

Getting Started with Smart Amp Development

Jorge Arbona

High Performance Analog / Audio

ABSTRACT

PurePath™ Smart Amp provides powerful tools to make speaker characterization and tuning easy.

Smart Amp replaces traditional continuous power design principles and hardware based speaker protection methods with algorithms that allow significant increases in peak power output, loudness and sound quality relative to conventional amplifiers.

Smart Amp tools allow developers to understand how speakers are performing in the system and then make informed decisions to improve performance. The algorithms, characterization and tuning tools allow developers to overcome a wide variety of audio challenges.

WARNING: EXPORT NOTICE

Recipient agrees to not knowingly export or re-export, directly or indirectly, any product or technical data (as defined by the U.S., EU, and other Export Administration Regulations) including software, or any controlled product restricted by other applicable national regulations, received from Disclosing party under this Agreement, or any direct product of such technology, to any destination to which such export or re-export is restricted or prohibited by U.S. or other applicable laws, without obtaining prior authorization from U.S. Department of Commerce and other competent Government authorities to the extent required by those laws. This provision shall survive termination or expiration of this Agreement.

According to our best knowledge of the state and end-use of this product or technology, and in compliance with the export control regulations of dual-use goods in force in the origin and exporting countries, this technology is classified as follows:

- **US ECCN: 3E991**
- **EU ECCN: EAR99**

And may require export or re-export license for shipping it in compliance with the applicable regulations of certain countries.

Contents

1	Supported Smart Amp Devices	2
2	What is Smart Amp?	3
3	Smart Amp Development Overview	5
4	What's Needed	6
5	Support	8

List of Figures

1	PurePath™ Smart Amp Block Diagram	3
2	Smart Base	4
3	Smart SPL	4
4	Smart EQ	4
5	Smart SOA	4
6	Smart Amp Development Overview	5
7	mySecureSoftware Page	7

List of Tables

1	Table 1. Equipment and Software	6
2	Miscellaneous Equipment	8
3	Microphones Tested for Smart SPL and Passive Radiator Systems	8

Trademarks

PurePath is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

1 Supported Smart Amp Devices

This document supports the following Smart Amp devices.

1. [TAS5766M](#)
2. [TAS5768M](#)

2 What is Smart Amp?

Conventional hardware-based speaker protection matches the continuous power output of the audio amplifier with the speaker output rating and sometimes incorporates high pass filtering to prevent over-excursion. PurePath™ Smart Amp replaces hardware based speaker protection methods with predictive algorithms, speaker characterization tools and real-time signal monitoring to increase the peak output of the speaker without damage.

The first implementation step of Smart Amp based audio solutions is characterizing the speaker with TI's PurePath™ Console 3 and the PurePath™ Learning Board. These are powerful, easy-to-use tools designed specifically to simplify system level characterization, tuning and implementation. The characterization process creates a digital model of the speaker based on thermal, electro-mechanical and acoustic parameters.

The output of the characterization process is an initial set of coefficients that define the Safe Operating Area (SOA) which establishes the boundaries of maximum speaker diaphragm excursion and voice-coil temperature during operation. If the SOA is set correctly, the audio engineer need not worry about speaker damage during the audio tuning process – depending on how hard the system is pushed audio might sound more or less desirable, but speaker safety is ensured if configured properly.

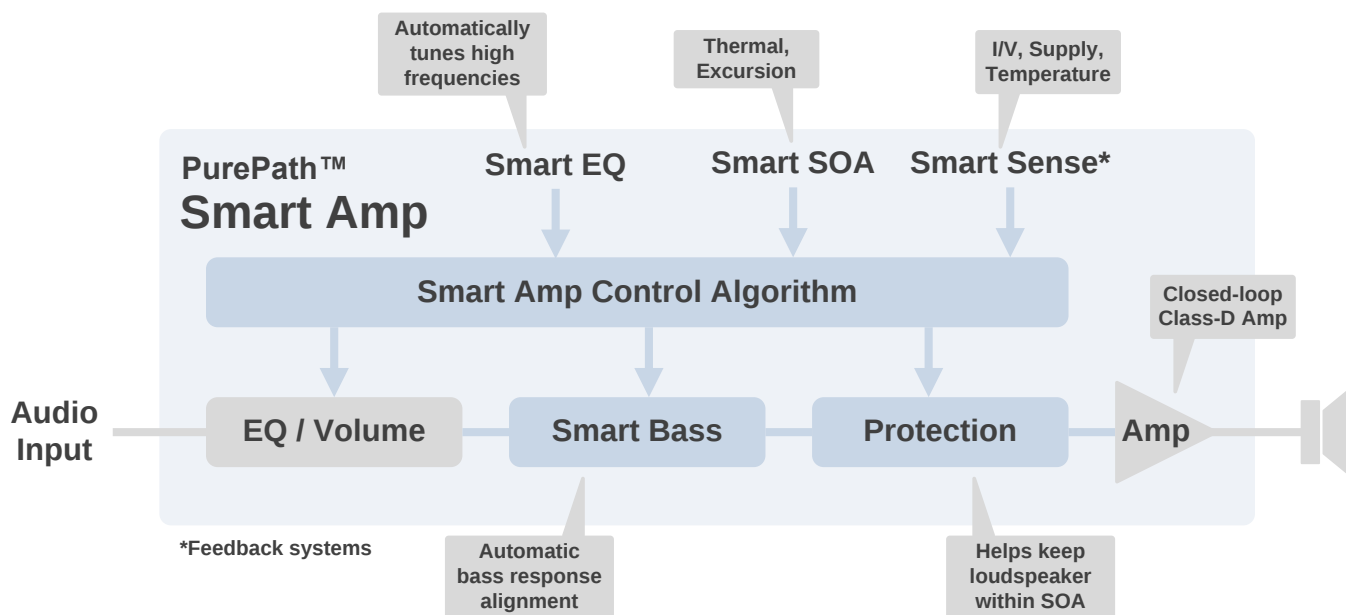


Figure 1. PurePath™ Smart Amp Block Diagram

PurePath™ Smart Amp technology enables significant sound quality and system reliability improvements while reducing component size and cost. The PurePath™ Console 3 graphical user interface and Learning Board speaker characterization hardware provide simple configuration of advanced properties fully describing an audio system's acoustical, electrical, thermal and reliability capabilities and simplifying system level characterization, tuning and integration.

2.1 Smart Amp Features

2.1.1 Smart Base

Bass can easily be extended into any alignment automatically. As signal amplitude is increased in the bass region, Smart Bass automatically morphs the response to accommodate for larger excursion.

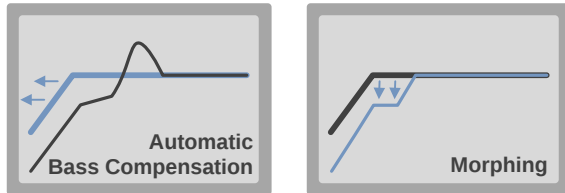


Figure 2. Smart Base

2.1.3 Smart EQ

Automatically tunes high frequencies to deliver a flat response or match a target curve in seconds. And it does it very efficiently.

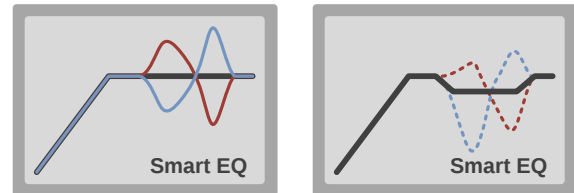


Figure 4. Smart EQ

2.1.2 Smart SPL

High-frequency behavior of the loudspeaker diaphragm cannot be obtained electrically. Similarly, it is difficult to obtain accurate low-frequency acoustical measurements without an expensive anechoic chamber. Smart SPL automatically merges electrical and acoustical measurements to create a full picture of the SPL response.

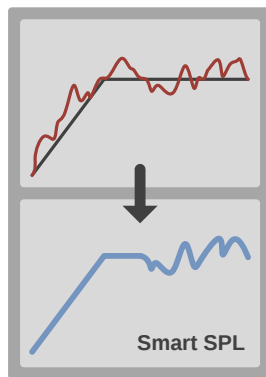


Figure 3. Smart SPL

2.1.4 Thermal and Excursion Protection

The Smart Amp algorithm understands the thermal and excursion limitations of the speaker. This allows to drive it at peak levels much louder than conventional amplifiers while keeping the voice coil temperature and excursion within the specified limits. This results in louder audio playback.

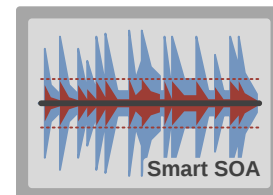


Figure 5. Smart SOA

3 Smart Amp Development Overview

The following steps summarize Smart Amp evaluation, planning, characterization, tuning and integration:

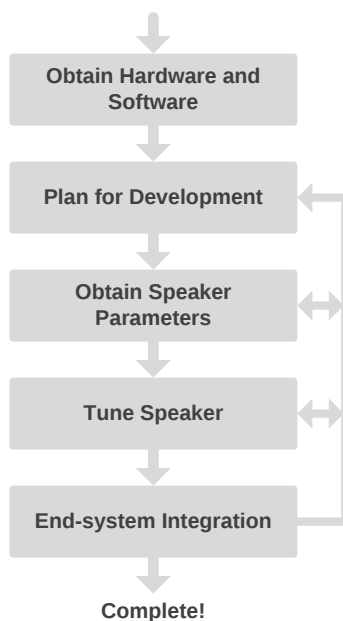


Figure 6. Smart Amp Development Overview

1. **Obtain Hardware and Software** - Speaker characterization and tuning are performed using the *PurePath™ Console 3* software. The *TI Learning Board* and the *Smart Amp Target EVM* are needed in order to fully evaluate and develop with Smart Amp.
2. **Plan for Development** – Developing *Smart Amp* based systems for the first time can be different than working with conventional amplifiers. Information obtained during the speaker characterization process often leads to changes to the speaker or enclosure to maximize output and quality.
3. **Obtain Speaker Parameters** – The next step is to understand the characteristics of the speaker to be tested. Once a speaker is characterized, the *ppc3* file obtained from this step will be used on the next step.
4. **Tune Speaker** – Once the speaker data is obtained, a speaker can be tuned using the *Learning Board* or the *Target EVM* by importing a *ppc3* file.
5. **End-system Integration** – Smart Amp fundamentally shifts how audio systems are designed. Using the Smart Amp tool set, a designer gathers an in-depth understanding of speaker electro-mechanical, thermal and acoustic parameters. Based on these parameters, Smart Amp algorithms deliver high peak voltage and current to the speaker while protecting the speaker from excessive heat or movement. Increased voltage and current levels lead to changes in the system power design. For these reasons it is important to understand the power supply requirements early in the design.

4 What's Needed

[Table 1](#) shows the hardware and software requirements organized by configuration type (e.g. 2.0, 2.1 or 4 channel). All the configurations require the Learning Board for characterization. The Target EVM is required to generate code to be implemented in the end-system.

Table 1. Table 1. Equipment and Software

	2 Channel Mid-Power Smart Amp	2.1 Channel Mid-Power Smart Amp	4 Channel Mid-Power Smart Amp
Hardware Tools (4.1)			
PurePath™ Smart Amp Learning Board	x	x	x
PurePath™ Console Motherboard	x	x	x
Target EVM (4.1)			
2 Channel TAS5766M EVM (TSSOP)	x		
4 Channel TAS5766M EVM (QFN)		x	x
Miscellaneous Equipment (4.2)			
Weigh Scale	o	o	o
Adhesive Putty	o	o	o
Metric Ruler	o	o	o
24V Power Supply	x	x	x
Microphone	p	p	p
Software Tools (4.1)			
PurePath™ Console 3	x	x	x

4.1 Obtaining TI Hardware and Software

TI approval is required to order Smart Amp-related hardware and software. Click the button in the *Target EVM* web site to begin the approval process. Once approved, the user will receive an email confirming access to the [mySecureSoftware](#) web site and hardware ordering information.

The PurePath™ Console 3 software can be downloaded from the *PUREPATHCONSOLE Software Product* page in mySecureSoftware, as shown below. There is no need to download separate plugins – Smart Amp Apps will automatically be available within PurePath™ Console 3 once the user is given access to the proper Software Product (e.g. *TAS5766MSW-SA*, etc.).

The *Target Software Product*, as shown in [Figure 7](#), contains hardware ordering information, documentation, videos, etc.

Target Software Product: Hardware ordering information, documentation, videos, etc

Action	Name	Software Product	Description
Access	TAS2555SW-SA EVM boards and Software for PurePath Smart Amp TAS2555 View EULA	TAS2555SW-SA	PurePath Smart Amp boards and software (TAS2555)
Access	EVM boards and Software for PurePath™ Smart Amp TAS5766M View EULA	TAS5766MSW-SA	PurePath Smart Amp boards and software (TAS5766M)
Access	PurePath Console Graphical Development Suite View EULA	PUREPATHCONSOLE	PurePath Console Graphical Development Suite

PurePath Console 3 Software

Figure 7. mySecureSoftware Page

Contact audio_software@ti.com for any issues related to software access

4.2 Miscellaneous Equipment

In order to perform a full characterization the following hardware is recommended. Some of these items are not needed if loudspeaker parameters are known.

Table 2. Miscellaneous Equipment

Equipment	Description
Weight Scale	20g in 1mg increments preferred. The Gemini-20 Portable Milligram Scale by American Weigh is recommended. Not required if the force factor BI is provided by the speaker manufacturer.
Adhesive Putty	Similar to Blu Tack or <i>Removable Adhesive Putty</i> by Scotch . Not required if the force factor BI is provided by the speaker manufacturer.
Metric Ruler	Size depends on loudspeaker diaphragm area (Sd). Also used to measure port area (Sp). Plastic is preferred to prevent the magnet from pulling the ruler. Not required if Sd and Sp parameters are known.
24V Power Supply	A lab power supply capable of providing peak power to the speakers. A 24V, 6A supply addresses most circumstances. An external AC/DC supply could be used as well, such as the MENB1100A2403F01 by SL Power Electronics .

A microphone is required for *Smart SPL* and characterizing passive radiator systems. [Table 3](#) is a list of microphones that have been tested for Smart Amp.

Table 3. Microphones Tested for Smart SPL and Passive Radiator Systems

Model	Manufacturer	Type
Mic: CME-1538-100LB	CUI, Inc.	Electret Condenser (requires external 1.8V bias)
Capsule: 4938 Preamp: Type 2670	Brüel & Kjær	¼" Diameter Pressure Field
Mic: EMM-6	Dayton Audio	½" Diameter Condenser (tested with Shure X2u USB Preamp)
Mic: IMM-6	Dayton Audio	Condenser (requires external 1.8V bias)

5 Support

Smart Amp is supported through the [Audio Amplifiers Support Forum](#). Please include the words Smart Amp and the part number in the subject line. Contact your local TI sales representative for additional details.

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from C Revision (July 2015) to D Revision	Page
Changed the Title From: PurePath™ Smart Amp Overview (TAS5766M/68M) to: Getting Started with Smart Amp Development.....	1

Revision History

Changes from B Revision (November 2014) to C Revision	Page
Complete re-write of the document.	1

Revision History

Changes from A Revision (July 2014) to B Revision	Page
- Added <i>Section 1</i> with links to TAS5766M and TAS5768M - Changed Figure 1 <i>Section 4.1 Hardware Tools</i>: Added passive radiator information - Deleted Appendix A	2 3 7 8

Revision History

Changes from Original (May 2014) to A Revision	Page
<i>Section 4.1 Obtaining TI Hardware and Software</i>: Added bullets and change wording in Smart Amp Device EVM bullet, Changed Smart Amp Learning Board bullet, and Added Adhesive Putty bullet <i>Section 4.2 Miscellaneous Equipment</i>: added a paragraph and changed bullets <i>Section 5 Documentation</i>, removed link and reworded second to last paragraph	7 8 8

IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ("TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>), [evaluation modules](#), and [samples](http://www.ti.com/sc/docs/sampterm.htm) (<http://www.ti.com/sc/docs/sampterm.htm>).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2017, Texas Instruments Incorporated