APOGEE TECHNOLOGY, INC.

Gain Compression Applications Using the DDX-8000

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Introduction

The following document will provide a high level as well as a detailed register view of the limiter used in the ddx8000 device. The Appendix will provide four examples of how the limiter block can be used in a 2.0, 2.1, 5.1 subsystem, and Nighttime listening mode.

Limiter Overview:

A limiter is basically a variable gain device, where the amount of gain used is dependent upon the level of the input signal into the limiter block. As the name implies, limiting and compression limit the dynamic range of a signal. A limiter will lower the gain when its threshold has been exceeded and raise the gain once the signal is below the threshold. The net result is smaller difference between softest and loudest parts of a signal, which evens out level variations.

Why Compression:

A limiter can be a desired effect in amplification systems for the following reasons.

1. Prevent Clipping: Clipping occurs when an amplifier's output exceeds it's maximum capable output. A clipped waveform contains a great deal of harmonic distortion and can sound very rough and harsh.
2. Perceived loudness: Psychoacoustically a user perceives a higher loudness for the same output level if the dynamic range is smaller, since the average level is higher.

Limiter Parameters:

Attack Threshold: Sets the level above which signals will have their gain decreased. The lower the threshold, the more the signal will be limited.

Release Threshold: Sets the level below which signal will have its gain increased or be uncompressed. The lower the threshold, the smaller the signal needs to be before uncompression begins. The higher the threshold, the higher the signal can be for uncompression to set in. When the release threshold is lower than the attack threshold a MDR is set.

Attack Rate: Sets the rate at which the gain is decreased once the attack threshold has been exceeded.

Release Rate: Determines the rate at which the gain is increased once a signal falls below the release threshold. The calculations for release are done using an RMS filtered version of the signal.

Why Two Thresholds?:

Dynamic range is the difference of the strongest, or loudest, part to the weakest, or softest, part of the signal content. When using a standard limiter the dynamic range of the signal content can be eliminated when the weakest part of the signal content is above the threshold. Often with normal limiters content with a large dynamic range can sound lifeless when the dynamic range is eliminated as explained above. Two thresholds allows for a minimum dynamic range (MDR) to be set, thus the sound can often be considered more musical than a source with dynamic range eliminated.

Calculating the MDR: The MDR is equal to the attack threshold value (dB) minus the release threshold value (dB).

MDR = Attack Threshold – Release Threshold.

Why Two Limiters?

Two limiters are efficient in satellite/sub systems and below are several advantages of such scenarios.

1. Separation of limiters: A phenomenon known as "pumping" occurs when musical content with large amounts of low frequency information is run through one compressor, the mids and highs seem to vary in amplitude or "pump" to the low frequency beat. By having two limiters this phenomenon is omitted when the low frequency information is processed on a separate limiter from the rest of the source (this procedure can be accomplished in the DDX8000 by using the bass management feature and routing channel 6 to a separate limiter or from standard 5.1 source material).

2. Separation of (different) limiter settings: Distortion is less noticeable in the lower frequency band than in the mid to high band. Because of this perception a separate limiter for the subwoofer channel can be used. This allows for different attack and release settings, which are often desirable for low-frequency content.

Anti-Clipping Mode:

The AC mode is intended primarily to prevent or limit the amount of distortion that can occur at the output of the amplifier from clipping. In AC mode, the output of the Gain/Attenuation (Volume) block is the input to the limiter algorithm. Figure 1 is a block diagram of the limiter in AC mode.

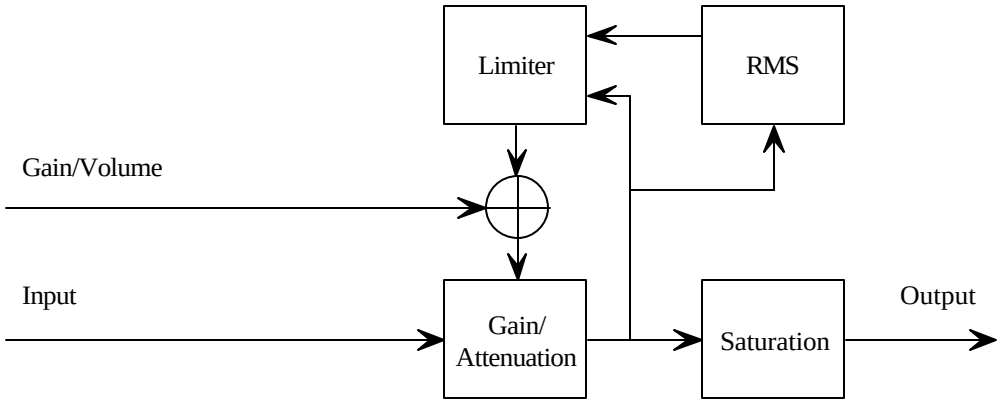

Figure 1: Block Diagram of Limiter in AC Mode

The 0dB setting in AC mode refers to maximum unclipped output power of a DDX amplifier. By setting the attack threshold to this setting, no clipping will occur with steady-state signals such as sine waves. It is possible to set this threshold higher than 0dB; in which a certain amount of clipping will be allowed before limiting takes place. This can often be beneficial as it will create an overall louder sounding output and also because clipping is not audible to the human ear unit ~2% THD. This number is even higher in subwoofer applications, so the attack threshold can be set even higher for low-frequency content.

Dynamic Range Compression Mode:

DRC mode limits the incoming signal based on the signal level before the Gain/Attenuation (Volume) block. Therefore the same amount of compression is applied independent of the volume setting. Refer to figure 2 for a block diagram of the limiter used in DRC mode.

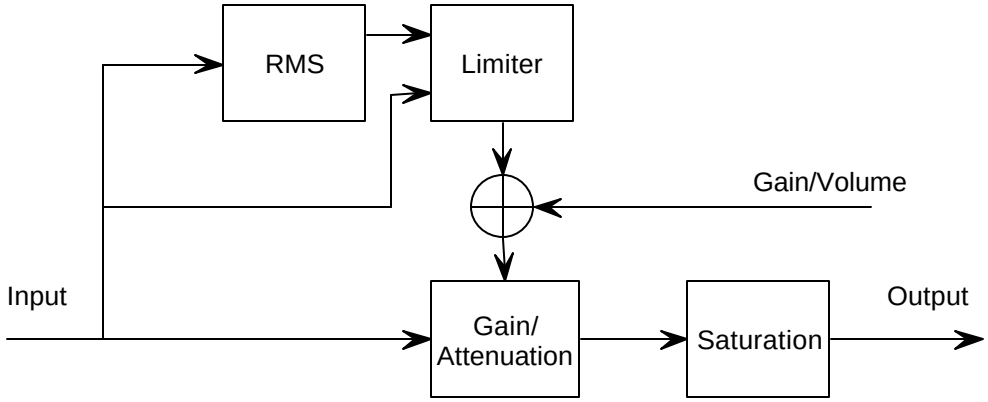

Figure 2: Block Diagram of Limiter in DRC Mode

If a user wishes to listen to the system at low levels, simply reducing the volume would cause the quietest passages to become too soft. The Dynamic range compression (DRC) can allow you to hear everything at low volume including the quietest passages by taking the sound dynamics and compressing them to maintain a more constant output level. This feature is especially useful for late night listening or when you want to play material at moderate levels without missing any of the program's content.

Limiter I/O:

The compression algorithm monitors the instantaneous signal level (Peak response) as well as the averaged signal level (RMS). The peak response is used for attack calculation, thus acting as a hard-limiter, while the averaged response is used for release purposes. These inputs are fed into the limiter and used in the desired modes mentioned above

Appendix A: Examples

Example of a 2.0 system with Anti-Clipping Enabled:

Follow the reference setting in *901-000011 I2C Procedure for 5.1 Applications Using DDX-8000.doc*. Note in this example Bass Management is not needed. These settings can be used in a stereo system with no subwoofer. These values should be written via I2C during the initialization sequence before the final unmuting.

Setting the Limiters to the following values will allow for no clipping with steady-state signals such as sine waves.

Table A-1: Limiter1 and Limiter2 AC MODE I2C Settings (2.0 system no clipping)

REG	DATA	COMMENTS
17h	A4h	Limiter1 Attack Rate = 1.3536dB/ms Release Rate = 0.0147dB/ms
18h	66h	Limiter1 Attack Threshold = -0dB Release Threshold = -7.40dB
15h	05h	Map Processing Channel 1 & Channel 2 (L & R) to Limiter1

If a limited amount of clipping is desired in a 2.0 system then follow steps provided in the example below. Using these setting allows for 10% THD numbers to be reached with a sine wave input on the Main channels (Left and Right).

Table A-2: Limiter1 and Limiter2 AC MODE I2C Settings (2.0 system limited clipping)

REG	DATA	COMMENTS
17h	A4h	Limiter1 Attack Rate = 1.3536dB/ms Release Rate = 0.0147dB/ms
18h	76h	Limiter1 Attack Threshold = +2dB Release Threshold = -7.40dB
15h	05h	Map Processing Channel 1 & Channel 2 (L & R) to Limiter1

Example of a 2.1 system with Anti-Clipping Enabled:

Follow the reference setting for a 2.1 system in *901-000011 I2C Procedure for 5.1 Applications Using DDX-8000.doc*. These settings can be used when a 5.1 system is in stereo mode and bass-redirection is desired. These values should be written via I2C during the initialization sequence before the final unmuting or when the user switches the system from surround to stereo mode.

Setting the Limiters to the following values will allow for no clipping with steady-state signals such as sine waves.

Table A-3: Limiter1 and Limiter2 AC MODE I2C Settings (2.1 system no clipping)

REG	DATA	COMMENTS
17h	A4h	Limiter1 Attack Rate = 1.3536dB/ms Release Rate = 0.0147dB/ms
18h	65h	Limiter1 Attack Threshold = -0dB Release Threshold = -9dB
19h	F7h	Limiter2 Attack Rate = 0.2256dB/ms Release Rate = 0.0147dB/ms
1Ah	65h	Limiter2 Attack Threshold = -0dB Release Threshold = -9dB
15h	05h	Map Processing Channel 1 & Channel 2 (L & R) to Limiter1
16h	08h	Map Processing Channel 6 (SUB) to Limiter2

If a limited amount of clipping is desired in a 2.1 system then follow steps provided in the example below. Using these setting allows for 10% THD numbers to be reached with a sine wave input on the Main channels (Left and Right).

Table A-4: Limiter1 and Limiter2 AC MODE I2C Settings (2.1 system limited clipping)

REG	DATA	COMMENTS
17h	A4h	Limiter1 Attack Rate = 1.3536dB/ms Release Rate = 0.0147dB/ms
18h	75h	Limiter1 Attack Threshold = +2dB Release Threshold = -9dB
19h	F7h	Limiter2 Attack Rate = 0.2256dB/ms Release Rate = 0.0104dB/ms
1Ah	98h	Limiter2 Attack Threshold = +4dB Release Threshold = -4.9dB
15h	05h	Map Processing Channel 1 & Channel 2 (L & R) to Limiter1
16h	08h	Map Processing Channel 6 (SUB) to Limiter2

Example of a 5.1 system with Anti-Clipping Enabled:

Follow the reference setting for a 5.1 system in *901-000011 I2C Procedure for 5.1 Applications Using DDX-8000.doc*. These settings are for a multi-channel source. These values should be written via I2C during the initialization sequence before the final unmuting or when the user switches the system from stereo to surround mode.

Setting the Limiters to the following values will allow for no clipping with steady-state signals such as sine waves.

Table A-5: Limiter1 and Limiter2 AC MODE I2C Settings (5.1 system no clipping)

REG	DATA	COMMENTS
17h	A4h	Limiter1 Attack Rate = 1.3536dB/ms Release Rate = 0.0147dB/ms
18h	65h	Limiter1 Attack Threshold = -0dB Release Threshold = -9dB
19h	F7h	Limiter2 Attack Rate = 0.2256dB/ms Release Rate = 0.0104dB/ms
1Ah	65h	Limiter2 Attack Threshold = -0dB Release Threshold = -9dB
15h	55h	Map Processing Channel 1,2,3,4 (L, R, LS, RS) to Limiter1
16h	09h	Map Processing Channel 5 (C) to Limiter1 and Channel 6 (SUB) to Limiter2

If a limited amount of clipping is desired in a 5.1 system then follow steps provided in the example below. Using these setting allows for >10% THD numbers to be reached with a sine wave input on the Main channels (Left, Right, Center, Surrounds).

Table A-6: Limiter1 and Limiter2 AC MODE I2C Settings (5.1 system limited clipping)

REG	DATA	COMMENTS
17h	A4h	Limiter1 Attack Rate = 1.3536dB/ms Release Rate = 0.0147dB/ms
18h	95h	Limiter1 Attack Threshold = +4dB Release Threshold = -9dB
19h	F7h	Limiter2 Attack Rate = 0.2256dB/ms Release Rate = 0.0104dB/ms
1Ah	FFh	Limiter2 Attack Threshold = +10dB Release Threshold = +0.6dB
15h	55h	Map Processing Channel 1,2,3,4 (L, R, LS, RS) to Limiter1
16h	09h	Map Processing Channel 5 (C) to Limiter1 and Channel 6 (SUB) to Limiter2

Example using DRC for Late-Night Listening:

This feature is especially useful for late night listening or when you want to play material at moderate levels without missing any of the programme's content. The user sets the level of the content to a desired level using the master volume. Below are the register setting for using DRC for late-night listening (assuming a 5.1 subsystem as in the reference for a 5.1 system in *901-000011 I2C Procedure for 5.1 Applications Using DDX-8000.doc*)

Table A-7: Limiter1 and Limiter2 I2C Settings Night-Time Mode (5.1 system)

REG	DATA	COMMENTS
17h	A4h	Limiter1 Attack Rate = 1.3536dB/ms Release Rate = 0.0147dB/ms
18h	44h	Limiter1 Attack Threshold = -14dB Release Threshold = -20.9dB
19h	F7h	Limiter2 Attack Rate = 0.2256dB/ms Release Rate = 0.0104dB/ms
1Ah	33h	Limiter2 Attack Threshold = -16dB Release Threshold = -23.4dB
01h	C2h	Enable DRC
15h	55h	Map Processing Channel 1,2,3,4 (L, R, LS, RS) to Limiter1
16h	09h	Map Processing Channel 5 (C) to Limiter1 and Channel 6 (SUB) to Limiter2