Application Report
SLOA215–March 2015

TPA3140D2 PLIMIT and AGL

ABSTRACT

The TPA3140D2 Class D audio power amplifier is the latest analog input amplifier with clipped power level limiter (PLIMIT) and advanced unclipped automatic gain limiter (AGL) features to limit the output power. Both of these features prevent excessive output power and safeguard the speakers. This application note describes the differences in and usage of these features.

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1 General Overview

The TPA3140D2 has built-in power limiters: PLIMIT and Adjustable Gain Limiter (AGL). These functions prevent excessive output power for speaker load protection. PLIMIT and AGL limit the output signal differently.

PLIMIT is a voltage limiting function that will simply limit the output signal. The voltage limit is done by setting external resistor divider. Operating above the PLIMIT set level will cause the output signal to clip. PLIMIT allows operating with output power specified at a predetermined THD level.

AGL is a non-clipping voltage limiter that sets the amplifier closed loop gain to a predetermined Vrms value. This value is also programmed by external voltage divider.

PLIMIT sets the voltage rail. AGL sets the Vrms level.

- Section 2 describes how to set the PLIMIT and AGL threshold by LIMTHRES voltage
- Section 3 describes the PLIMIT function amplifier
- Section 4 describes the AGL function of the amplifier
- Section 5 describes the typical operation of PLIMIT and AGL

2 Limiter Threshold, LIMTHRES

The AGL and PLIMIT voltage threshold is set by the applied LIMTHRES voltage. The LIMTHRES voltage is programmed by a voltage divider from GVDD to GND to set the desired voltage threshold for the AGL or PLIMIT operation.

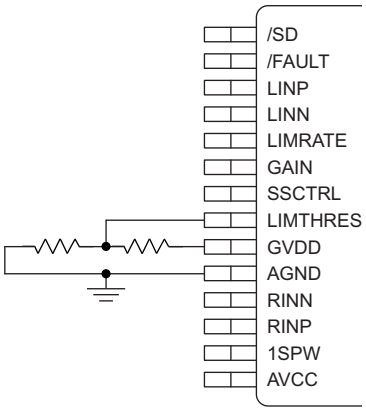

Figure 1. TPA3140D2 LIMTHRES Voltage Divider

The limiting is done by limiting the amplifier output voltage to a fixed preset value. This limit can be thought of as a "virtual" voltage rail which is lower than the P_{VCC} supply. This virtual rail is 4 times the voltage at the LIMTHRES pin. This output voltage can be used to calculate the maximum output voltage (unclipped using AGL and clipped using PLIMIT) and power for given LIMTHRES voltage and speaker impedance.

$$P_{OUT} = \frac{\left(\left(\frac{R_L}{R_L + 2 \times R_S}\right) \times V_P\right)^2}{2 \times R_L}, \text{ for unclipped power}$$

where

- R_S is the total series resistance including $R_{DS(on)}$ and any resistance in the output filter.
- R_L is the load resistance. V_P is the peak amplitude of the output possible within the supply rail.
- V_P = 4 × LIMTHRES voltage if $V_P < P_{VCC}$
- P_{OUT} = Maximum unclipped output power. 10% THD using PLIMIT: 1.25 × P_{MAX} (unclipped) (1)

Increasing the LIMTHRES voltage from a given value increases the maximum output voltage swing until it equals P_{VCC}.

Adjusting LIMTHRES to a higher value will disable both the AGL and PLIMIT function and will offer highest available, clipped, output power; however, it is always advised to use the LIMTHRES function if P_{VCC} is higher than nominal value to prevent shutdown due to overcurrent protection or to reduce the frequency of thermal foldback events. If LIMTHRES is applied at too high voltage, higher than P_{VCC} nominal value, an overcurrent shutdown can occur with low load impedance. To disable the AGL or PLIMIT function, the PLIMIT pin is simply connected to GVDD

3 Clipped Power Limiter, PLIMIT

The PLIMIT operation will, if selected, limit the output voltage level below the supply rail. In this case the amplifier operates as if it was powered by a lower supply voltage, thereby limiting the output power by voltage clipping. PLIMIT threshold is set by the LIMTHRES pin voltage. Figure 2 shows the function of the clipped power limiter PLIMIT whereas Figure 3 shows the AGL function.

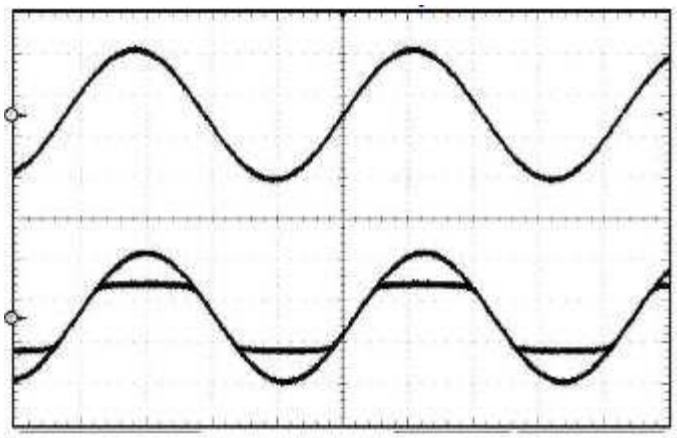

Figure 2. Clipped Power Limiter, PLIMIT

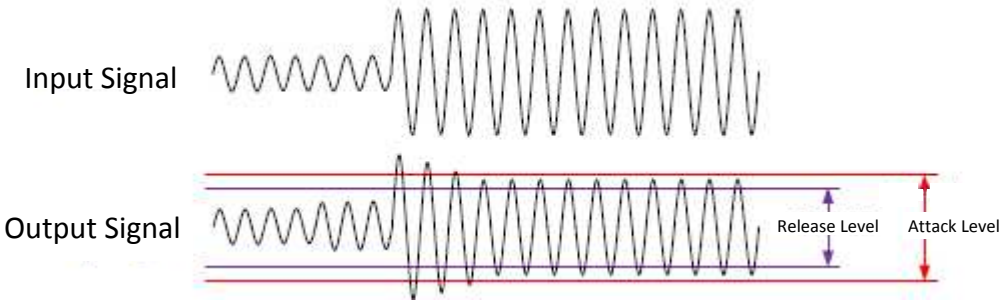

Figure 3. Unclipped Power Limiter, AGL

4 Automatic Gain Limiter, AGL

The gain limit threshold of AGL adjusts the input gain control with a fast attack. When the input approaches the gain-limit threshold, the audio output is being attenuated without clipping. Fast attack helps prevent high output distortion and reduce output power when the input signal is much higher than the limit threshold. AGL will also reduce the amount of high frequency audio energy fed to a tweeter in a 2-way speaker, thus protecting the speaker and increasing overall system reliability. The AGL release speed is slow and adjustable so audible artifacts are minimized.

The AGL functions by attenuating the amplifier input signal in steps of 0.5 dB, with a maximum of 12 dB (24 steps). The attenuation will occur with a controlled attack and release speed given by a fixed time for each gain step.

4.1 Gain Release Speed

The AGL release speed is set by an external voltage divider (LIMRATE voltage). LIMRATE voltage can be used to select different modes, disabling audio limiter, hard clip action (PLIMIT operation), non-adjustable fast, medium or slow rates. Figure 4 and Table 1 show the attack and release timing of the AGL function.

Table 1. AGL Attack/Release Speed

LIMRATE Voltage	Mode	AGL Attack Time	TFB Attack Time	AGL/TFB Release Time
GVDD	Fast	40 µs	200 ms	400 ms
2/3 × GVDD	Medium	80 µs	400 ms	800 ms
1/3 × GVDD	Slow	160 µs	800 ms	1600 ms
GND	PLIMIT	Disabled	Disabled	Disabled

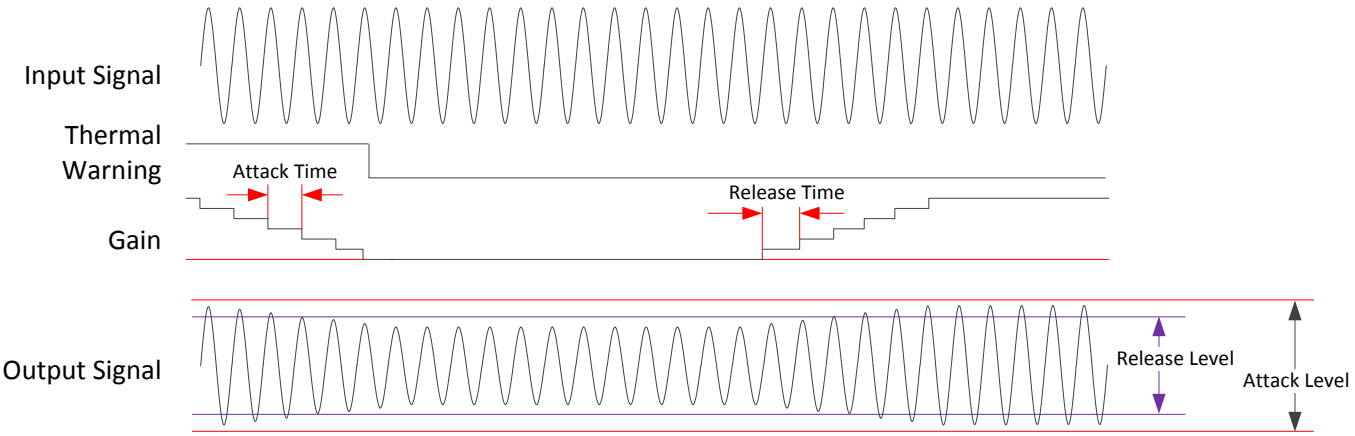

Figure 4. TPA3140D2 AGL Attack/Release

The AGL attack level is controlled by the voltage on the LIMTHRES pin. To prevent oscillation behavior with a constant audio signal, a release level for the AGL is made slightly lower than the attack level.

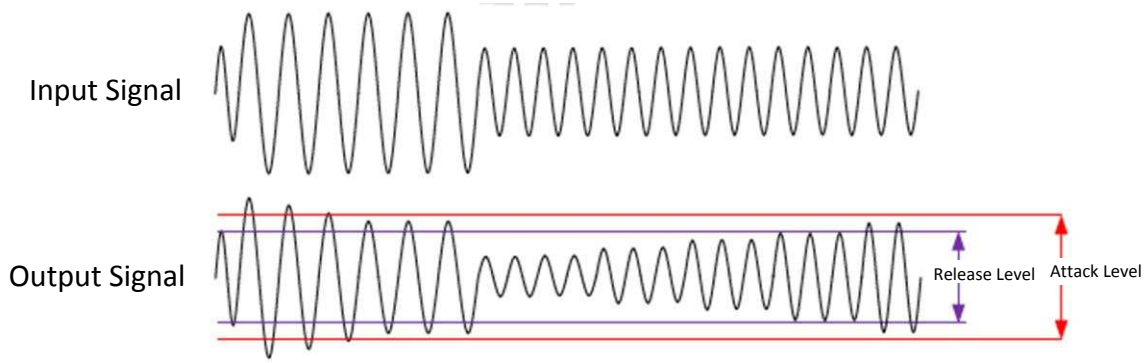

Figure 5. TPA3140D2 AGL Attack/Release Levels

5 Output Power Control with PLIMIT and AGL

By adjusting the maximum output voltage (and thereby the output power) to the same peak voltage level, the maximum output power is larger using the PLIMIT function than when using the AGL due to the allowed clipping of the output signal. A 10% THD output power (with PLIMIT) will be about 25% higher than maximum unclipped output power (using the AGL). Table 2 shows the typical operation of the PLIMIT and AGL functions.

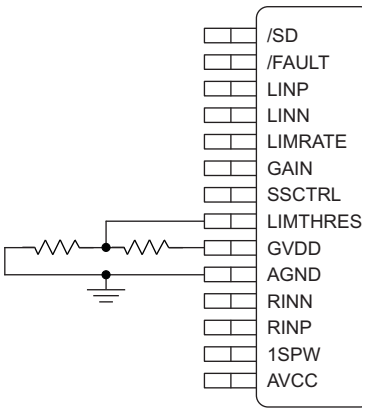

Figure 6. TPA3140D2 LIMTHRES Voltage

Table 2. PLIMIT, AGL Typical Operation

Test Conditions	LIMTHRES Voltage (V)	R to GND (Ω)	R to GVDD (Ω)	PLIMIT Output Power (W), 10% THD	AGL Output Power (W), Unclipped
P_{VCC} = 12 V, R_L = 6 Ω	1.9	33 k	82 k	6	4.75
P_{VCC} = 12 V, R_L = 6 Ω	2.19	39 k	82 k	8	6.5
P_{VCC} = 12 V, R_L = 6 Ω	2.45	39 k	68 k	10	8
P_{VCC} = 13 V, R_L = 8 Ω	2.19	39 k	82 k	6	4.75
P_{VCC} = 13 V, R_L = 8 Ω	2.53	39 k	68 k	8	6.5
P_{VCC} = 13 V, R_L = 8 Ω	2.83	47 k	68 k	10	8

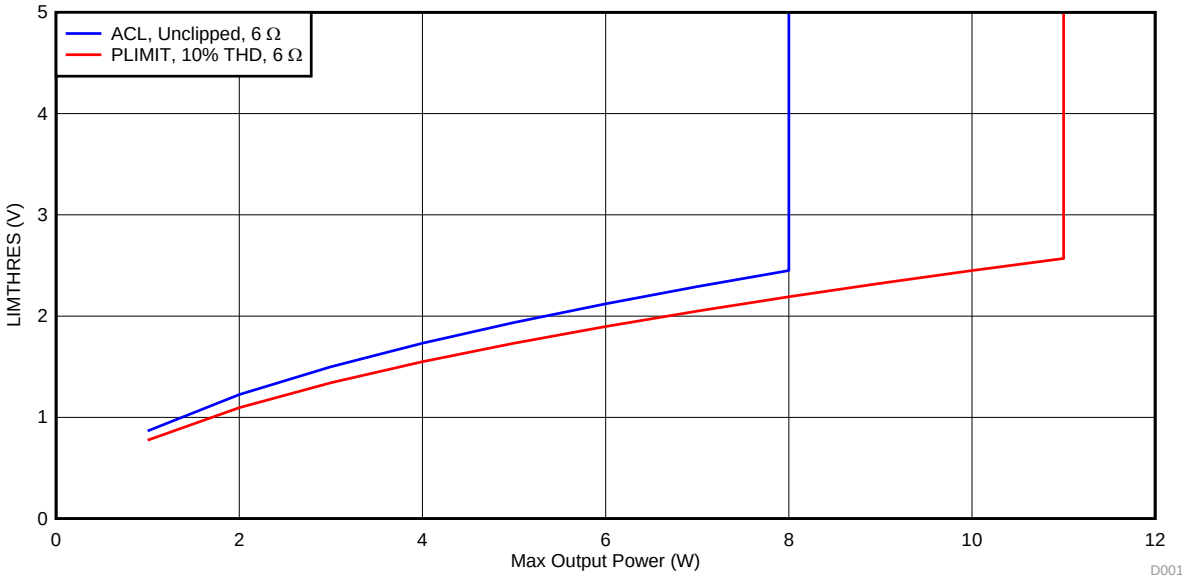

Figure 7. LIMTHRES Voltage vs Output Power with 6-Ω Load

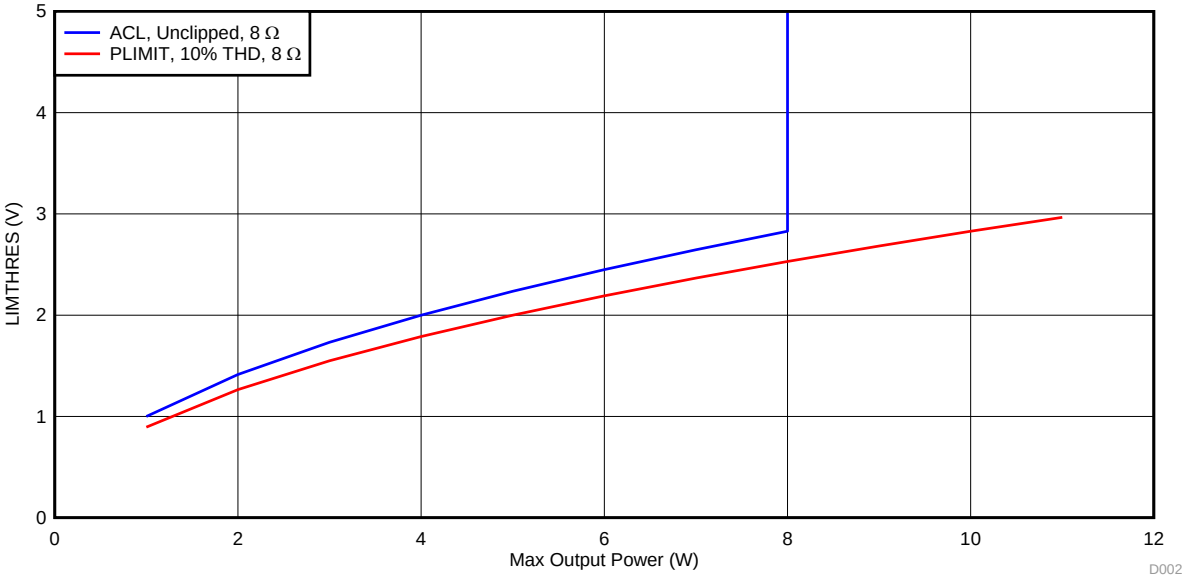

Figure 8. LIMTHRES Voltage vs Output Power with 8-Ω Load

6 Thermal Foldback (TFB)

The TPA3140D2 Thermal Foldback (TFB) is designed to protect the TPA3140D2 in case of excessive temperature, power output, or limited thermal dissipation in a system. The TFB works by reducing the TPA3140D2 closed-loop gain in steps of 0.5 dB (a maximum of 12 dB attenuation), if the TFB trip point is exceeded. Once the die temperature drops below the TFB trip point, the TPA3140D2 closed-loop gain is increased by single or multiple 0.5-dB steps. The TFB gain adjustment is applied with a ramp speed selectable by the LIMRATE pin setting as shown in Table 1.

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