Application Report
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Advantages of Thermal Foldback on SmartAmps

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ABSTRACT

The new generation of Texas Instruments SmartAmps, TAS2110, TAS2562, TAS2563 and TAS2564, introduce a new feature called Thermal Foldback. This feature allows the device to keep playing audio even when the temperature of the device is rising. Most audio amplifiers nowadays have thermal protection, which stops the audio playback or even shuts-down the device completely, so that it is not damaged due to high temperatures exposure. Thermal Foldback will automatically attenuate the output signal, by reducing the gain, letting the device cool-down while audio is still present at the output.

This application report is purposed to provide a thorough explanation of the Thermal Foldback functionality, how it can improve the end audio applications as well as show a comparison between the feature disabled and enabled.

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Trademarks

1 Advantages of Thermal Foldback Feature

Some audio applications, like automotive or industrial, require devices to operate in harsh environments where temperature is higher than consumer electronic goods typically endure. Most of the modern devices have protection schemes; however this typically stops the device from functioning or disables it completely. Once the temperature is back in a safe region, the device needs to be reinitialized.

Thermal Foldback feature on TAS2110, TAS2562, TAS2563 and TAS2564 has the advantage of allowing the device to keep operating and playing audio in increasing temperature situations. The device monitors the die temperature and automatically limits the audio signal above a set threshold. This will ultimately allow the device to keep or reduce its temperature while it is still operating. This is specially useful in fire & security applications as well as automotive applications where ambient temperature can be considerably higher than other applications but the system has to be fully operational. In any case, the over-temperature protection will shut down the device if the die temperature continually increases in order to prevent damages. In addition, over-temperature protection is an auto-retry feature so the device does not have to be reinitialized when temperature is back to a safe region.

2 Temperature Monitor

TAS2110, TAS2562, TAS2563 and TAS2564 have an internal die temperature sensor that has a measurement range from -40°C to 150°C and a resolution of 8 bits. This sensor is always enabled in order to keep the device within safe operating limits.

If needed, the value of this temperature monitor can be read from register 0x2C on page 0x00; further details on how to obtain the actual temperature value are available in the SAR ADC section of each device data sheet.

3 Thermal Foldback Configuration

It is recommended to use PurePath Console 3 to configure the features of this device, this way all the necessary calculations are made by the software.

Thermal Foldback settings can be configured within the Device Control panel; the default values are as shown in Figure 1.Thermal foldback is enabled by default on TAS2110, TAS2562 and TAS2563, and it is disabled by default on TAS2564

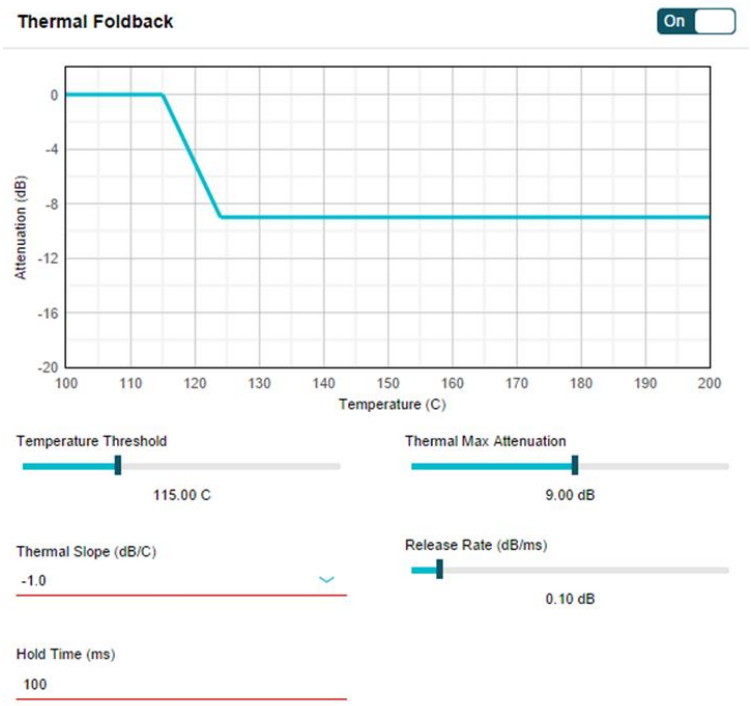

Figure 1. Thermal Foldback Control Panel

3.1 Temperature Threshold

This slider control is used to set the temperature threshold where the attenuation starts to be applied to the signal. The minimum is 100°C and maximum is 150°C.

The device recommended operating conditions specifies a maximum temperature of 140°C. It is recommended to set this threshold 15°C below the maximum recommended operating temperature of 140°C in order to let the feature act and keep the device within a safe temperature region. In addition, the slope must be considered when setting the threshold as the attenuation is gradually been applied as the temperature rises, it is not an instantaneous change.

3.2 Thermal Max Attenuation

This slider control is used to set the maximum attenuation that will be applied to the signal due to the action of the Thermal Foldback. The minimum is 1 dB and maximum is 16.5 dB in steps of 0.5 dB. The maximum attenuation can be set depending on the end application.

3.3 Thermal Slope

There are three selectable options for the thermal slope: -0.5 dB/°C, -1 dB/°C and -2 dB/°C. This configuration establishes how much attenuation is applied to the signal for each degree Celsius above the temperature threshold.

This control can be adjusted depending on the required attack rate of the application; using the maximum setting allows the device to control its temperature faster when the threshold has been surpassed, however the attenuation will be more perceptible.

3.4 Hold Time

Hold time is the time that the device waits before releasing the attenuation if it has been applied. The maximum is 500 ms and it goes down to 0 ms for an immediate release.

Hold time can be used to avoid gain oscillations due to temperature fluctuations and it can be fine-tuned depending on the end application.

3.5 Release Rate

This configuration causes a gradual release of the attenuation when the temperature has been reduced. It can be seen as the decay rate and it's given in dB/ms.

This slider control goes from a minimum of 0.01 dB/ms up to 1 dB/ms in steps of 0.01 dB/ms; using low values close to the minimum causes a steady release of the attenuation, although it takes longer time for the device to get back to its nominal gain.

4 Thermal Foldback Performance

This section covers two configurations using TAS2563. The thermal foldback feature is disabled and enabled, respectively.

Each section shows the status of the interrupt flags and output waveforms at an initial temperature and then the device is heated up and its temperature is tracked using the integrated temperature monitor.

4.1 Device Configuration

This section shows how the device is configured for both thermal foldback disabled and enabled tests.

Initial device configuration for thermal foldback disabled sets the device in ROM mode and -4 dB attenuation on the volume control. This adjustment in gain allows to get an output signal without clipping as ROM mode does not control excursion, clipping or temperature on the speaker.

Thermal foldack enable configuration is the same but only adding settings from Figure 2 please note that at 105°C the attenuation is around -2.3 dB

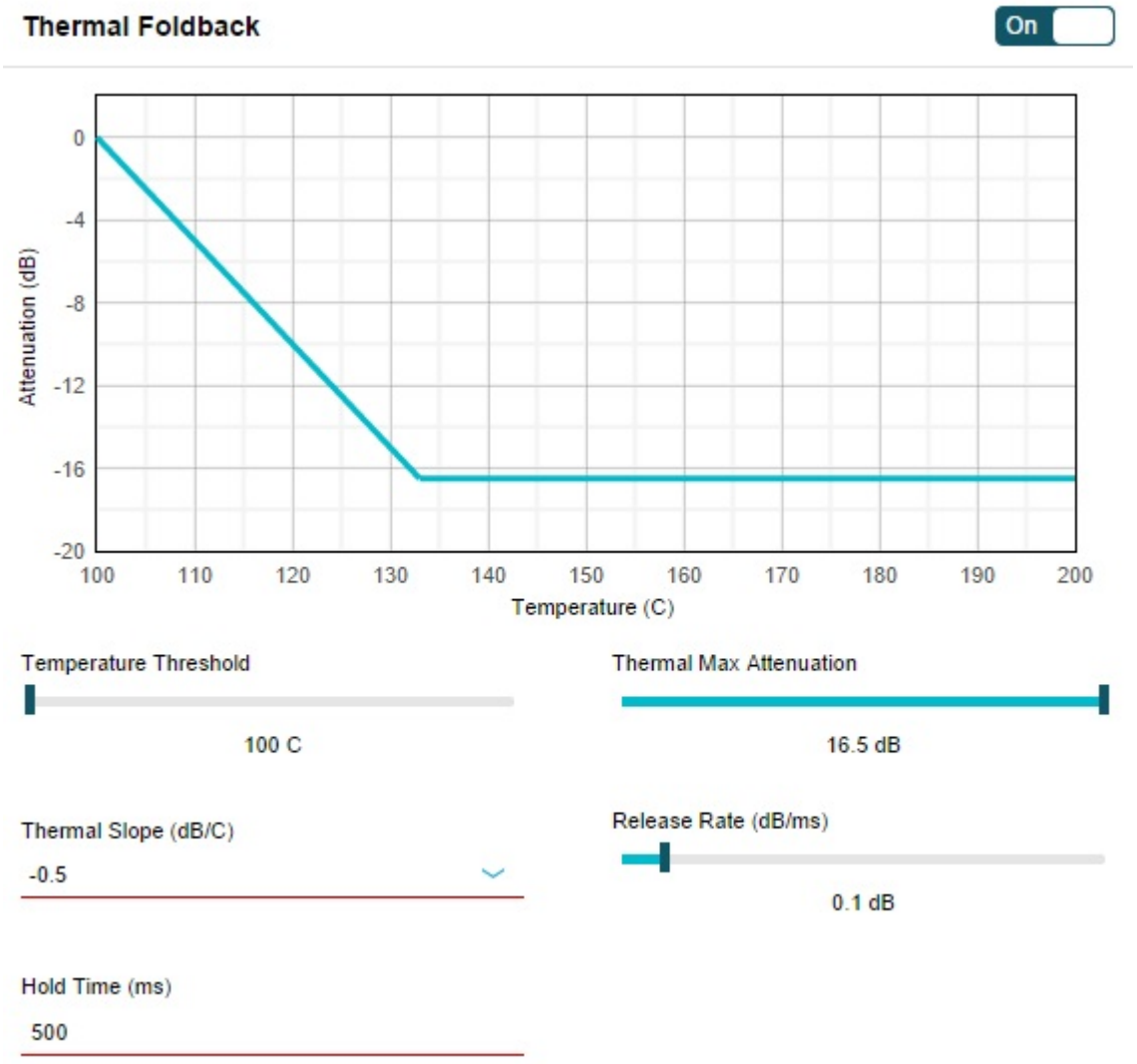

Figure 2. Thermal Foldback Settings

4.2 Thermal Foldback Disabled

4.2.1 Initial Temperature

For this test, the thermal foldback has been disabled and an initial temperature of 23°C is observed in Figure 3 using the temperature monitor.

A hot air stream is used to heat up the device. As the hot air is applied to the device, the temperature rises until it triggers the over-temperature protection causing the device to shut down.

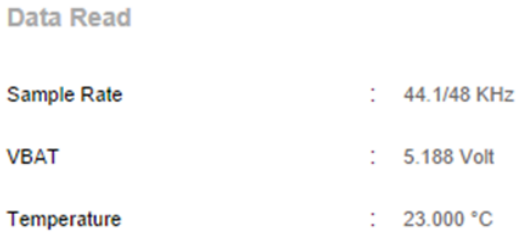

Figure 3. Temperature Monitor - Ambient Temperature

At this initial temperature, a full-scale input signal is played. Figure 4 shows the output of the amplifier at full-scale; this plot shows the differential signal across the speaker load, the amplitude of this signal is later compared versus the output signal when thermal foldback is triggered.

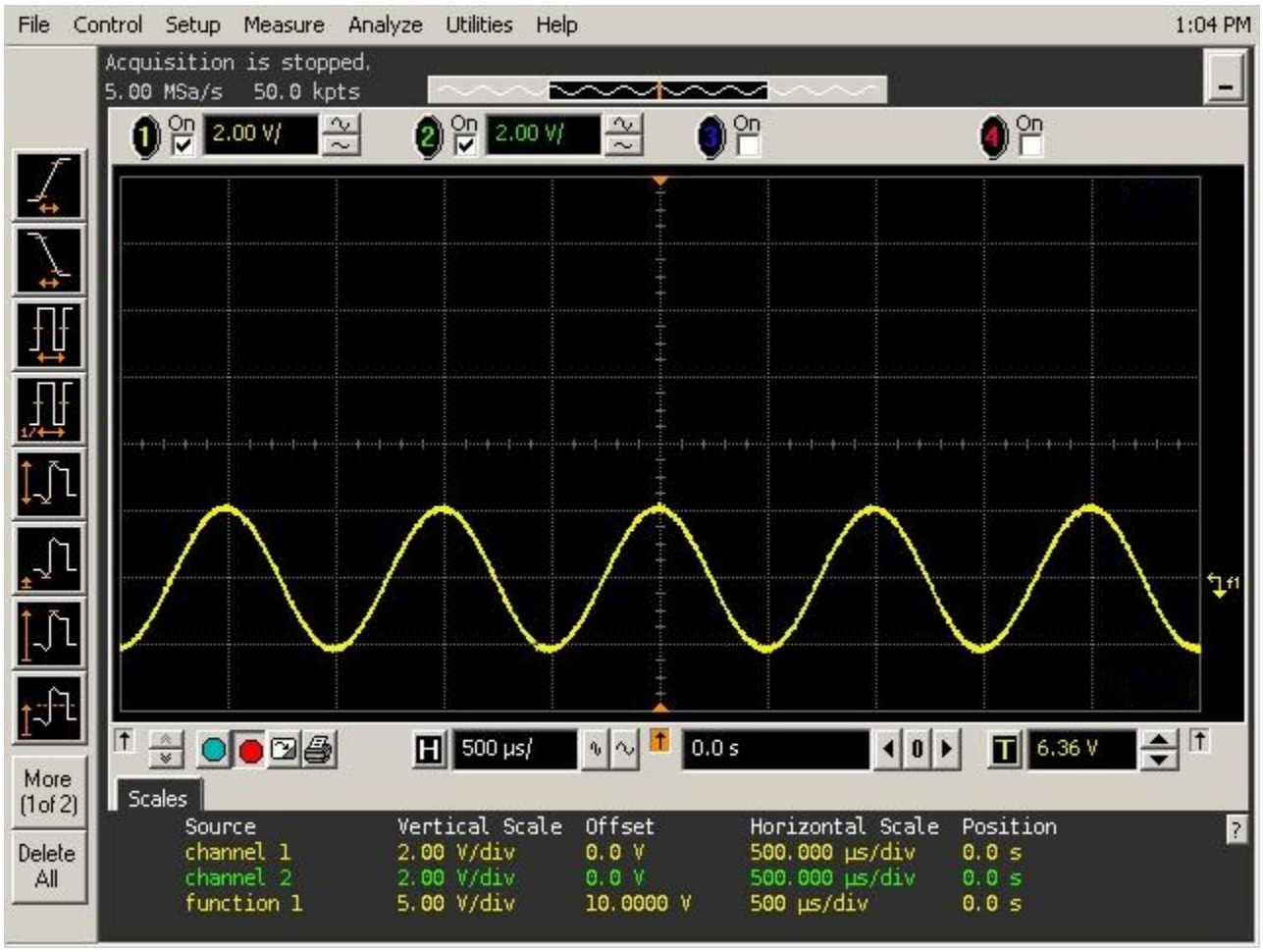

Figure 4. Output Waveforms - Ambient Temperature

4.2.2 Final Temperature

The last temperature reading from the monitor is 132°C, this is the temperature at which the device triggers its over-temperature protection. Figure 4 shows the temperature reading and Figure 5 shows the live status of the device powered down.

Figure 5. Temperature Monitor - OTP Triggered

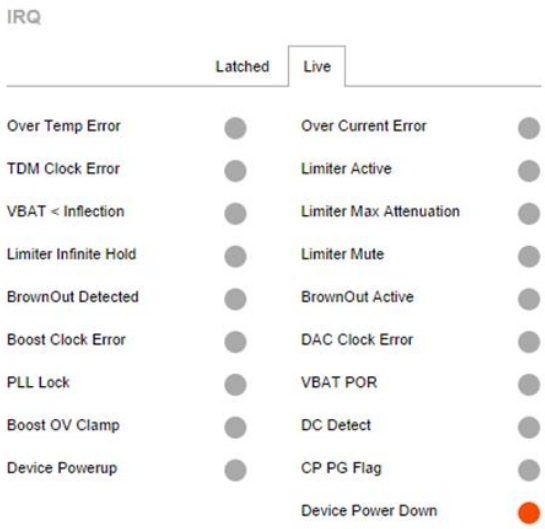

Figure 6. Live Status - OTP Triggered

4.3 Thermal Foldback Enabled

The initial temperature status for this test is the same as in the previous section, thus only the final temperature status is shown to highlight the differences.

4.3.1 Final Temperature

Thermal foldback is able to maintain the device below 132°C successfully, by lowering the gain. Figure 6 shows the temperature monitor at 105°C.

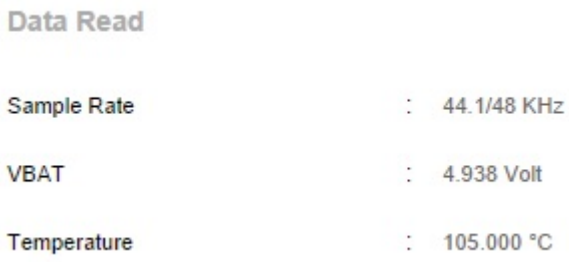

Figure 7. Temperature Monitor - Thermal Foldback

The full-scale signal played at ambient temperature keeps playing on the amplifier. Figure 5 shows the comparison of the output at initial temperature and at final temperature. Initial temperature shows an amplitude of 11.22 Vpp while final temperature shows an amplitude of 8.42 Vpp, this is an attenuation of around -2.5 dB, close to the expected attenuation based on the thermal foldback settings.

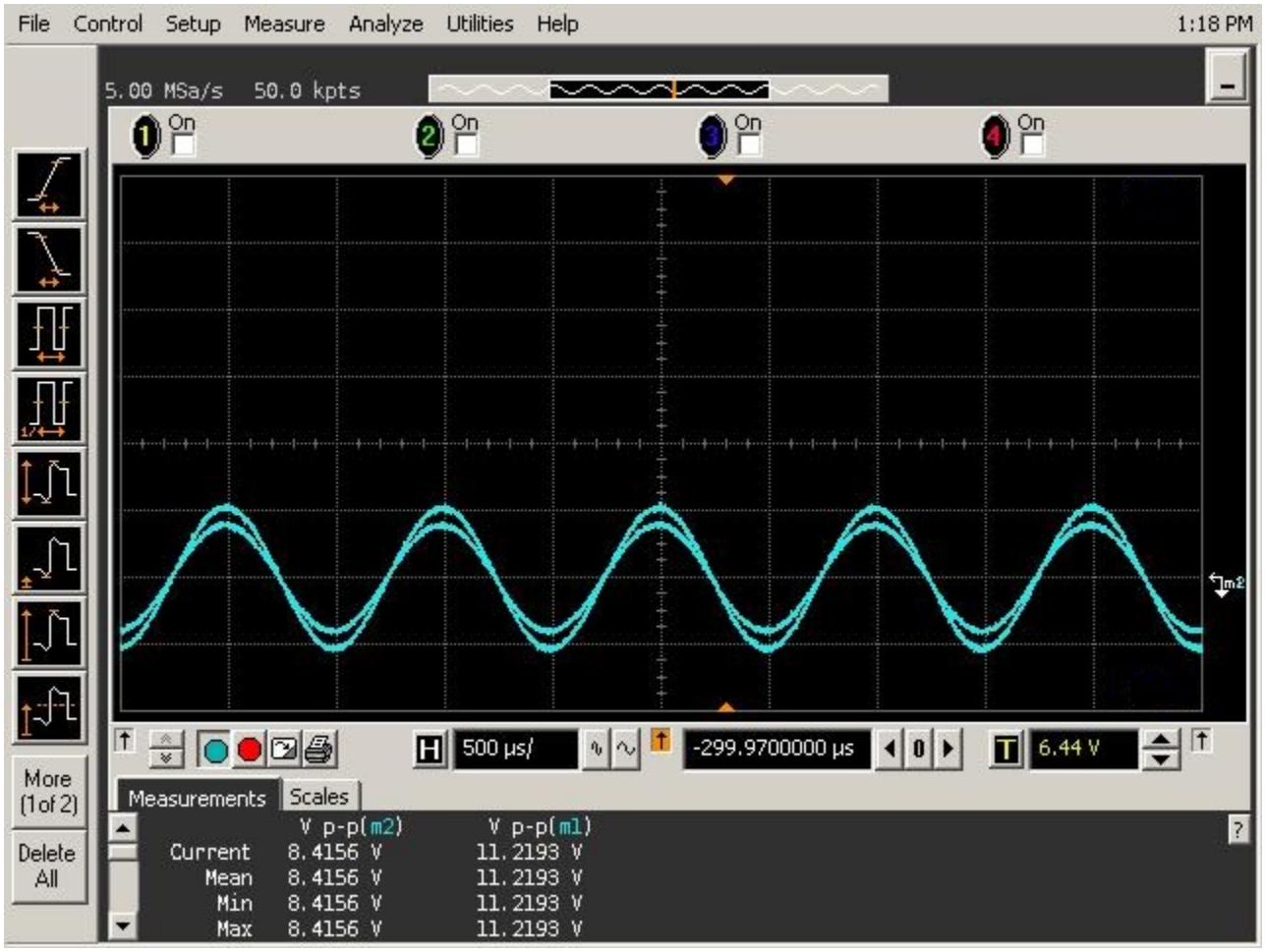

Figure 8. Output Waveforms - Thermal Foldback

5 Conclusions

As demonstrated in this document, the thermal foldback in TAS2110, TAS2562, TAS2563 and TAS2564 enables these amplifiers to output audio as the die temperature approaches 140°C. The necessary configuration for this feature can be applied directly from PurePath Console 3 and, as shown in this application note, it is very straightforward and yet very flexible for every use-case.

If further test and analysis is required on this or other device features, we encourage you to try our devices on its evaluation modules. Additionally if you have any questions do not hesitate to visit our e2e forum; there are plenty of answers and FAQs online and you can ask a new question if yours is not already there.

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