latched	Live	
Over Temp Error	○	○	Over Current Error
TDM Clock Error	○	○	Limiter Active
VBAT < Inflection	○	○	Limiter Max Attenuation
Limiter Infinite Hold	○	○	Limiter Mute
BrownOut Triggered Shutdown	○	○	BrownOut Active
DAC Clock Error	○	○	BrownOut Detected
VBAT POR	○	○	Boost Clock Error
DC Detect	○	○	PLL Lock
CP PG Flag	○	○	Boost OV Clamp
Device Power Down	○	○	Device Power Up

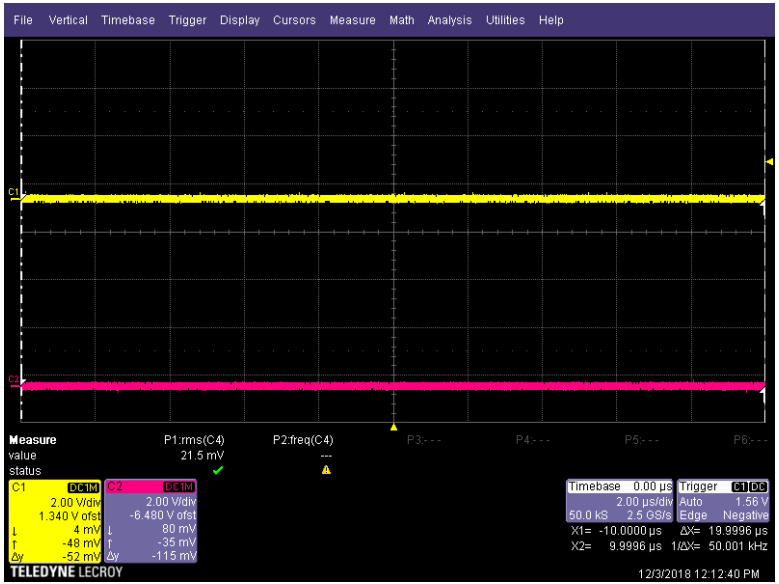
Idle Channel Detect

- TAS2563 has a configurable Idle Channel input level. If desired, the device will treat all inputs below this threshold as if in an idle channel state
- Additionally, the device can enter Noise Gate mode during idle channel conditions. In this mode the output switching is completely disabled. Once inputs exceed the minimum threshold the outputs are enabled and playback resumes.
- Benefits:
  - Achieves minimum idle channel noise by disabling output switching when idle
  - Prevents low level inputs from activating output if desired



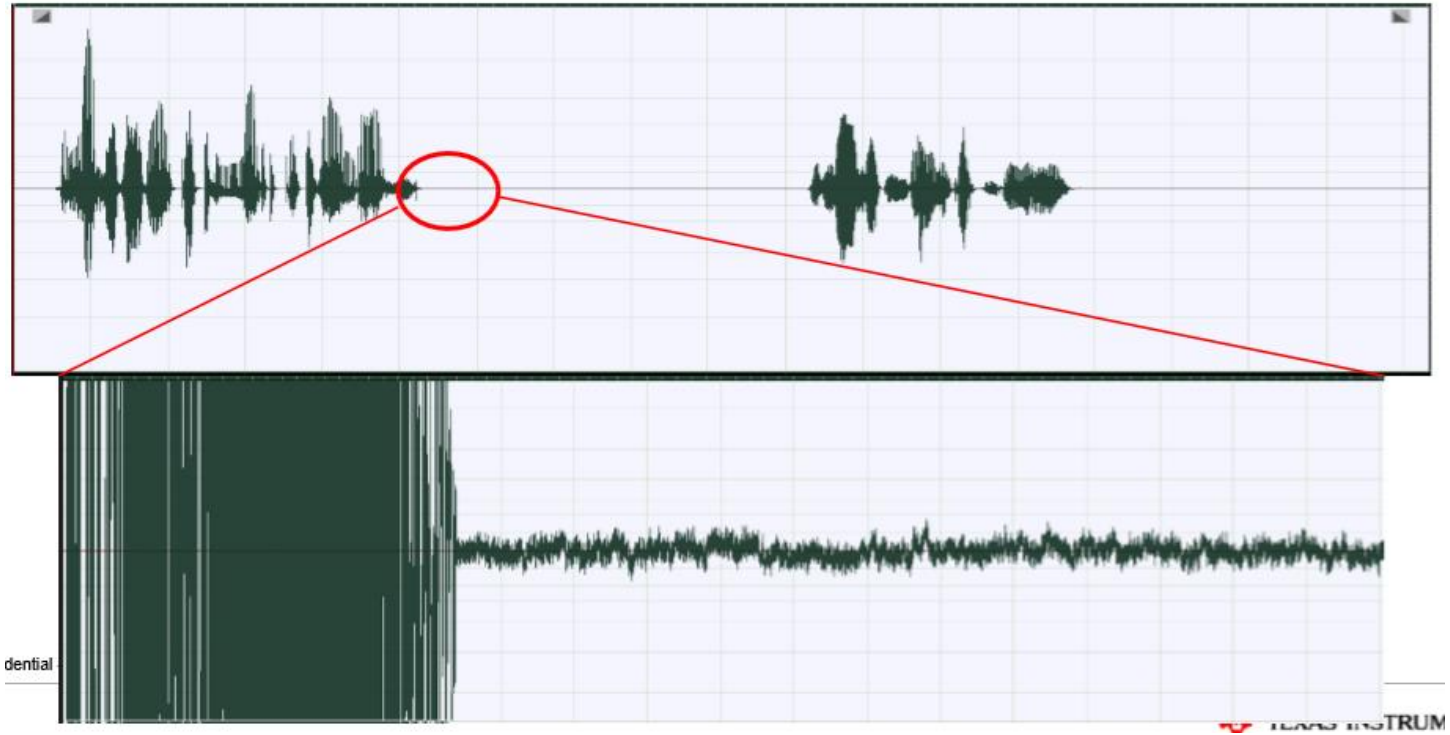
Idle Channel vs. Noise Gate





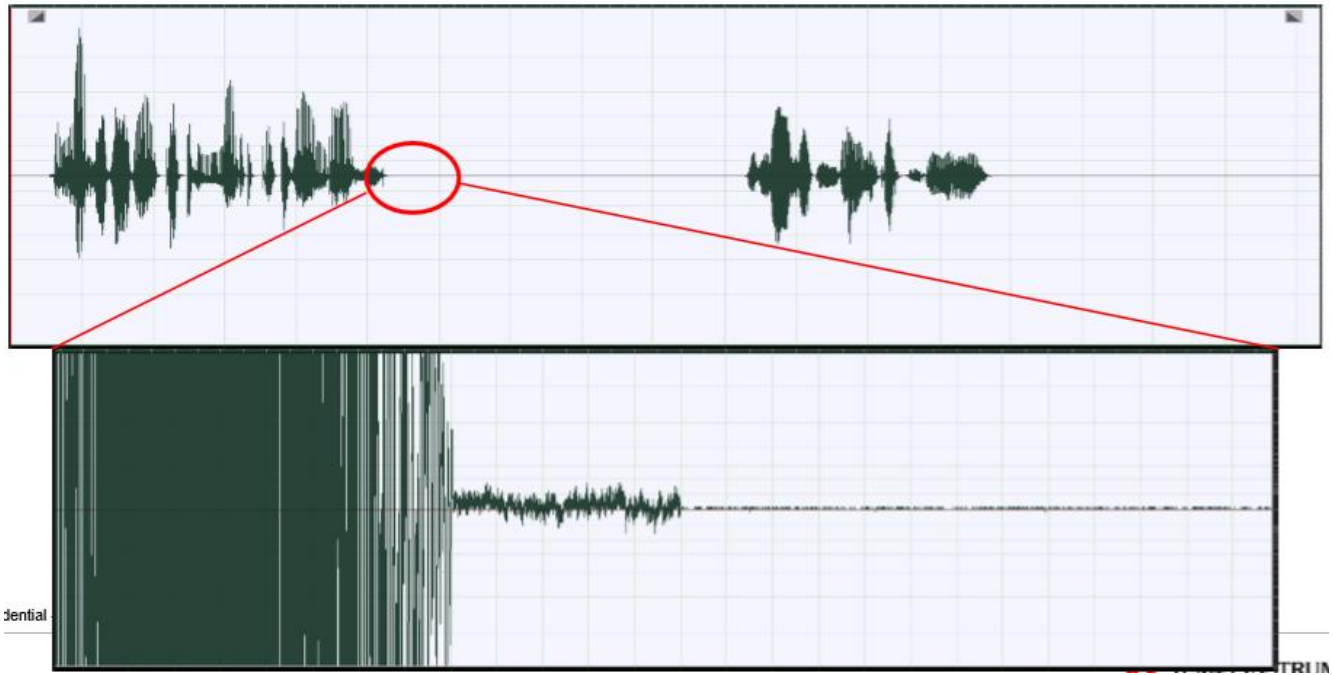
Noise Gate	ICN (uV)	DVDD Current (uA)	VBAT Current (mA)
Enabled	**1**	8.23	**1.617**
Disabled	13.6	8.22	4.306

Noise Gate Disabled



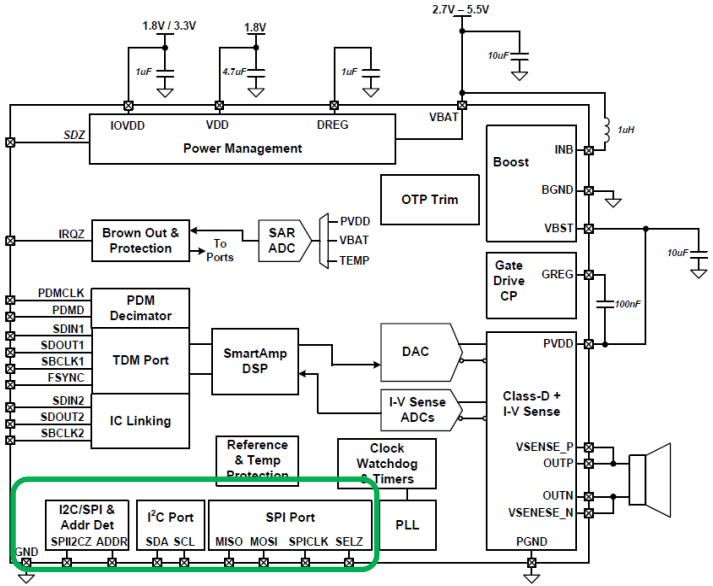
Noise Gate Enabled

The noise gate threshold and attack time are programmable



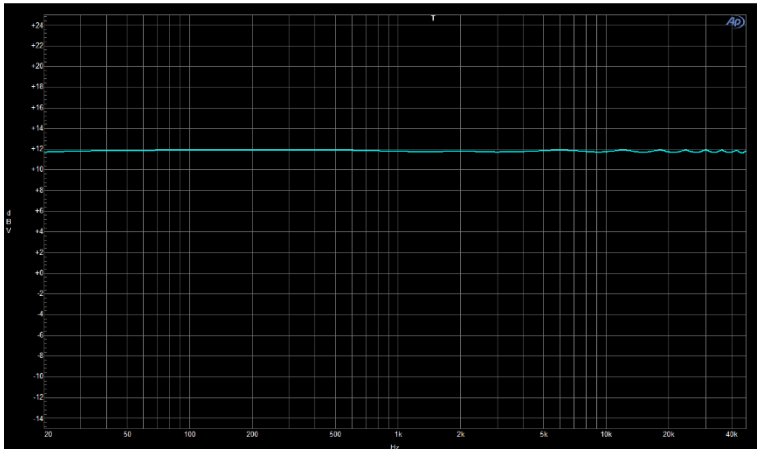
Control Interface

- TAS2563 can accept both SPI and I2C inputs based on hardware setup
- TAS2563 can easily be setup to function with most host controllers



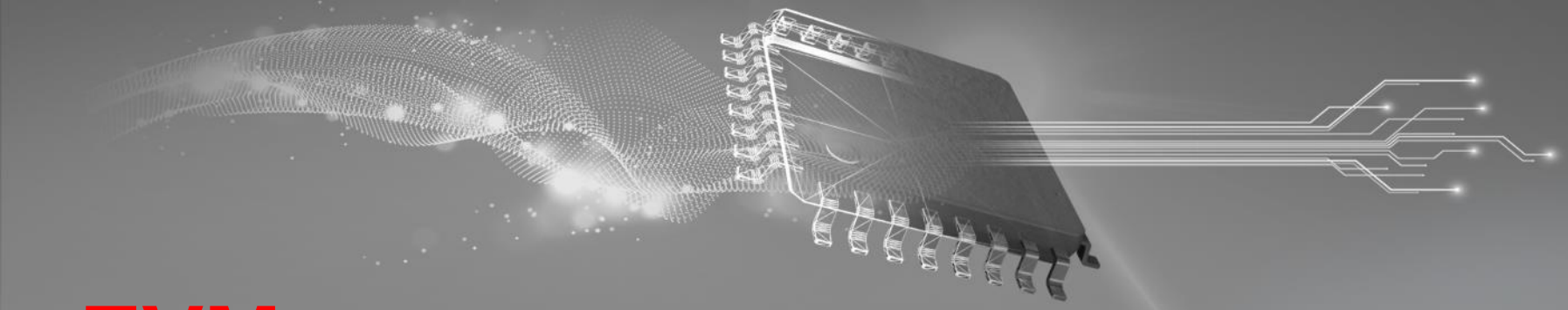
Ultrasound

- When provided with a frame clock 96kHz, TAS2563 can support output above 40kHz.



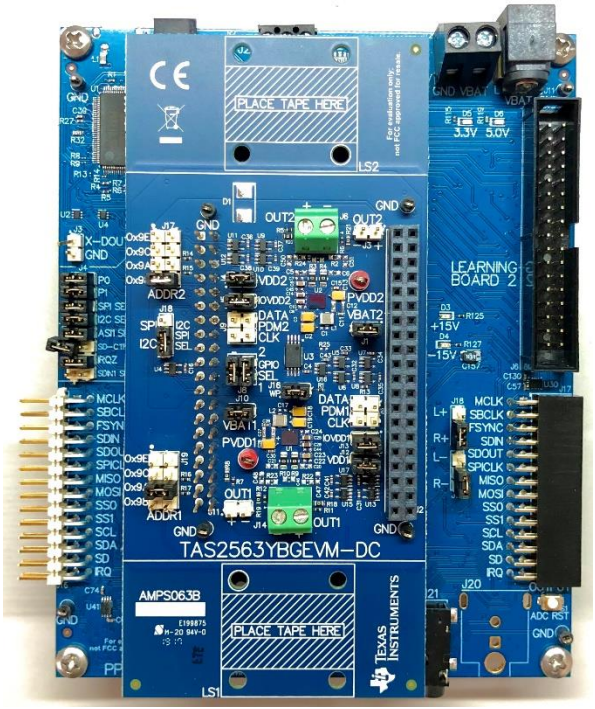
- Benefits:
  - Ultrasound applications can easily be implemented using this amplifier

TI TECH DAYS



EVM

TAS2563 EVM

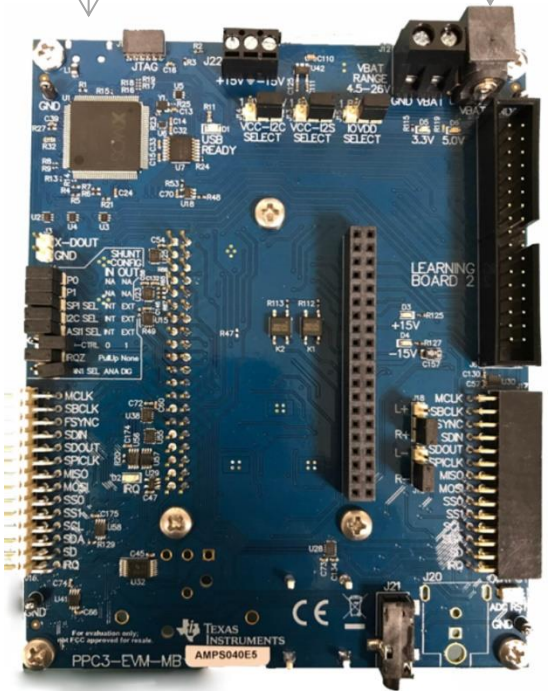


=

USB to PC

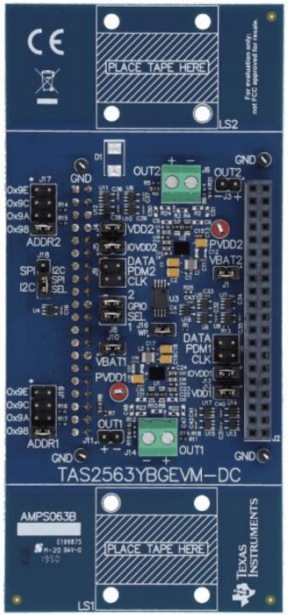
+5V Power Supply

Motherboard



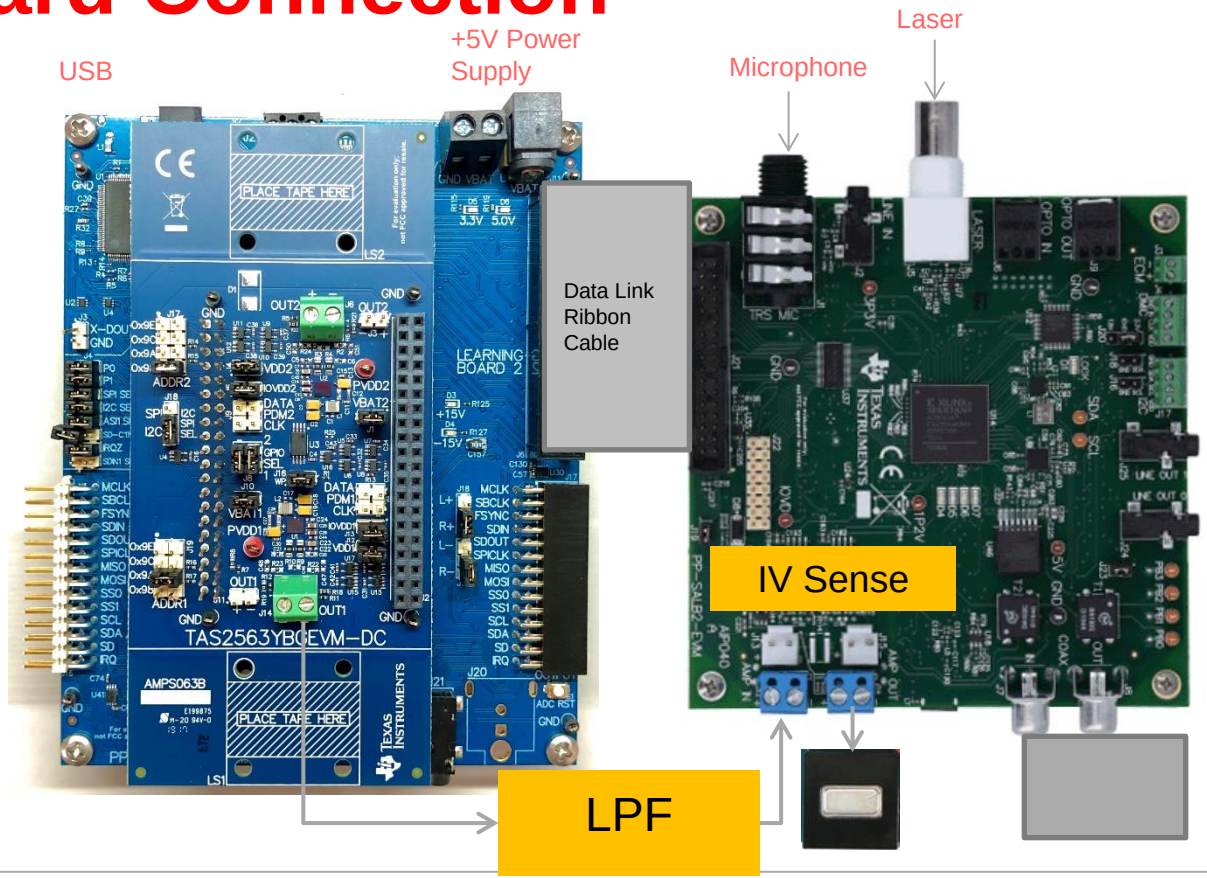
+

Daughter Card



Learning Board Connection

- LPF (included) is required to filter the class-D switching output down to audio band
- The amp output must feed through the LPF and the LB IV sense before feeding to the speaker
- Data link ribbon cable is required to interact between the amplifier device and the LB FPGA



Sample Order

Texas Instruments TAS2563YBGEVM-DC

To get started:

Step 1: Hardware
Order TAS2563YBGEVM-DC evaluation board, TAS2563 motherboard & PP-SALB2-EVM learning board

Step 2: Software
Request PurePath Console 3 (PPC3) control GUI, be sure to indicate you are working with the TAS2563YBGEVM-DC

EVM

Device

↓↑ Orderable part number	Datasheet	↓↑ Part number	↓↑ Package	↓↑ Temp (C)	↓↑ Pins	Carrier	Availability	Priced from	Request sample
TAS2563YBGEVM-DC		TAS2563YBGEVM-DC	BOARD		0	Not Required	Available	Free sample	Add to cart
TAS2563YBGR		TAS2563	DSBGA (YBG)	I (-40 to 85)	42	Cut Tape	Available	Free sample	Add to cart

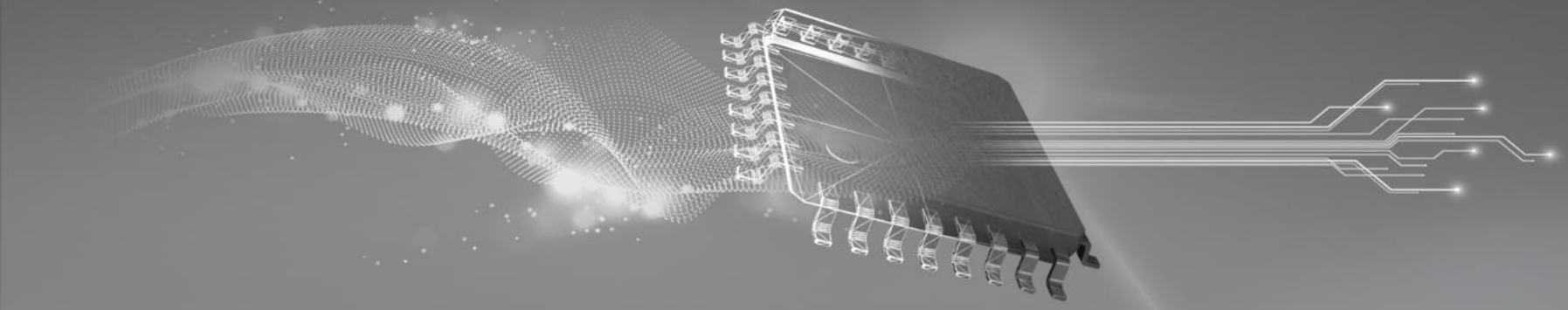
Mother Board

↓↑ Orderable part number	Datasheet	↓↑ Part number	↓↑ Package	↓↑ Temp (C)	↓↑ Pins	Carrier	Availability	Priced from	Request sample
PPC3-EVM-MB		PPC3-EVM-MB	BOARD		0	Not Required	Available	Free sample	Add to cart

Learning Board

↓↑ Orderable part number	Datasheet	↓↑ Part number	↓↑ Package	↓↑ Temp (C)	↓↑ Pins	Carrier	Availability	Priced from	Request sample
PP-SALB2-EVM		PP-SALB2-EVM	BOARD		0		Available	Free sample	Add to cart

TI TECH DAYS

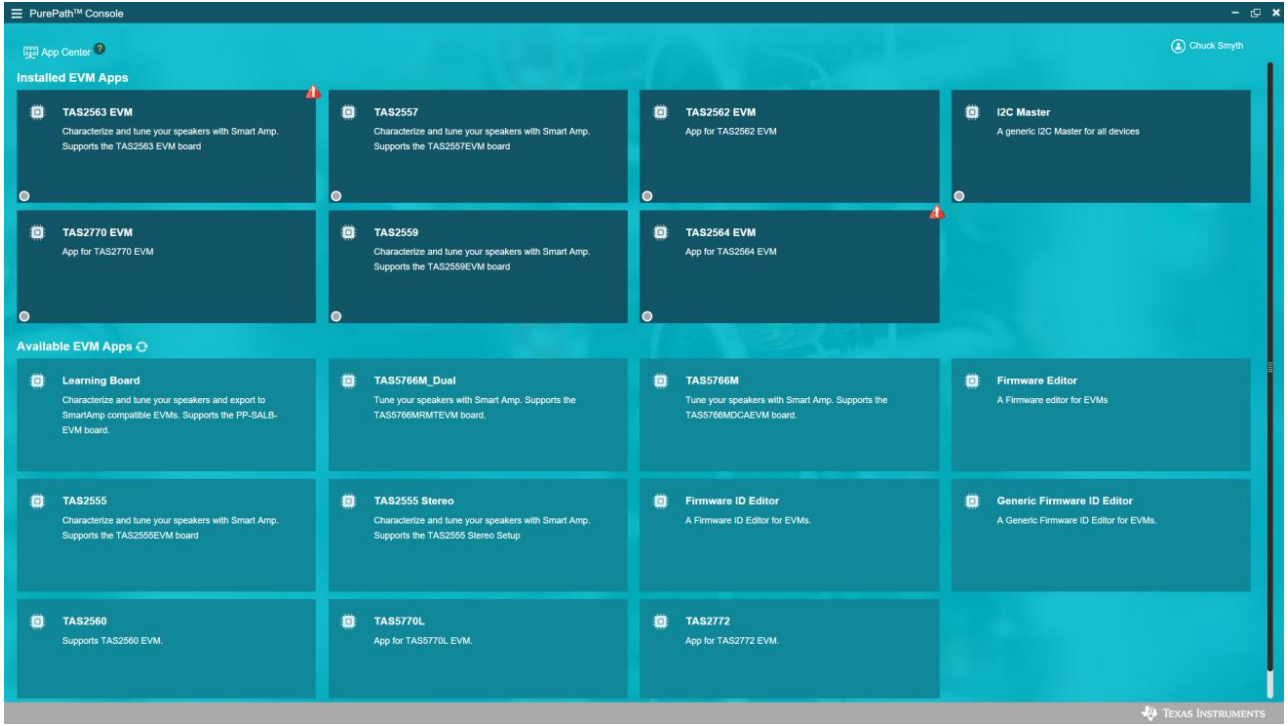


PPC3 (TAS2563 GUI Interface)

PurePath Console 3 (PPC3)

- Single, easy to use tool for Smart Amp integration
- Always up to date with notifications for platform / application updates
- Step by step wizard for speaker characterization
- SmartEQ for quick tuning evaluation
- 10 Bi-quads & 3 band prioritization for manual tuning adjustments
- Track temperature and excursion performance during verification
- Built-in audio player and tuning snapshots
- In-system tuning capable

PPC3 App Center



PPC3 App Center: TAS2563 EQ

PPC3 Access Request

Access Request App Note

PUREPATHCONSOLE

Description & Features | Technical documentation | Support & Training | Order Now

Order Now

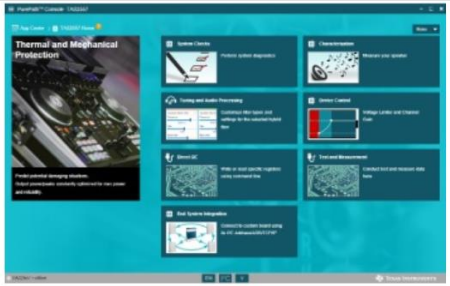
Part Number	Buy from Texas Instruments or Third Party	Status
PUREPATHCONSOLE: PurePath™ Console graphical development suite for audio system design and development	Request	ACTIVE

Description

PurePath™ Console is a highly integrated and easy-to-use audio development suite designed specifically to simplify the evaluation, configuration and debug process associated with the development of audio products. Watch how easy it is to use the PurePath™ Console 3 software.

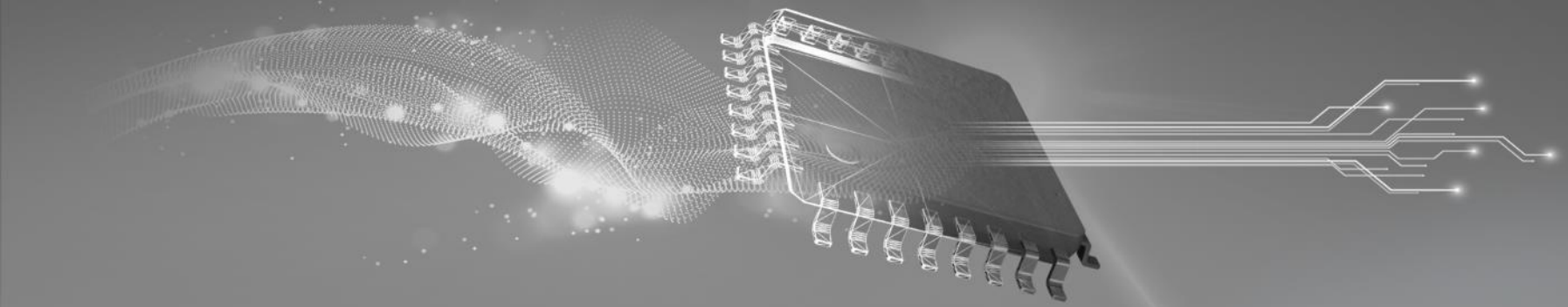
PurePath Console's intuitive graphical interface makes audio design straightforward as no advanced audio engineering expertise is required. Highly optimized audio performance, minimal power consumption and seamless system integration are made possible with PurePath Console's many advanced control features implemented in an easy to use graphical interface targeted at reducing product development time.

Supported devices:



PurePath™ Console Software Dashboard

TI TECH DAYS

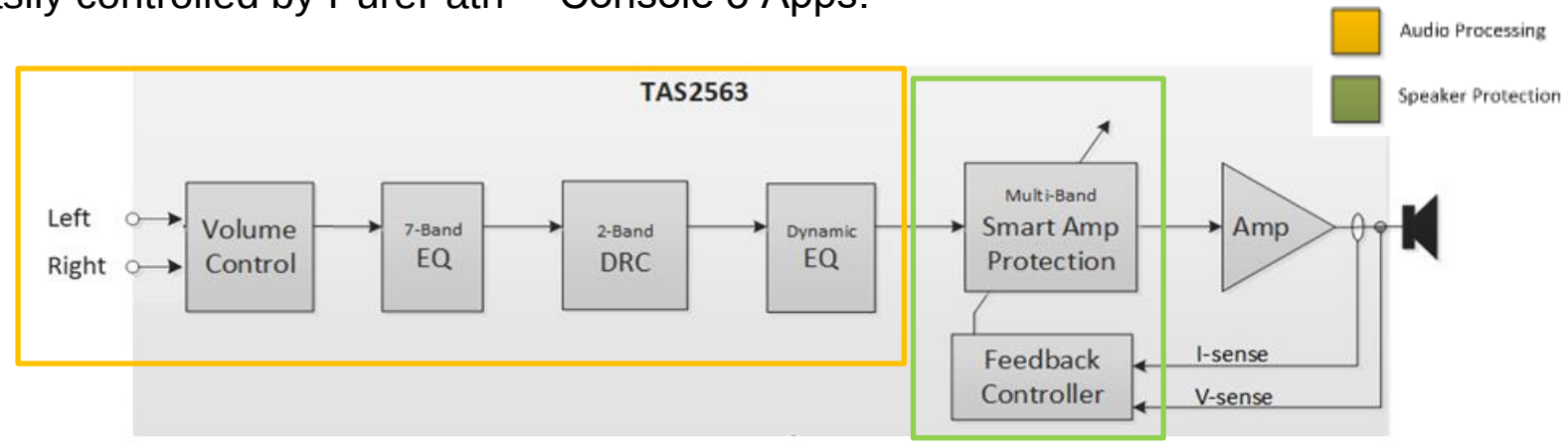


SmartAmp Algorithm TAS2563

TAS2563 | Algorithm Block Diagram

High Level Features

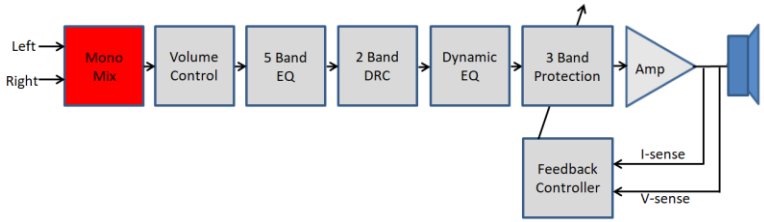
- Multi-band Smart Amp Speaker Protection with I/V sense feedback.
- Pre-processing blocks to maximize loudness, bass and clarity.
- Support for mono, dual-mono, with gain linking.
- Easily controlled by PurePath™ Console 3 Apps.



Smart Amp | Algorithm Features

- Dynamic speaker EQ(resonance tracking and THD reduction)
- Ultrasound (96kHz) support with SA
- PI controller for high ambient protection
- Dynamic gain allocation for excursion and thermal models
- Low ambient temperature protection
- Three wire dc offset control (ROM spin)
- Beam forming using microphones (development)
- ANC, AEC, Passive Radiators (development)

Mono Mix

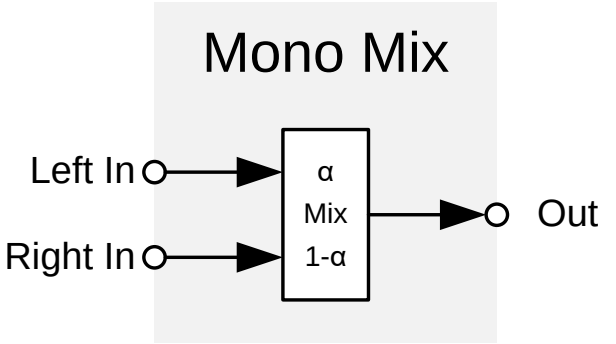


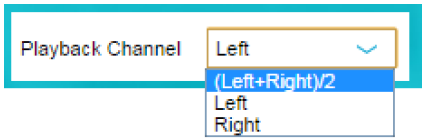
What is it?

- It mixes left and right inputs.

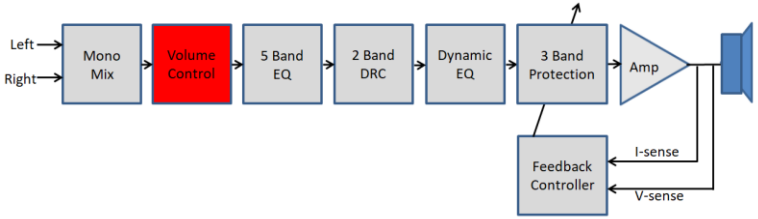
Why do we need it?

- To ensure that all instruments are heard regardless of the channel. Example: You will not be able to hear Paul McCartney in Eleanor Rigby if you ignore the right channel!



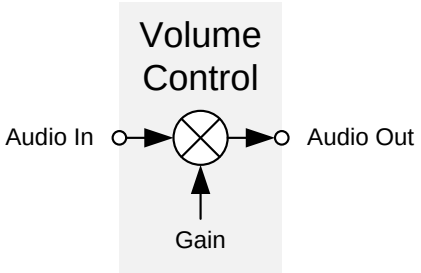


Volume Control



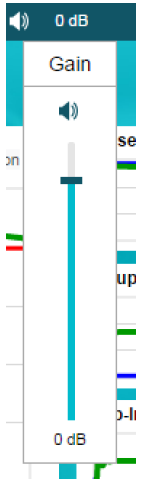
What is it?

- It gains/attenuates the input signal before it reaches the rest of the algorithm.

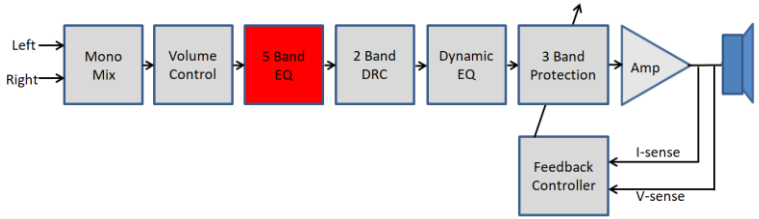


Why do we need it?

- To be consistently loud across all music genres and movies. When used in combination with the DRC and Protection, soft music will end up sounding loud – this is especially important when playing audio in noisy environments.



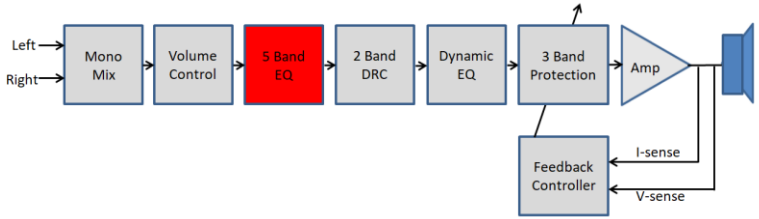
EQ



What is it?

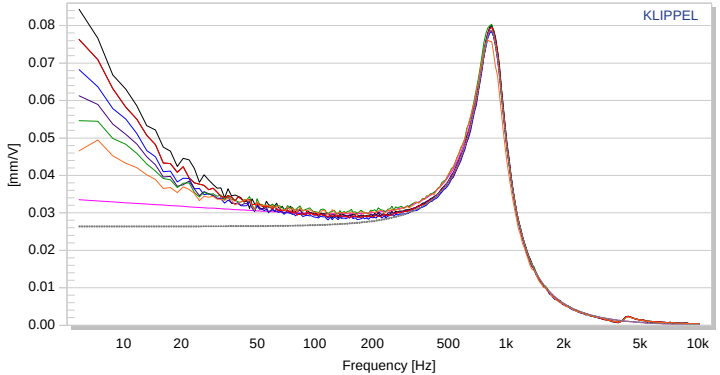
- 5 biquad filters that can be used for multiple functions.

EQ

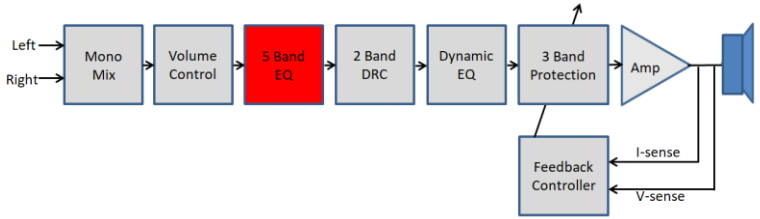


Why do we need it?

- Overall voicing.
- Attenuate frequencies that produce high THD (in combination with protection limiting).
- Remove very low frequencies to mitigate the effects of speaker excursion creep.

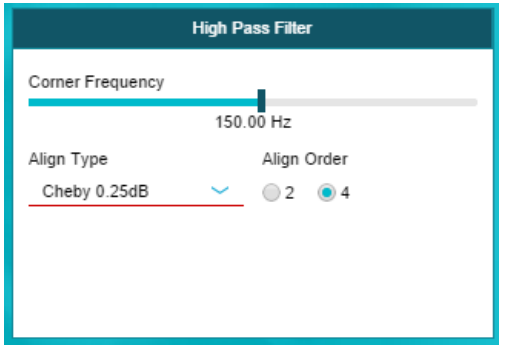


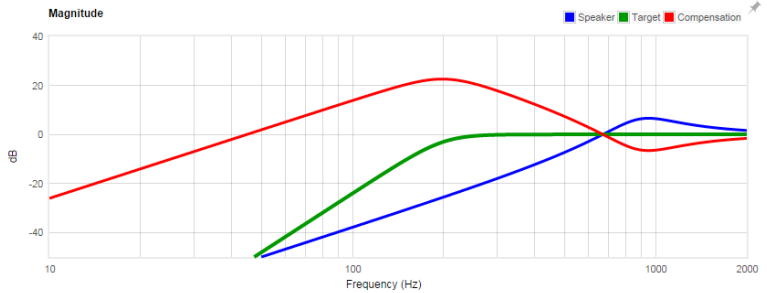
EQ | Smart Bass



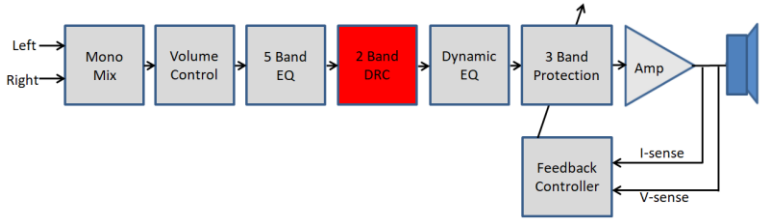
What is it?

- Smart Bass automatically compensates for the speaker Qts and matches your target alignment type.
- Example: you can configure Smart Bass to achieve an SPL response of a 150Hz, 4th order Cheby alignment.



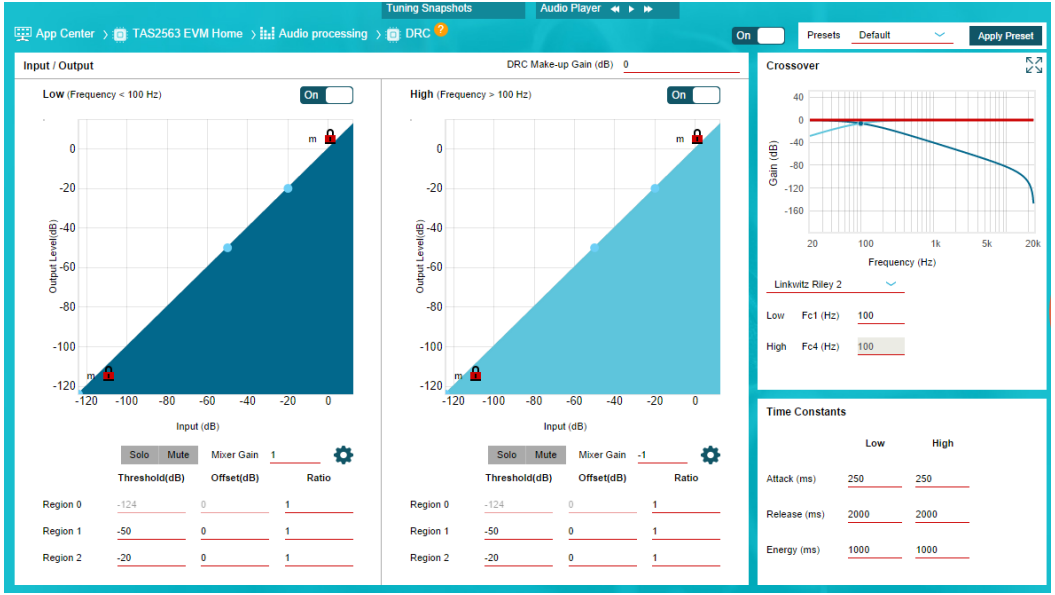


Multi-band DRC

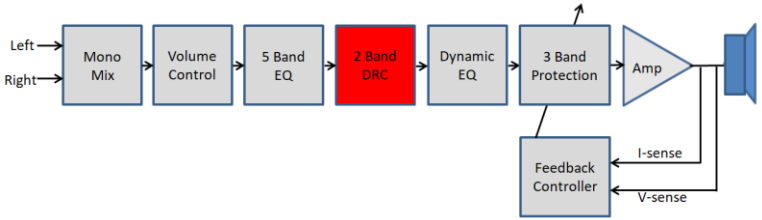


What is it?

- It compresses loud signals to ensure consistent loudness across all music genres.
- It also works as an expander.

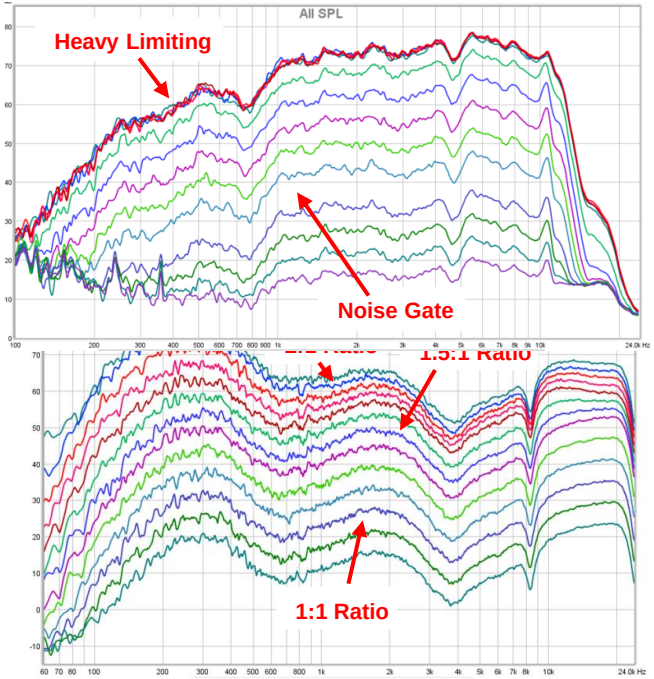


Multi-band DRC



Benefits

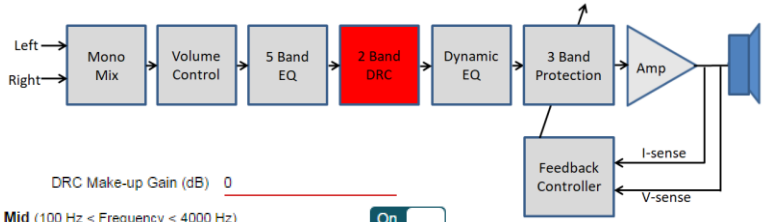
- Multi-band
  - Helps maintain a consistent spectrum. Music energy typically decreases with increasing frequency. Also, the speaker excursion limit is usually the protection bottleneck which may cause high frequencies to be overly loud, making the sound thin at high SPL levels. The multi-band DRC can be tuned to ensure that high frequencies are properly controlled.
  - Independent compression ratios, thresholds and time constants per band maintain loud SPL which would otherwise be compressed by slow time constants of bass frequencies. It also avoids gain fluctuations.
- Adjustable compression ratios help maintain punch. Limiters can make the music sound noisy, especially when using large gain levels.

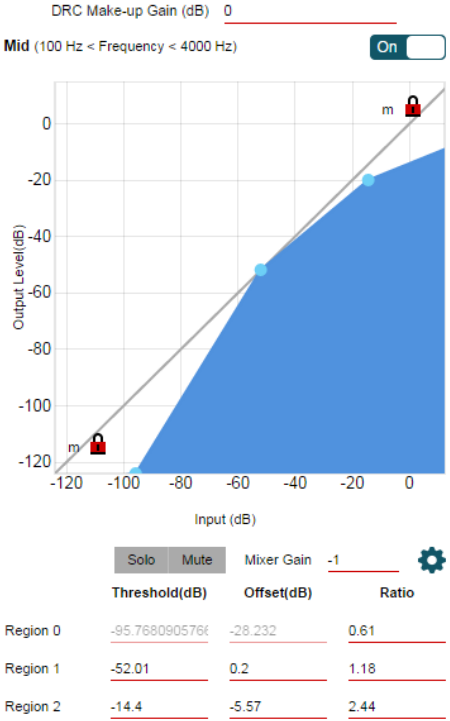


Multi-band DRC

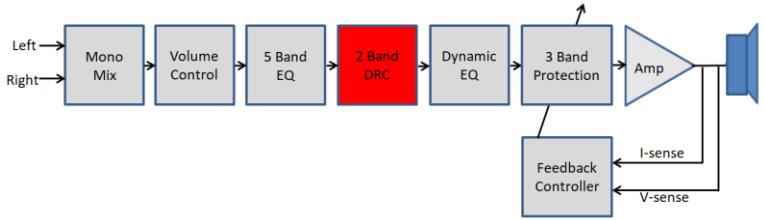
Features

- It allows you to independently control:
  - **The input / output characteristic of each band.**
  - **Solo or Mute each band.**
  - Time constants for each band.
  - Noise Gate for each band.
  - Multi-band crossover filters.



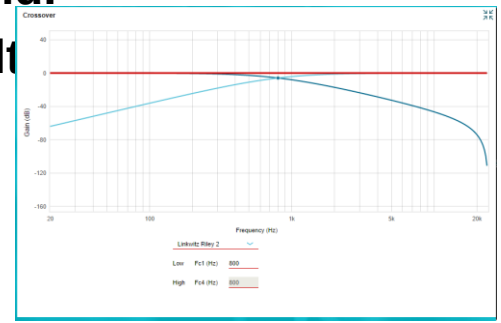


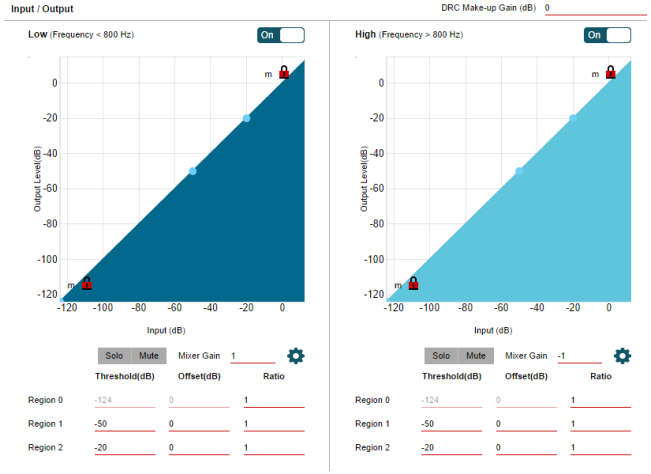
Multi-band DRC

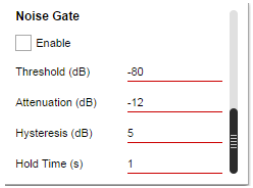


Features

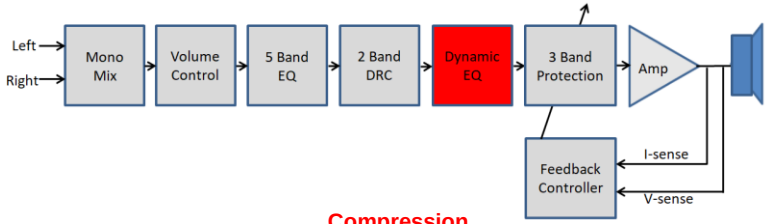
- It allows you to independently control:
  - The input / output characteristic of each band.
  - Solo or Mute each band.
  - **Time constants for each band.**
  - **Noise Gate for each band.**
  - **Multi-band crossover filt**







Dynamic EQ



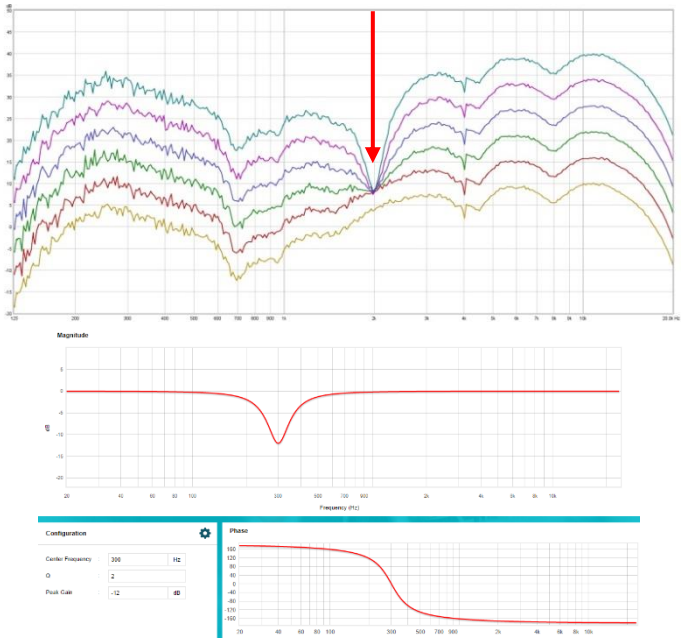
What is it?

- It compresses loud signals at a particular frequency

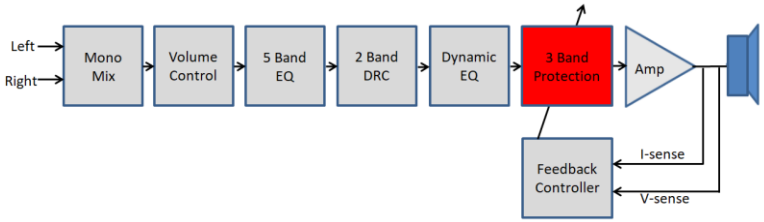
Why do we need it?

- It helps reduce distortion due to rocking mode/rub-and-buzz which occurs at a particular frequency

Compression

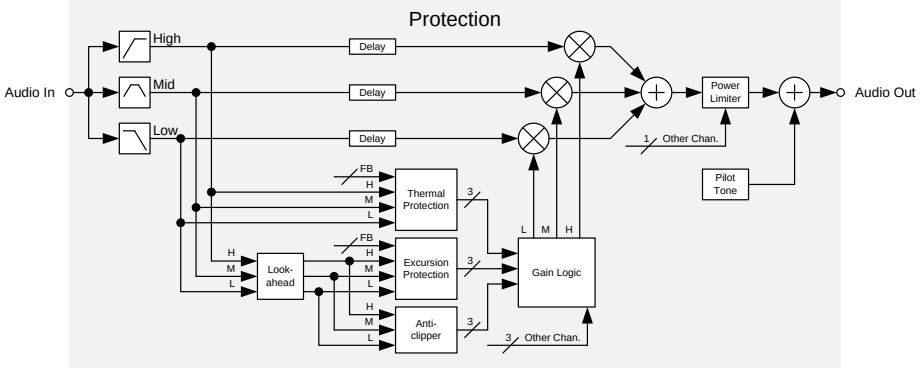


Protection

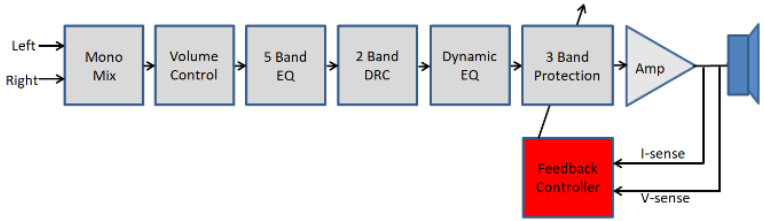


What is it?

- Keeps speaker within excursion and thermal limits.
- Anti-clipper prevents digital clipping.
- Model is updated in real-time by feedback controller.



FB Controller



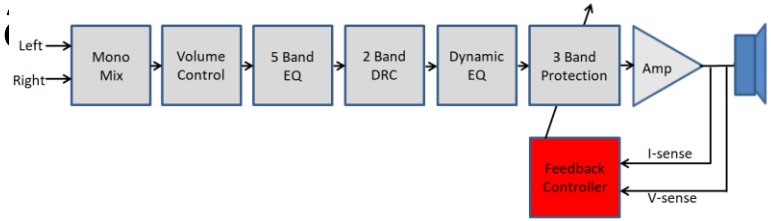
What is it?

- The Feedback Controller updates the excursion and thermal protection models by monitoring the speaker load current and voltage.

Features

1. Voice coil DC resistance (Re) estimator.
2. Voice coil temperature (Tv) estimator and controller.
3. F0/Q tracker.

FB Controller | Re Estima



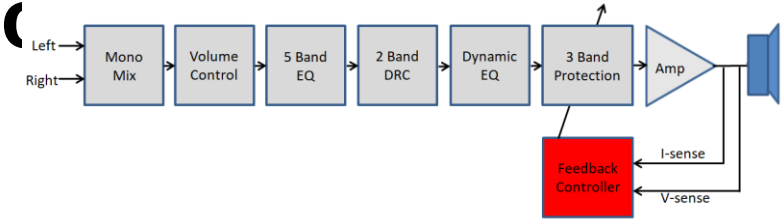
What is it?

- It calculates the voice coil DC resistance.

Features

- Programmable pilot tone amplitude and frequency.
- Quick Re estimation.

FB Controller | Tv Contro..



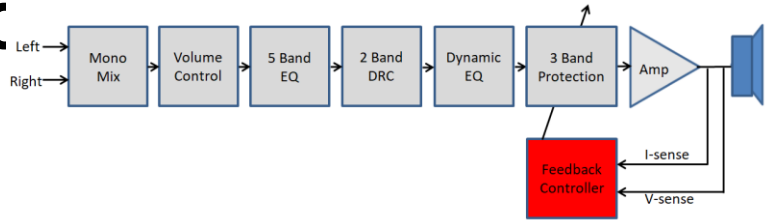
What is it?

- It calculates voice coil temperature and keeps Tv below Tmax.

Features

- Keeps Tv within limits due to increases in power and/or ambient temperature (Ta).
- Controls the threshold of the Thermal Limiter. This avoids long term fluctuations in audio since the user has direct control of the limiter's time constants.

FB Controller | F0/Q Trac



What is it?

- It estimates the excursion transfer function to protect against f0/Q shifts due to temperature, aging, leaks, blocked ports, etc.

Features

- Determines back-emf signal quality to prevent tones from affecting the accuracy of the tracker.
- Excursion transfer function bounds can be adjusted to avoid over-excursion due to large DC offsets.
- Anti-resonant dynamic tracking filter at resonance

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale (www.ti.com/legal/termsofsale.html) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265