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ABSTRACT

This document was translated from a simplified Chinese source. [\(ZHCAG74\)](#)

TI Class-D audio amplifier ICs are widely used in consumer electronics and automotive applications due to their high performance and high efficiency. Among them, the TAS58xx series is widely used in consumer electronics products such as TVs, speakers, soundbars, and party boxes. One of the most common issues encountered by engineers when using the TAS58xx series is overcurrent protection. The TAS58xx series amplifiers feature fast overcurrent shutdown capability. By detecting the MOSFET peak current, the amplifier can achieve shutdown within 100 ns when a severe short-circuit event occurs, thereby protecting the amplifier IC from damage. An overcurrent shutdown event cannot be automatically recovered. After an overcurrent shutdown event occurs, the user must restart the device to resume audio playback. Therefore, during normal signal playback, frequent triggering of overcurrent shutdown should be avoided.

Overcurrent shutdown events are highly correlated with inductor selection and amplifier configuration. This article briefly introduces several considerations for avoiding overcurrent shutdown during normal operation in system design. The discussion mainly focuses on two aspects: inductor selection in hardware design, and CBC/DRC/AGL/Clipper configuration in software.

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1 Troubleshooting Overcurrent Protection Events

An overcurrent protection event occurs when the current flowing through the MOSFET exceeds OCE_{THRES} . The amplifier IC will stop outputting, and the overcurrent protection threshold OCE_{THRES} for the TAS58xx series is as follows:

Part Number	TAS5805M	TAS5815	TAS5822M	TAS5825M/P	TAS5827	TAS5828M	TAS5830
OCE_{THRES}	5A	7A	7A	7.5A	8A	8A	8A

When an overcurrent event occurs, the 0x68 Power State register reports HIZ, and the 0x70 Channel Fault status register reports an over current fault. The 0x78 Fault Clear register can be used to manually clear the fault and restore playback.

Under BTL configuration, the current flowing through the MOSFET is equal to the current flowing through the inductor. Therefore, an overcurrent event is also caused by the inductor current exceeding OCE_{THRES} and triggering OCP.

Channel Fault		Description
Field	Value	
Reserved_7_4	0x00	Reserved
Ch1 DC	0	left channel DC fault
Ch 2 DC	0	right channel DC fault
Ch1 OC	0	left channel over current fault
Ch 2 OC	1	right channel over current fault

Figure 1-1. OCP status register reporting overcurrent

2 Inductor Selection

At the initial stage of circuit design, appropriate inductor selection should be ensured. Common inductor values include 4.7μH, 6.8μH, 10μH, and 15μH. The inductor selection should follow at least the following principles:

1. The inductance value should be selected such that the maximum peak current flowing through the inductor does not exceed OCE_{THRES} , mainly including Sections 2.1–2.3 below, namely: $MAX\{I_{P1}, I_{P2}, I_{P3}\} < OCE_{THRES}$.
2. The inductor should have an appropriate saturation current I_{sat} to prevent overcurrent shutdown caused by inductor saturation. The inductor saturation current I_{sat} should be at least greater than OCE_{THRES} . Otherwise, the inductor will saturate before the amplifier protection is triggered, namely: $I_{sat} > OCE_{THRES}$.
3. The LC frequency response curve should ensure that the attenuation at 20kHz is no greater than -1.5dB. The frequency response should also be close to critical damping. Excessive underdamping should be avoided, as it may result in excessive peaking in the frequency response, causing excessive amplification of the output signal and triggering OCP.
4. A larger inductance value can reduce idle current, lower idle power consumption, and reduce the risk of OCP. When PVDD is greater than 12V, it is recommended to use an inductance value of 10μH or greater.

2.1 Startup Current

At the final stage of initialization, when Device Control 2 register 0x03 is set to 0x03 (Play state), as shown in [Figure 2-1](#) below, the audio amplifier starts operating and begins outputting. The capacitor in the downstream LC filter begins charging, resulting in a relatively large startup current.

```
//Register Tuning
    { 0x00, 0x00 },
    { 0x7f, 0x00 },
    { 0x02, 0x00 },
    { 0x30, 0x00 },
    { 0x4c, 0x30 },
    { 0x53, 0x00 },
    { 0x54, 0x00 },
    { 0x03, 0x03 },
    { 0x78, 0x80 },

};
```

Figure 2-1. Initialize the play command line

The article [Analysis of Startup Current of Class-D Audio Amplifiers Under Different Operating Modes](#) provides a detailed explanation of startup current under various operating conditions. When starting in Idle mode, the current after the first PWM cycle is:

$$I_{P1} = \frac{V_1}{\omega L} e^{-\delta t} \sin \omega t \approx PVDD \times \sqrt{\frac{C}{L}} \times \sin\left(1/\sqrt{L \times C} \times \theta / F_{sw}\right) \quad (1)$$

θ is the duty cycle in Idle mode, where $\theta = 0.5$ (BD Modulation), 0.14 (1SPW Modulation), and 0.14 (Hybrid Modulation). Under the condition of $F_{sw} = 768\text{kHz}$, the current reaches its maximum value during the second PWM cycle.

2.2 Peak Current at Maximum Output Power

Ignoring inductor current ripple, the maximum peak current corresponding to maximum audio power is:

$$I_{P2} = \sqrt{\frac{2 \times P_{max}}{R_{speak}}} \quad (2)$$

2.3 Maximum Current Under Burst Signal

When a 0dB signal is applied to the power stage, severe clipping occurs at the output, resulting in a large current:

$$I_{P3} = PVDD \times (1 - \theta) / (F_{sw} \times L) \quad (3)$$

3 Parameter Configuration

All TAS58xx devices integrate a DSP and provide advanced DRC/AGL/Clipper algorithms that can effectively suppress maximum output and prevent overcurrent. In addition, TAS5825M/P, TAS5827, TAS5828M, and TAS5830 also support Cycle-By-Cycle current limiting, which can limit the current within a preset threshold before overcurrent shutdown is triggered.

3.1 Overcurrent Limit (Cycle-By-Cycle)

The purpose of Cycle-By-Cycle current limiting protection is to limit the inductor current to a fixed value when large audio signals occur, thereby preventing direct overcurrent shutdown. Taking TAS5827 as an example, as shown in Figure 3-1 below, the CBC_CONTROL register 0x77 can enable the CBC Overcurrent Limit function and set the current limit value to 80%, 60%, or 40% of OCE_{THRES} .

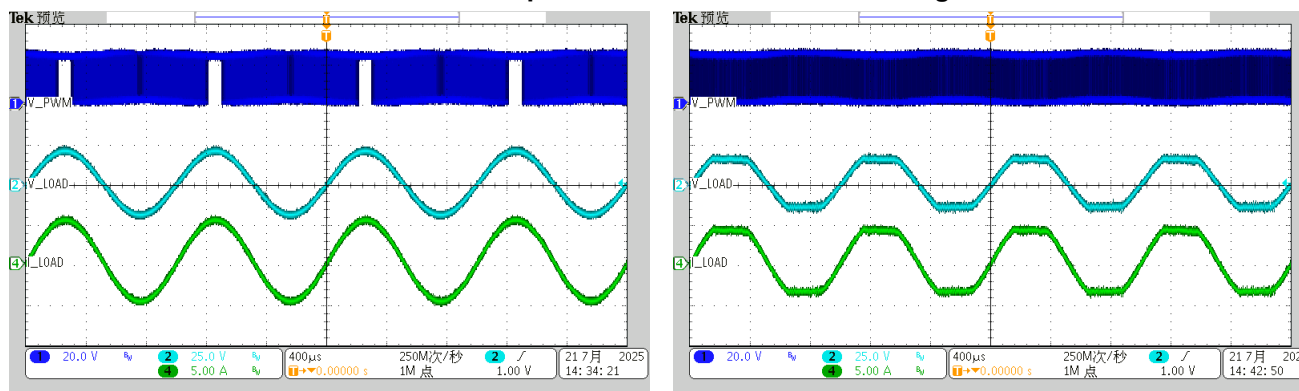
Table 6-54. CBC_CONTROL Register Field Descriptions

Bit	Field	Type	Reset	Description
7-5	RESERVED	R/W	0h	
4-3	CBCLEVEL_SEL	R/W	0h	These bits set Cycle-By-Cycle current limiting level, which is a percentage of the Over-Current Threshold: 2b'00: 80% 2b'10: 60% 2b'01: 40% 2b'11: reserved
2	CBC_EN	R/W	0h	0: Disable CBC function 1: Enable CBC function
1	CBCWARN_EN	R/W	0h	0: Disable CBC warning 1: Enable CBC warning
0	CBCFAULT_EN	R/W	0h	0: Disable CBC fault 1: Enable CBC fault

Figure 3-1. CBC current limiting configuration

The effect of Overcurrent Limit is similar to voltage clipping and is manifested as current clipping, limiting the maximum output current, as shown in Table 3-1 below.

Table 3-1. Current waveform comparison with CBC current limiting disabled/enabled



a) Current waveform with CBC disabled

b) Current waveform with CBC current limiting enabled

3.2 DRC/AGL Configuration

DRC/AGL can be used to limit the maximum output power. When the signal energy exceeds the threshold, DRC/AGL can automatically reduce gain to limit the output voltage within a predefined range. In an audio system, Analog Gain and DRC/AGL must be configured correctly. Analog Gain is used to limit the output voltage below PVDD to avoid clipping distortion. DRC/AGL is used to limit output power and prevent excessive output from causing OCP or damaging the speaker. Example:

NO.	SPECIFICATION	CALCULATION	COMMENTS
1	Maximum peak voltage on speaker	10.89 V	Maximum $P_{Out} = 14.8$ W.
2	Output peak voltage at $P_{Out_Max} = 2 \times 8$ W	8 V	No clipping at 2×8 W at 4Ω
3	Choose no clipping output peak voltage.	10.89 V	Range = [8 V, 10.89 V]. Choose 10.89 V for maximum dynamic range.
4	Calculate analog gain at step 3.	-9 dB	$20 \times \log(10.89 \text{ V} / 29.5 \text{ V}) = -8.7$ dB, set -9 dB.
5	Calculate total gain at 2×8 W.	-11.34 dB	$20 \times \log(8 \text{ V} / 29.5 \text{ V}) = -11.34$ dB
6	Obtain AGL/DRC threshold.	-2.5 dB	$-11.34 - (-9) = -2.3$ dB. Choose -2 dB or -2.5 dB.

Set Analog Gain to -9dB and DRC/AGL threshold to -2.5dB.

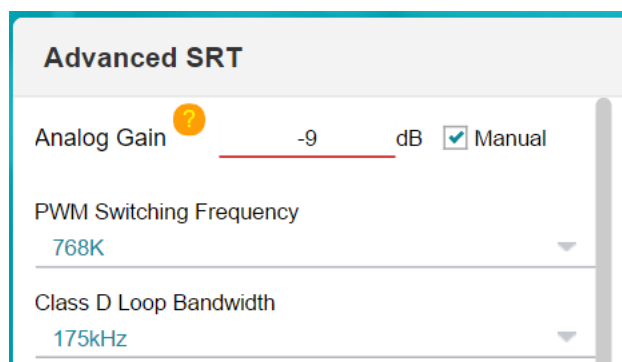


Figure 3-2. Analog Gain configuration in PPC3

The DRC tuning interface in PPC3 is shown in [Figure 3-3](#) below. When the output exceeds the threshold within the energy time window, DRC must act to limit the output. Typically, $T_{attack} \geq (2\sim3) \times 1 / F_{min}$. Attack time describes how quickly the DRC suppresses the output to the threshold level. Moderately reducing Attack time can reduce current levels.

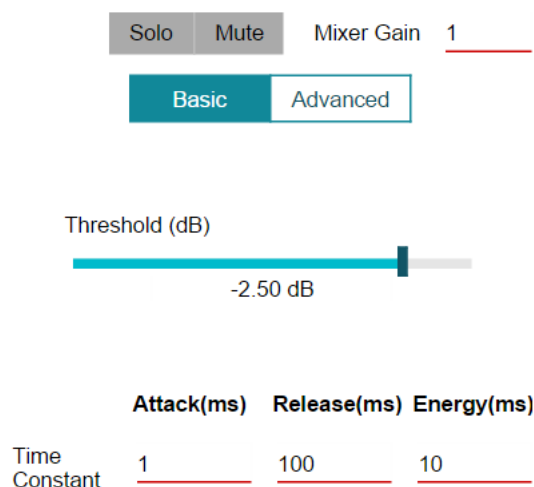
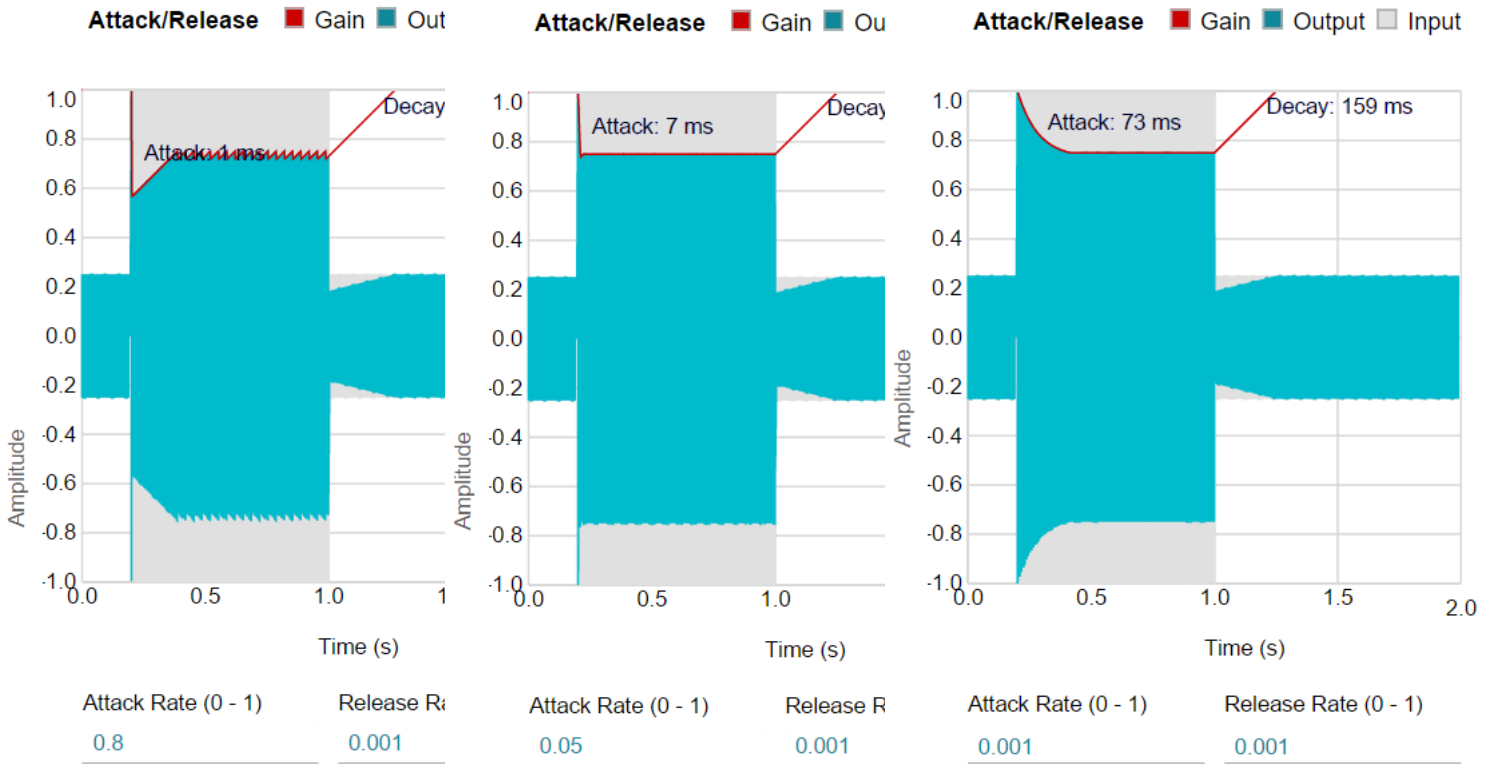


Figure 3-3. DRC settings in PPC3

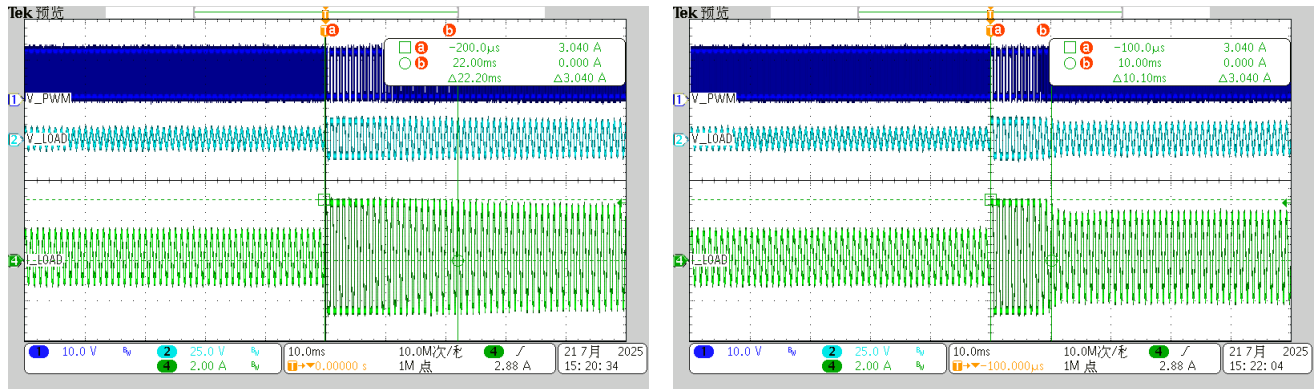
The AGL tuning interface is shown in [Figure 7](#). Increasing the Attack rate can reduce Attack time, allowing fewer audio signals to exceed the threshold and resulting in lower output current. However, this may reduce the maximum achievable loudness. Therefore, the gain curve (red curve below) should not fall below the threshold. As shown in [Table 3-2](#) below, an Attack time of 1 ms is too aggressive, while an Attack time of 73 ms is too slow. An Attack time of 7 ms provides better performance. It is recommended to set the attack time between 2 ms and 10 ms during tuning.

Table 3-2. AGL settings in PPC3



Unlike DRC, AGL performs attack and release on a sample-by-sample basis and therefore responds faster, as shown in Table 3-3 below. DRC detects energy over a fixed time interval and responds more slowly. However, in listening tests, DRC sounds more natural.

Table 3-3. Current waveform response of DRC and AGL



a) Current waveform with DRC current limiting

a) Current waveform with AGL current limiting

3.3 Clipper Configuration

The Clipper tuning interface is shown in Figure 9. Unlike DRC/AGL, Clipper has no attack or release time. Signals exceeding the threshold are discarded directly in the DSP. Therefore, Clipper has no delay and can limit output voltage and current in the fastest way through output voltage clipping, as shown in Figure 3-4 below.

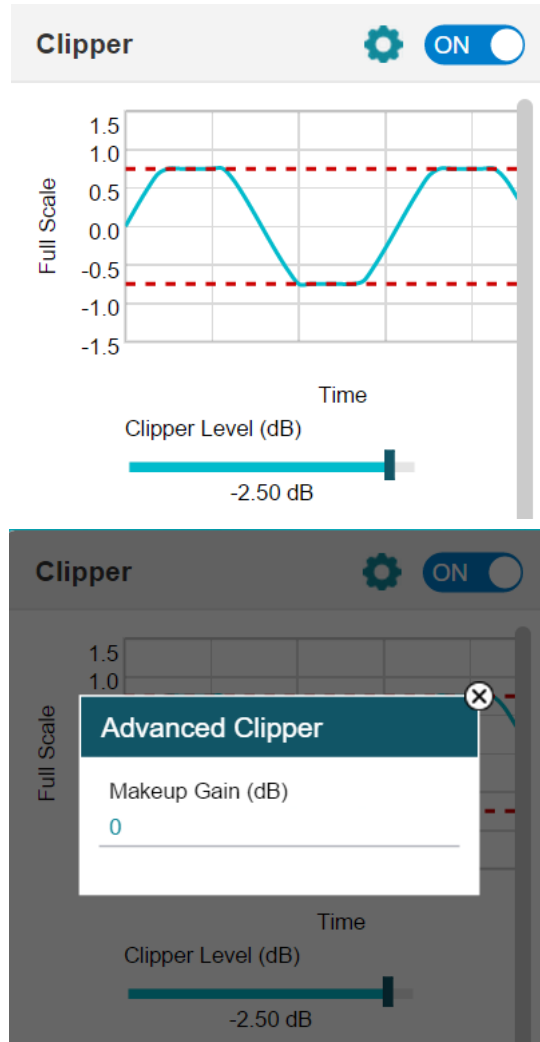
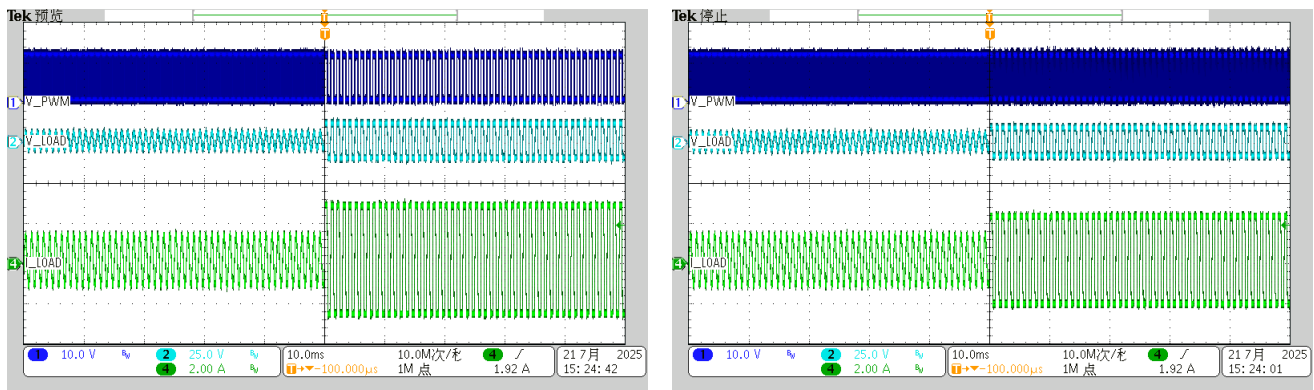


Figure 3-4. Clipper settings in PPC3

Table 3-4. Current waveform comparison with Clipper current limiting disabled/enabled



a) Current waveform with Clipper current limiting disabled

b) Current waveform with Clipper current limiting enabled

4 Summary

This article briefly introduces several considerations for avoiding overcurrent shutdown during normal operation from two aspects: hardware inductor selection and software configuration of CBC/DRC/AGL/Clipper. For inductor selection, the maximum peak current should not exceed OCE_{THRES} , and the inductor should have an appropriate saturation current I_{sat} to prevent overcurrent shutdown caused by inductor saturation. In terms of parameter configuration, CBC current limiting can constrain current to a preset threshold. Clipper provides the fastest response with no delay, but causes voltage clipping and waveform distortion. AGL provides a relatively fast response. DRC responds more slowly, but produces more natural sound compared with AGL.

5 References

1. Texas Instruments, [General Tuning Guide for TAS58xx Family](#) application report.
2. Texas Instruments, [TAS5828M 50W Stereo, Digital Input, High Efficiency Closed-Loop Class-D Amplifier with Hybrid-Pro Algorithm](#) data sheet.
3. Texas Instruments, [PurePath™- Console 3 \(PPC3\) Overview](#) Video library.
4. Texas Instruments, [Analysis of Startup Current of Class-D Audio Amplifiers Under Different Operating Modes](#)

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