NVIDIA Audio Effects SDK

Programming Guide

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Chapter 1. Introduction to the NVIDIA Audio Effects SDK

The NVIDIA® Audio Effects SDK provides the following audio effects for broadcast use cases with real-time audio processing:

- **Noise Removal/Denoising**: Recordings of speech made outside of a recording studio can contain a lot of background noise, which causes the speech to be garbled and difficult to understand.

  The audio denoising effect removes this background noise from audio.
- **Room Echo Removal/Dereverb/Room Echo Cancellation**: Recordings of speech might contain reverberations from the recording environment, which can affect speech clarity.

  The dereverb effect helps remove or suppress these reverbs from audio.
- **Noise Removal and Room Echo Removal/Denoise Plus Dereverb**: The effect combines both the above effects to remove/suppress both noise and reverbs from audio.

  This offers much better performance than applying these effects separately.
- **Audio Super-Resolution**: This effect improves the sound quality by adding higher frequency content to the audio stream.

  For low-frequency audio, this feature predicts the higher frequency spectrum of input audio, which improves audio quality.
- **Acoustic Echo Cancellation (AEC)**: This effect removes acoustic echo and feedback from audio, which improves the bidirectional audio quality.

> **Note:** The Windows SDK is optimized for client-side application integration, and the Linux SDK is designed and optimized for server-side (datacenter/cloud) deployments.
>
> Using these SDKs for testing, experimentation, and production deployment outside these use cases **is not** officially supported.

1.1. About the Noise Removal/ Background Noise Suppression Effect

Recordings of speech made outside a recording studio can contain a lot of background noise. The Audio Denoiser Effect removes a variety of background noises from audio recordings.

This effect retains emotive tones in speech, such as happy, sad, excited, and angry tones, which were removed as noise in previous releases of the SDK. Extreme emotive cases such as loud laughing, shrieking, screaming, and crying might not be retained.

Note: In this guide, the term *Background Noise Suppression* is used interchangeably with *Denoising and Noise Removal* (referred to as `denoiser` in the API).

This effect supports removing the following types of background noise:

- AC noise
- Babble/crowd noise
- Baby crying
- Bird chirping
- Body noises
- Chatter from other people
- Clapping
- Construction site sounds
- Cooking sounds (cutting, cooker, and so on)
- Door slamming
- Drums
- Fan noise
- Gaussian/white noise
- Keyboard
- Metal sounds
- Mouse clicks
- PC noise
- Pet sounds
- Phone ringing
- Rains
- Sirens

- Sounds of a train passing by
- Sounds of a vacuum cleaner
- Sounds of furniture moving
- Sounds of glass breaking
- Tapping
- Traffic noise
- Washing machine
- Water taps/running water
- Wrappers (plastic/non-plastic rustling)

To run the sample application on Windows for this effect, use the following command (refer to Running the Sample Application for more information):

```
:: For SDK Developer Package:
:: Format: run_effects_demo.bat <architecture> <effect> <input_sample_rate>
 <output_sample_rate>
:: 16k effect on turing GPU
run_effects_demo.bat turing denoiser 16k 16k
:: 48k effect on ampere GPU
run_effects_demo.bat ampere denoiser 48k 48k
:: For SDK Redistributable Package:
:: Format: run_effects_demo.bat <effect> <input_sample_rate> <output_sample_rate>
:: 16k effect
run_effects_demo.bat denoiser 16k 16k
:: 48k effect
run_effects_demo.bat denoiser 48k 48k
```

To run the sample application on Linux for this effect, use the following command (refer to Running the Sample Application Using the Helper Script for more information):

```
# Format: ./run_effect.sh -g gpu -s sample_rate -e denoiser
# 16k effect
./run_effect.sh -g t4 -s 16 -e denoiser
# 48k effect
./run_effect.sh -g t4 -s 48 -e denoiser
```

This effect has the following characteristics:

- Supported input/output audio format is 32-bit float audio with a sampling rate of 16kHz/48kHz.
- In the Linux SDK, this effect has the following maximum throughput (# batches supported in real-time):

Architecture	Maximum Throughput for the 16K Effect	Maximum Throughput for the 48K Effect
T4	2700	1280
V100	5700	2700
A100	11800	5300
A10	6000	3072

Note: This effect might miss some noises in the first 1-2 seconds of input audio. Low-volume noises during speech might also be missed.

1.2. About the Room Echo Removal/Room Echo Cancellation Effect

Recordings of speech made in a large room/hall contain echoes and reverbs. The Audio Room Echo Cancellation Effect removes/suppresses these echoes and reverbs from audio recordings.

> **Note:** In this guide, the term *Room Echo Cancellation* is used interchangeably with *Dereverb and Room Echo Removal* (referred to as `dereverb` in the API).

To run the sample application on Windows for this effect, use the following command (refer to Running the Sample Application using the Helper Batch Script for more information):

```
:: For SDK Developer Package
:: Format: run_effects_demo.bat <architecture> <effect> <input_sample_rate>
 <output_sample_rate>
:: 16k effect
run_effects_demo.bat turing dereverb 16k 16k
:: 48k effect
run_effects_demo.bat ampere dereverb 48k 48k
:: For SDK Redistributable Package:
:: Format: run_effects_demo.bat <effect> <input_sample_rate> <output_sample_rate>
:: 16k effect
run_effects_demo.bat dereverb 16k 16k
:: 48k effect
run_effects_demo.bat dereverb 48k 48k
```

To run the sample application on Linux for this effect, use the following command (refer to Running the Sample Application Using the Helper Script for more details):

```
# Format: ./run_effect.sh -g gpu -s sample_rate -e dereverb
# 16k effect
./run_effect.sh -g t4 -s 16 -e dereverb
# 48k effect
./run_effect.sh -g t4 -s 48 -e dereverb
```

This effect has the following characteristics:

- Supported input/output format is 32-bit float audio with a sampling rate of 16kHz/48kHz.
- In the Linux SDK, this effect has the following maximum throughput (# batches supported in real-time):

Architecture	Maximum Throughput for the 16K Effect	Maximum Throughput for the 48K Effect
T4	2700	1280
V100	5600	2600
A100	10100	5300
A10	5700	3072

1.3. About the Noise Removal and Room Echo Removal/Room Echo Cancellation + Background Noise Suppression Effect

This effect applies a denoising and a dereverb effect on input audio.

> **Note:** In this guide, the term *Room Echo Cancellation + Background Noise Suppression* is used interchangeably with *Dereverb+Denoiser and Noise Removal and Room Echo Removal* (referred to as `dereverb_denoiser` in the API).

To run the sample application on Windows for this effect, use the following command (refer to Running the Sample Application using the Helper Batch Script for more details):

```
:: For SDK Developer Package:
:: Format: run_effects_demo.bat <architecture> <effect> <input_sample_rate>
 <output_sample_rate>
:: 16k effect on turing GPU
run_effects_demo.bat turing dereverb_denoiser 16k 16k
:: 48k effect on ampere GPU
run_effects_demo.bat ampere dereverb_denoiser 48k 48k
:: For SDK Redistributable Package:
:: Format: run_effects_demo.bat <effect> <input_sample_rate> <output_sample_rate>
:: 16k effect
run_effects_demo.bat dereverb_denoiser 16k 16k
:: 48k effect
run_effects_demo.bat dereverb_denoiser 48k 48k
```

To run the sample application on Linux for this effect, use the following command (refer to Running the Sample Application Using the Helper Script for more details):

```
# Format: ./run_effect.sh -g gpu -s sample_rate -e dereverb_denoniser
# 16k effect
./run_effect.sh -g t4 -s 16 -e dereverb_denoiser
# 48k effect
./run_effect.sh -g t4 -s 48 -e dereverb_denoiser
```

This effect has the following characteristics:

- Supported input/output format is 32-bit float audio with a sampling rate of 16kHz/48kHz.
- In the Linux SDK, this effect has the following maximum throughput (# batches supported in real-time):

Architecture	Maximum Batch Size for the 16K Effect	Maximum Batch Size for the 48K Effect
T4	1200	400
V100	2600	1200
A100	5300	2300
A10	3072	1300

1.4. About the Audio Super-Resolution Effect

The Audio Super-Resolution effect upsamples the audio. For low-frequency audio, this feature predicts the higher frequency spectrum of input audio, which improves audio quality.

> **Note:** In this guide, the term *Super-Resolution* is used interchangeably with *Superres/superresolution* (referred to as `superres` in the API).
>
> The main purpose of this effect is to enhance the sampling rate of input audio. The level of enhancement seen in the output audio depends on the type of audio.
>
> Audio that is captured on Windows with the audio enhancement settings disabled produces better superres outputs than when this setting is enabled.

To run the sample application on Windows for this effect, use the following command (refer to Running the Sample Application using the Helper Batch Script for more information):

```
:: For SDK Developer Package:
:: Format: run_effects_demo.bat <architecture> <effect> <input_sample_rate>
 <output_sample_rate>
:: 8k - 16k effect on turing GPU
run_effects_demo.bat turing superres 8k 16k
:: 16k - 48k effect on ampere GPU
run_effects_demo.bat ampere superres 16k 48k
:: 8k - 48k effect on ADA GPU
run_effects_demo.bat ada superres 8k 48k
:: For SDK Redistributable Package:
:: Format: run_effects_demo.bat <effect> <input_sample_rate> <output_sample_rate>
:: 8k - 16k effect
run_effects_demo.bat superres 8k 16k
:: 16k - 48k effect
run_effects_demo.bat superres 16k 48k
:: 8k - 48k effect
run_effects_demo.bat superres 8k 48k
```

To run the sample application on Linux for this effect, use the following command (refer to Running the Sample Application Using the Helper Script for more information):

```
# Format: ./run_effect.sh -g gpu -s sample_rate -e superres
# 8k - 16k effect
./run_effect.sh -g t4 -s 8 -o 16 -e superres
# 8k - 48k effect
./run_effect.sh -g t4 -s 8 -o 48 -e superres
# 16k - 48k effect
./run_effect.sh -g t4 -s 16 -o 48 -e superres
```

> **Note:**
>
> This effect works best on clean input audio. If the input audio contains noise or echoes/reverbs, the output audio may contain minor artifacts.
>
> If input audio is expected to contain noise, use this effect in combination with the Noise Removal Effect or Noise Removal and Room Echo Removal Effect. For further details, refer to Chaining Effects.

This effect has the following characteristics:

- Supported input/output format is 32-bit float audio.
- Supported upsampling of 8kHz input audio to 16kHz output (2x), 8kHz input audio to 48 kHz output (6x), and 16kHz input audio to 48kHz output (3x).
- In the Linux SDK, this effect has the following maximum throughput (# batches supported in real-time):

Architecture	Maximum Throughput for the 8K to 16K Effect	Maximum Throughput for the 8K to 48K Effect	Maximum Throughput for the 16K to 48K Effect
T4	192	64	96
V100	512	200	256
A100	928	400	448
A10	416	128	192

1.5. About the Acoustic Echo Cancellation Effect (BETA)

This effect removes acoustic echo and feedback from audio, which improves the bidirectional audio quality.

Note: In this guide, the term *Acoustic Echo Cancellation* is used interchangeably with *AEC* (referred to as `aec` in the API).

An acoustic echo occurs when a microphone, also known as a near-end microphone, picks up audio signals from the speaker and sends it back to the original recipient. The original recipient hears his or her own delayed voice mixed with a target signal, which makes the communication unintelligible. The Acoustic Echo Cancellation Effect (AEC) effect cancels/suppresses this delayed voice, also known as an acoustic feedback/echo, from the audio. This process improves the overall quality of the recording.

Note: Acoustic Echo Cancellation is useful only for near mic echo. For echo caused by reverberations, use the Room Echo Removal effect (see About the Room Echo Removal/Room Echo Cancellation Effect for more details).

To run the sample application on Windows for this effect, use the following command (refer to Running the Sample Application using the Helper Batch Script for more information):

```
:: For SDK Developer Package:
:: Format: run_effects_demo.bat <architecture> <effect> <input_sample_rate>
 <output_sample_rate>
:: 16k effect on turing GPU
run_effects_demo.bat turing aec 16k 16k
:: 48k effect on ampere GPU
run_effects_demo.bat ampere aec 48k 48k
:: For SDK Redistributable Package:
:: Format: run_effects_demo.bat <effect> <input_sample_rate> <output_sample_rate>
:: 16k effect
```

```
run_effects_demo.bat aec 16k 16k
:: 48k effect
run_effects_demo.bat aec 48k 48k
```

To run the sample application on Linux for this effect, use the following command (refer to Running the Sample Application Using the Helper Script for more information):

```
# Format: ./run_effect.sh -g gpu -s sample_rate -e aec
# 16k effect
./run_effect.sh -g t4 -s 16 -e aec
# 48k effect
./run_effect.sh -g t4 -s 48 -e aec
```

This effect has the following characteristics:

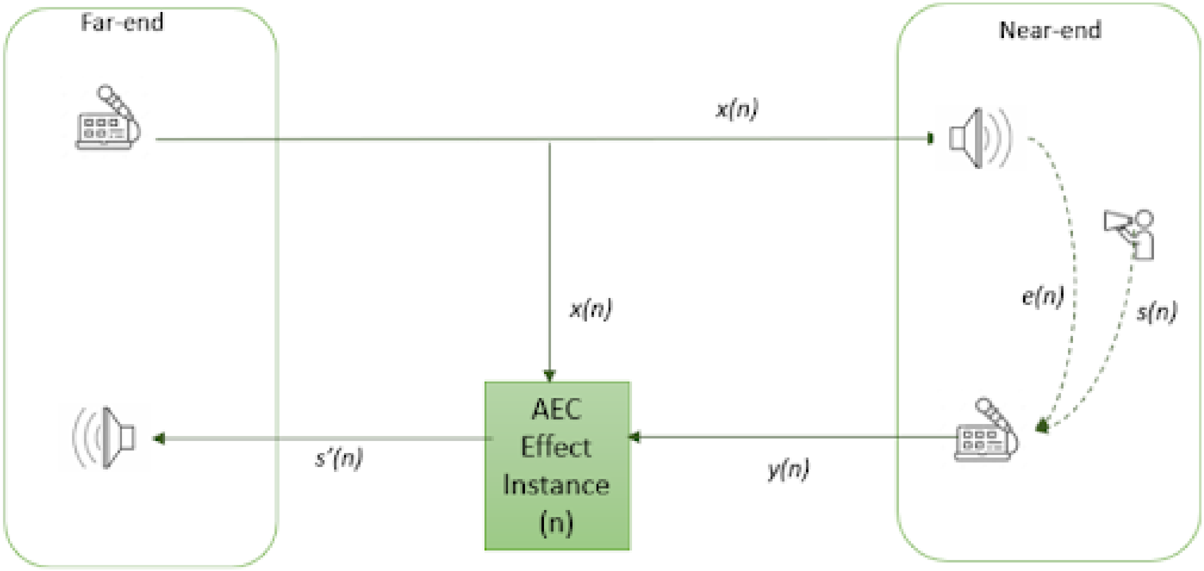
- Supported input/output format is 32-bit float audio with a sampling rate of 16kHz/48kHz.
- In the Linux SDK, this effect has the following maximum throughput (# batches supported in real-time):

Architecture	Maximum Throughput for the 16K Effect	Maximum Throughput for the 48K Effect
T4	1664	576
V100	3500	1536
A100	5700	3072
A10	3600	1536

1.5.1. Using the Acoustic Echo Cancellation Effect

This section describes the procedure for using the AEC effect.

Figure 1. Basic AEC Scenario



The AEC Effect takes the following inputs:

- The near-end microphone signal (denoted by y).
- The far-end microphone signal (denoted by x).

The far-end speaker signal x is the microphone signal of the original recipient. The near-end microphone signal (`y`) can be described as a combination of the near-end speech signal s and echo signal of the far-end speaker e. The output of the effect is the near-end speech signal `s'`, which is the input combination `s + e` with the far-end echo signal `e` removed:s' = (Mixture of s + e) - es' = (Mixture of s + e) - e

```
s' = (Mixture of s + e) - e
```

If only the far-end echo signal e is present, and near-end signal s is silent, the output from this effect will be silent.

When the AEC effect is integrated in a conferencing application server, multiple streams of data need to run in a batch, one for each speaker. Consider the scenario in Figure 2, where s(1) corresponds to AEC batch 1, and s(2) corresponds to batch 2:

The AEC Effect takes the following inputs:

- The near-end microphone signal (denoted by `y`).
- The far-end microphone signal (denoted by `x`).

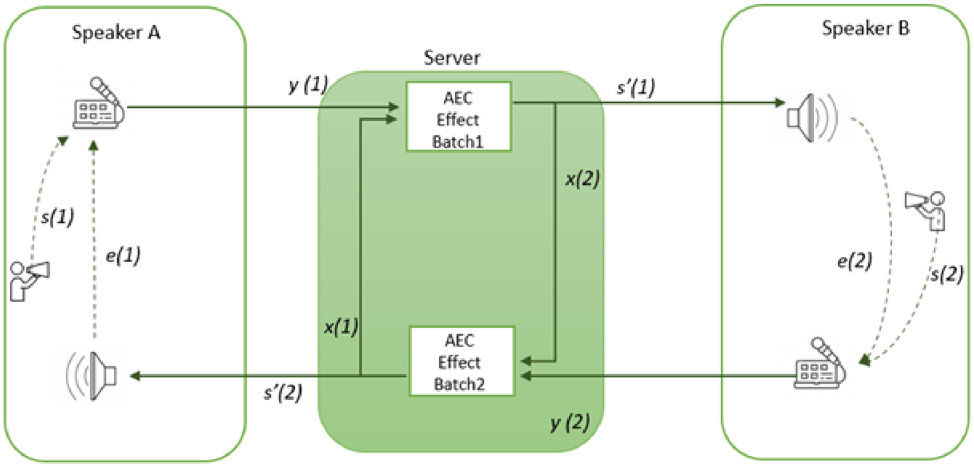
The far-end speaker signal x is the microphone signal of the original recipient. The near-end microphone signal (y) can be described as a combination of the near-end speech signal s and echo signal of the far-end speaker e. The output of the effect is the near-end speech signal s', which is the input combination s + e with the far-end echo signal `e` removed:

```
s' = (Mixture of s + e) - e
```

If only the far-end echo signal e is present, and near-end signal s is silent, the output from this effect will be silent.

When the AEC effect is integrated in a conferencing application server, multiple streams of data need to run in a batch, one for each speaker. Consider the scenario in Figure 2, where `s(1)` corresponds to AEC batch `1`, and `s(2)` corresponds to batch `2`:

Figure 2. Batched Audio Processing



The following steps describe how the AEC effect processes audio as seen in Figure 2:

1. The application server receives a microphone recording from Speaker A y(1).
2. The Application server passes y(1)to the AEC batch (1).

   Silence is passed down as a far-end speech signal x(1) to the effect because the server does not yet have the far-end speech.
3. The Effect produces processed audio s'(1), which is passed down to Speaker B.
4. Speaker B sends the near-end audio y(2) to the application server.

   This data consists of speech (s(1)), and audio played on speakers (e(2)).
5. The Application server processes batch (2) with y(1) as near-end audio, and the s'(1) that was received from Step 3 as far-end audio.

   This is the same audio that was played on the server.
6. The output from batch s'(2) is passed to Speaker A.

Refer to Setting the Parameters of an Audio Effect for the settings that are required for the AEC effect.

Chapter 2. Getting Started with the Audio Effects SDK for Windows

This section provides information about the hardware and software requirements to install the Windows SDK.

2.1. Hardware and Software Requirements

The Audio Effects SDK requires specific GPUs, a specific version of the Windows OS, and other software dependencies.

2.1.1. Hardware Requirements

The SDK is supported on NVIDIA GPUs with Tensor Cores.

Hardware	Required Version
GPU	NVIDIA GPUs with Tensor Cores

2.1.2. Software Requirements

The NVIDIA CUDA® and NVIDIA TensorRT™ dependencies are bundled with the SDK Installer (refer to Installing the Audio Effects SDK for Windows).

The Audio Effects SDK is designed and optimized for client-side application integration and for local deployment. We **do not** officially support the testing, experimentation, deployment of this SDK in a datacenter/cloud environment.

Software	Required Version
Windows OS	64-bit Windows 10
Microsoft Visual Studio	2017 (MSVC15.0) or later
CMake	3.9 or later

Software	Required Version
NVIDIA Graphics Driver for Windows	520.46 or later

Note: All libraries that are required to use the SDK are in the package, under `external`, do not need to be separately installed.

2.2. Installing the Audio Effects SDK for Windows

The Audio Effects SDK for Windows is distributed in the following parts:

- A *developer package* that contains the AI models, binaries, header file, and a sample app.
- A *redistributable package* that contains only the AI models and binaries.

  This package streamlines the installation and usage of the SDK on the end-user's computer.

To develop applications with the Audio Effects SDK, you must install the *developer* package and provide the path to this package during compilation and linking. Your app will use the SDK functions that are exposed by the SDK header and dynamically link against the provided libraries.

During deployment, the *redistributable* package installer helps install the necessary runtime components. To help your app access the runtime components on the end-user's computer, after the *redistributable* package is installed, the installer completes the following tasks:

- Copies the AI models and binaries to the install location.
- Sets the `NVAFX_SDK_DIR` environment variable, which points to the directory where the redistributable package is installed and contains the AI models and binaries.

  Your app needs to use this environment variable to locate and load the binaries and the AI model.

2.3. Audio Effects SDK Sample Application

The sample includes the application `effects_demo.exe` that can be directly executed and also its corresponding `effects_demo.cpp` source file that can optionally be compiled and run.

2.3.1. (Optional) Building the Sample Application

To build the sample application:

1. Start the CMake GUI and specify the source folder and a build folder for the binary files.
   a). For the source folder, ensure that the path ends in `package`.

   b). For the build folder, ensure that the path ends in `package/build`.

2. Use CMake to configure and generate the Visual Studio solution file.

   a). Click **Configure**.

   b). When prompted to confirm whether CMake can create the build folder, click **OK**.

   c). To enable CMake to locate the CUDA compiler, select **Visual Studio** for the generator and **x64** for the platform.

   d). To finish configuring the Visual Studio solution file, click **Finish**.

   e). To generate the Visual Studio solution file, click **Generate**. Click **Open Project** to open the project.

3. Use Visual Studio to generate the application binary (`.exe`) file from the solution file that was generated in the previous step.

   a). In CMake, to open Visual Studio, click **Open Project**.

   b). In Visual Studio select **Build** > **Build Solution** .

2.3.2. Running the Sample Application

To run the application, in a Command Prompt window, enter the following command:

```
effects_demo.exe -c config-file
```

where `-c` *`config-file`* specifies the path of the effect sample config file, for example, `denoise48k_cfg_turing.txt`, which is supplied with the sample app.

Configurations for other effects can be generated on the fly using `run_effects_demo.bat`. Refer to `readme.txt` in the `samples/effects_demo` folder for more information.

The SDK Developer package also includes the following sample windows batch/config files for the 48k denoiser model:

```
# 48k effect
run_denoiser_48k_ada.bat //for ADA based GPU architecture
run_denoiser_48k_ampere.bat //for Ampere based GPU architecture
run_denoiser_48k_turing.bat //for Turing based GPU architecture
```

The SDK Redistributable package includes the following sample windows batch/config files for the 48k denoiser model:

```
# 48k effect
run_denoiser_48k.bat
```

The following example runs the `effects_demo.exe` sample application:

```
effects_demo.exe -c denoise48k_cfg_turing.txt
```

The config files contain the following parameters with one pair per line:

`effect` ***`effect`***

Specifies the effect that will be applied, for example, denoiser. Refer to Introduction to the NVIDIA Audio Effects SDK for a complete list of supported effects.

`model` ***`model-file`***

Specifies the path of the model file that will be used in the sample application, for example, `denoiser_48k.trtpkg`.

> **Note:** The models, which were in the `bin/models` folder in previous SDK versions, have been moved to the `samples/effects_demo/models` folder.

`input_wav` ***`input-audio-file`***

Specifies the path of the noisy input audio `.wav` file to use, for example, `noisy_48k.wav`. The file should contain mono channel audio in signed 16-bit or 32-bit float format with a basic WAV header.

> **Note:** The sample inputs, which were in the `samples/effects_demo` folder in previous SDK versions, have been moved to the `samples/effects_demo/input_files` folder.

`input_farend_wav input-farend-audio-file`

Specifies the path of the farend input audio .wav file to use, for example, farend_48k.wav.

> **Note:** The `input_farend_wav` audio file is only for the AEC effect, which requires the following inputs:
>
> - Far-end (specified by the input_farend_wav parameter)
> - Near-end (specified by the input_wav parameter)
>
> The near-end input is picked up from the microphone, and the far-end audio might have leaked speaker audio data that is picked up by the microphone.

> **Note:** Sample input audio files are included with the sample application.

`output_wav` ***`output-audio-file`***

Specifies the path of the file to which the processed audio output will be written by the sample application, for example, `denoised_48k.wav`.

> **Note:** Only the `.wav` file format is supported.

`intensity_ratio` ***`intensity-ratio`***

Specifies the effect intensity ratio. The value of this parameter ranges from `0.0f` to `1.0f`, where a higher value indicates a stronger suppression of noise/reverb. A value of `0.0f` is equivalent to a passthrough of input audio.

`real_time` ***`enable`***

Simulates real-time audio input, set to 1 to enable or 0 to disable (disabled by default). When this option is enabled, each audio frame is passed to the SDK with a delay of 10ms, similar to how audio is received from a physical device or stream.

`enable_vad` ***`enable`***

Specifies whether to enable the Voice Activity Detection (VAD) algorithm.

Set to `1` to enable or `0` to disable. (By default, the parameter is disabled.)

When this option is enabled, the sample application passes each audio frame to the VAD algorithm to check voice activity and zeros out the frames that do not have voice activity.

2.3.2.1. Running the Sample Application Using the Helper Batch Script on Windows

`run_effects_demo.bat` is a windows batch file that can be used to run the sample application for various effects. This script generates a config file for the specified effect, GPU, and sample inputs for that effect and runs `effect_demo.exe` on the sample files.

To apply the effect on custom input files, place the input files in the input sample folder that corresponds to the effect/sample rate and run the helper script. This will generate a configuration file to apply the effect on these inputs and run `effect_demo.exe` with this file. The processed audio outputs will be placed in the output folder that corresponds to the effect/output sample rate.

For example, to apply the Background Noise Removal (Denoiser effect) on custom 48kHz files, copy the files to `input_files/denoiser/48k` and run `run_effects_demo.bat`. Processed outputs will be generated in `output_files/denoiser/48k`.

Refer to readme.txt in the `samples/effects_demo` folder in SDK for more information.

For the SDK Developer package, an effect can be run using the following command:

```
run_effects_demo.bat <architecture> <effect> <input_sample_rate>
 <output_sample_rate>
```

where:

`architecture`: GPU Supported Architecture

The supported values are `turing`, `ampere`, and `ada`.

`effect`: Effect to be applied

The supported values are `denoiser`, `dereverb`, `ndereverb`, `denoiser`, `aec`, and `superres`.

`input_sample_rate`: Input Sample Rate for the effect

The supported values are `8k`, `16k`, and `48k`.

`output_sample_rate`: Output Sample Rate for the effect

The supported values are `16k` and `48k`.

For example, to run the 16kHz AEC effect on ADA, run `run_effects_demo.bat ada aec 16k 16k`.

Refer to the readme.txt in the `samples/effects_demo` folder in SDK for more information.

For the SDK Redistributable package, NVIDIA provides separate installers for each GPU architecture, an effect can be run using the following command:

```
run_effects_demo.bat <effect> <input_sample_rate> <output_sample_rate>
```

where:

`effect`: Effect to be applied

The supported values are `denoiser`, `dereverb`, `dereverb_denoiser`, `aec`, and `superres`.

`input_sample_rate`: Input Sample Rate for the effect

The supported values are 8k, 16k, and 48k.

`output_sample_rate`: Output Sample Rate for the effect

The supported values are 16k and 48k.

For example, to run the 16kHz AEC effect, run `run_effects_demo.bat ada aec 16k 16k`.

2.3.3. Chaining Effects

This section describes how to run effects in a chain.

The `effects_demo` sample application also provides config files in which multiple effects are run in a chain (refer to Running Multiple Effects in a Chain for more information). For example, the following command runs the 16kHz to 48kHz Superresolution effect followed by the 48kHz Denoiser effect on input audio on turing GPU:

For the SDK Developer package:

```
run_effects_demo.bat turing superres 16k 48k denoiser 48k 48k
```

For the SDK Redistributable package:

```
run_effects_demo.bat superres 16k 48k denoiser 48k 48k
```

To run effects in a chain, the configuration file uses syntax similar to the syntax used when running one effect, with the following changes:

`effect` ***`effect-1,effect-2`***

Specifies the effects in sequence to be used for chaining. For more information about possible chaining combinations, refer to Running Multiple Audio Effects in a Chain.

Note: Chaining effects only support combination of Superres and Denoiser/Dereverb and Combined Denoiser+Dereverb. Other effect chains are not supported. If combining Denoiser effect and Dereverb effect, use the combined Denoiser+Dereverb model (refer to About the Room Echo Cancellation + Background Noise Suppression Effect for more information).

`model` ***`model-file-1,model-file-2`***

Specifies the path of the model files in sequence that will be used in the sample application, for example, `superres_16kto48k.trtpkg,denoiser_48k.trtpkg`.

`intensity_ratio` ***`intensity-ratio-1,intensity-ratio-2`***

Specifies the intensity ratio for the effects. The value of this parameter ranges from 0.0f to 1.0f, where a higher value indicates a stronger suppression of noise/reverb. A value of 0.0f is equivalent to a passthrough of input audio.

2.3.3.1. Running the Sample Application Using the Helper Script for Chaining

Users can modify the sample config/batch files provided with the SDK as required and use them with `effect_demo.exe`.

To apply the effect on custom input files, place the input files in the input sample folder that corresponds to the effect/sample rate and run the helper script. The processed audio outputs will be placed in the output folder that corresponds to the effect/output sample rate.

For example, to apply the Background Noise Removal effect on custom 48kHz files, copy the files to the `input_files/denoiser/48k` folder and run `run_effects_demo.bat`. The processed outputs will be generated in the `output_files/denoiser/48k` folder.

To apply the Background Noise Removal (Denoiser effect) + Superres effect on 16k files, copy the files in the `input_files/chaining/denoiser/16k` folder and run `run_effects_demo.bat`. The outputs will be generated in the `output_files/chaining/denoiser16k_superres16kto48k` folder.

For the SDK Developer package, chained effects can be run with the helper script using the following command:

```
run_effects_demo.bat <architecture> <effect_1> <input_sample_rate_1>
 <output_sample_rate_1> <effect_2> <input_sample_rate_2> <output_sample_rate_2>
```

where:

`architecture`: GPU Supported Architecture.

The supported values are `turing`, `ampere`, and `ada`.

`effect_1`: 1st Effect to be applied.

The supported values are `denoiser`, `dereverb`, `dereverb_denoiser`, and `superres`.

`input_sample_rate_1`: Input Sample Rate the first effect.

The supported values are `8k`, `16k`, and `48k`.

`output_sample_rate_1`: Output Sample Rate the first effect.

The supported values are `16k` and `48k`.

`effect_2`: The second effect to be applied.

The supported values are `denoiser`, `dereverb`, `dereverb_denoiser`, and `superres`.

`input_sample_rate_2`: Input Sample Rate for the second effect.

The supported values are `8k`, `16k`, and `48k`.

`output_sample_rate_2`: Output Sample Rate for the second effect.

The supported values are `16k` and `48k`.

Refer to readme.txt in the `samples/effects_demo` folder in SDK for more information.

For the SDK Redistributable package, as separate installers are provided for each supported GPU architecture, chained effects can be run with the helper script using the following command:

```
run_effects_demo.bat <effect_1> <input_sample_rate_1> <output_sample_rate_1>
 <effect_2> <input_sample_rate_2> <output_sample_rate_2>
```

where:

`effect_1`: First effect to be applied

Supported values are `denoiser`, `dereverb`, `dereverb_denoiser`, and `superres`.

`input_sample_rate_1`: Input Sample Rate for the first effect

The supported values are `8k`, `16k`, and `48k`.

`output_sample_rate`: Output Sample Rate for the first effect

The supported values are `16k` and `48k`.

`effect_2`: Second effect to be applied

Supported values are `denoiser`, `dereverb`, `dereverb_denoiser`, and `superres`.

`input_sample_rate_2`: Input Sample Rate for the second effect

The supported values are `8k`, `16k`, and `48k`.

`output_sample_rate_2`: Output Sample Rate for the second effect

The supported values are `16k` and `48k`.

Chapter 3. Getting Started with the Audio Effects SDK for Linux

This section provides information about the hardware and software requirements and installing the Linux SDK.

3.1. Hardware and Software Requirements

The Audio Effects SDK requires specific GPUs, a specific version of the Linux OS, and other software dependencies.

3.1.1. Hardware Requirements

The Audio Effects SDK is supported on systems with a minimum of 10 GB RAM and NVIDIA GPUs with Tensor Cores.

Table 1. Hardware Requirements

Hardware	Required Version
GPU	GPUs with Tensor Cores: ▶ NVIDIA Turing™: NVIDIA Tesla® T4 ▶ NVIDIA Volta™: V100 ▶ NVIDIA Ampere architecture: A2, A10, A16, A30, A40, and A100 **Note:** NVIDIA® Ada GPU architecture and NVIDIA® Hopper architecture are currently **not supported for Linux SDK.** **Note:** The SDK supports Multi-Instance GPU (MIG) only on NVIDIA Tesla® A30 and A100. When MIG is enabled, the GPU instance and corresponding compute instance must be defined, regardless of whether

Hardware	Required Version
	the SDK is executed on a specific GPU instance or on the entire GPU.

Note: For best performance with NVIDIA T4 and other server GPUs, ensure that you use a server that meets the thermal and airflow requirements for these types of products. Refer to Qualified Server Catalog for the latest list of qualified servers.

3.1.2. Software Requirements

The SDK has the following requirements:

Table 2. Software Requirements

Software	Required Version
Linux distribution	64-bit Linux distribution The supported distros are: ▶ Ubuntu (18.04) ▶ RHEL7 ▶ RHEL8 ▶ CentOS7 ▶ CentOS8 ▶ Debian 10+
NVIDIA Graphics Driver for Linux	520.61.05 or later 450/470 can be used with NVIDIA CUDA® Forward Compatible Upgrade. Refer to Using Older Drivers (450/470) with CUDA Forward-Compatible Upgrade for more information.
CUDA/NVIDIA TensorRT™/NVIDIA CUDA Deep Neural Network (cuDNN) **Note:** All libraries that are required to use the SDK are in the package under `external/cuda`, do not need to be separately installed.	▶ CUDA: 11.8 ▶ TensorRT™: 8.5.1.7 ▶ cuDNN: 8.6.0

Note: The Linux SDK is designed and optimized for server-side (datacenter/cloud) deployment.

Using this SDK for testing, experimentation, and production deployment of these SDKs outside this use case **is not** officially supported.

3.2. Installing the Audio Effects SDK for Linux

To develop applications with the Audio Effects SDK, extract the files from the SDK package and provide the library path to the extracted library during compilation and linking. A sample application is also bundled with the SDK (source/pre-built binaries).

To install the SDK, extract the contents of the Audio Effects SDK archive to the required location on your computer, for example, by using the following command:

```
tar xvf Audio_Effects_SDK.tar.gz
```

3.2.1. Using Older Drivers (450/470) with a CUDA Forward-Compatible Upgrade

Applications can use the SDK with older drivers (450/470) by using the CUDA Forward-Compatible upgrade path (refer to CUDA Forward-Compatible Upgrade Path for more information).

To use older supported drivers with the SDK, download the user-mode CUDA libraries (`libcuda.so.*`) and the JIT compiler libraries for PTX files (`libnvidia-ptxjitcompiler.so.*`) from one of the following locations:

- The CUDA 11.8 Toolkit/datacenter drivers.
- The CUDA network repositories (`cuda-compat-11.8`).

Before you run the applications by using the SDK, ensure that `LD_LIBRARY_PATH` contains the location that contains these libraries.

For example, to use the CUDA network repository on an Ubuntu 18.04 system with older drivers:

1. To add the CUDA repository to your system, go to CUDA Toolkit 11.8 Downloads:
   a). Under **Operating System**, click **Linux**.
   b). Under **Distribution**, click **Ubuntu**.
   c). Under **Installer Type**, click **deb (network)**.
   d). To add the CUDA repository to the system, follow the steps under **Installation Instructions**.
2. Update the `apt` repository cache.
   ```
   $ sudo apt-get update
   ```
3. Install the compatibility package.
   ```
   $ sudo apt-get install -y cuda-compat-11-8
   ```
   The commands in this step will install the compatibility package libraries in the `/usr/local/cuda-11.8/compat` folder.
4. Append this path to `LD_LIBRARY_PATH` when the SDK applications are run.

```
# Add path to LD_LIBRARY_PATH

# Note: This command works only for the current terminal session, please add to
 ~/.bashrc or similar to make this permanent. For further details,
# refer to your distribution's documentation.
$ export LD_LIBRARY_PATH=/usr/local/cuda-11.8/compat:$LD_LIBRARY_PATH
# Run application
$ ./effects_demo -c t4_denoise48k_1_cfg.txt
```

Refer to CUDA Forward-Compatible Upgrade Path for more information.

3.3. Sample Applications

The SDK provides the following sample applications:

- `effects_demo`
- `effects_delayed_streams_demo`

> **Note:** These applications include the source code (`effects_demo.cpp/ effects_delayed_streams_demo.cpp`) and the pre-built binaries.

3.3.1. effects_demo Application

This application demonstrates how to use the SDK to apply effects to audio.

3.3.1.1. (Optional) Building the Application

To build the application:

1. Navigate to the samples/effects_demo directory.
2. **Optional:** To compile the application instead of running the pre-built binary file, run the `make` command.

   ```
   :/Audio Effects SDK/samples/effects_demo$ make
   ```

3.3.1.2. Running the Application

The sample application can be run by using the `run_effect.sh` helper script or directly by using the `effects_demo` executable file.

3.3.1.2.1. Running the Sample Application Using the Helper Script

The `run_effect.sh` helper script is a wrapper around the `effects_demo` application.

Depending on the arguments that are passed to `run_effect.sh`, the script generates a temporary config file and runs the `effects_demo` application with this config file.

The helper script can be run using the following command:

```
./run_effect.sh -g gpu -e effect -s input_sample_rate -o output_sample_rate -b
 batch_size
```

For example, to run the sample application on T4 with the 16k denoiser effect that has a batch size of 10, run the following command:

```
./run_effect.sh -g t4 -s 16 -b 10 -e denoiser
```

This command generates a config file at `/tmp/tmp_cfg.txt` with the above configuration.

Run the application using one of the following scripts:

```
:/Audio Effects SDK/samples/effects_demo$ ./run_effect.sh -g v100 -s 16 -b 1 -e
 denoiser
:/Audio Effects SDK/samples/effects_demo$ ./run_effect.sh -g v100 -s 48 -b 1 -e
 dereverb
:/Audio Effects SDK/samples/effects_demo$ ./run_effect.sh -g v100 -s 16 -b 400 -e
 denoiser
:/Audio Effects SDK/samples/effects_demo$ ./run_effect.sh -g v100 -s 48 -b 400 -e
 dereverb_denoiser
:/Audio Effects SDK/samples/effects_demo$ ./run_effect.sh -g v100 -s 48 -b 400 -e
 aec
:/Audio Effects SDK/samples/effects_demo$ ./run_effect.sh -g v100 -s 8 -o 16 -b 400
 -e superres
```

or

```
:/Audio Effects SDK/samples/effects_demo$ ./run_effect.sh -g t4 -s 16 -b 1 -e
 denoiser
:/Audio Effects SDK/samples/effects_demo$ ./run_effect.sh -g t4 -s 48 -b 1 -e
 dereverb
:/Audio Effects SDK/samples/effects_demo$ ./run_effect.sh -g t4 -s 16 -b 400 -e
 denoiser
:/Audio Effects SDK/samples/effects_demo$ ./run_effect.sh -g t4 -s 48 -b 400 -e
 dereverb_denoiser
:/Audio Effects SDK/samples/effects_demo$ ./run_effect.sh -g t4 -s 48 -b 400 -e aec
:/Audio Effects SDK/samples/effects_demo$ ./run_effect.sh -g t4 -s 8 -o 16 -b 96 -e
 superres
```

Note: Ensure that the application uses the correct versions of TensorRT (requires the exact version)/CUDA libraries (requires the exact version or later). Refer to Software Requirements for the required versions. The SDK includes all required libraries under `external/cuda/lib`. If the distro/OS exports `LD_LIBRARY_PATH` from `~/.bashrc` or similar, or the external libraries are moved to a different folder structure, the path of TensorRT and CUDA libraries loaded by the SDK might be overridden. As a result, the SDK might load incompatible CUDA/TensorRT library versions and return errors. (Libraries loaded can be verified using `ltrace`/`strace`/similar - some libraries are loaded dynamically, hence ldd/similar may not show full results). To avoid this issue, before you run the sample program, append the external directory to `LD_LIBRARY_PATH` by executing the following command: `$ export LD_LIBRARY_PATH=external/cuda/lib:$LD_LIBRARY_PATH`

Note: The sample app might hit the limit for the maximum number of open files that is imposed by default by the Linux kernel, especially for large batch sizes. When this occurs, the sample application will exit with the following error message:`[Error] Unable to read wav file: ../input_files/denoiser/48k/Fan_48k.wav`. Open file limit reached. To increase this limit, before you run the sample application, use the `ulimit` command in the same shell to increase the number of open files. For example, `ulimit -n 20000` will increase the open file limit to 20,000 for that shell. For more information, refer to your distribution's documentation on how to increase open file descriptor limits.

The helper script supports the following parameters:

- `-i/--input-file (default: Not specified)` specifies the input files/folder on which to run the effect.

If this parameter is not specified, the helper script will use the sample files that are distributed with the SDK in the `samples/input_files` directory. If this parameter specifies a file/folder, the helper script will use this file/files in this folder.

The supported value is a path to the input file in the correct format (refer to Directly Running the Sample Application for more information), or a folder that contains multiple input files in the correct formats. If a folder is specified, only the files that are present at the top level of the folder will be processed. For example, if the input folder is folder1, then `folder1/a.wav`, `folder1/b.wav`, and so on will be processed, while `folder1/subfolder/a.wav` will not be processed.

- `-g / --gpu (default=t4)` specifies the GPU on which to run the effect.

  Supported options are `a2`, `v100`, `a16`, `a100`, `a10`, `t4`, `a30`, and `a40`.

  The helper script selects the appropriate model based on the value of this parameter. If a model is not specified, the default value is `t4`.
- `-e / --effect (default=denoiser)` specifies whether to use the `denoiser`, `dereverb`, `dereverb_denoiser`, `aec`, or `superres`.

  If an effect is not specified, the default value is denoiser.
- `-s / --sample_rate (default=16)` specifies the sample rate of input audio in kHz.

  Supported options are `48`, `16`, or `8`. If the rate is not specified, the default value is `16`.
- (**Superresolution only**) `-o / --output_sample_rate (default=16)` specifies the sample rate of output audio.

  If the rate is not specified, the default value is `16`.
- `-b / --batch_size (default=1, max=1024)` specifies the batch size to use.

  The script generates an input file list and corresponding output file list with a size that is equal to the batch size. The input file list is taken from the sample input files provided with the SDK (from `samples/input_files`).

  If the batch size is not specified, the default value is `1`.
- `-c / --cfg-file (default=/tmp/tmp_cfg.txt)` specifies the path to which the temporary configuration file will be written.

  If the path is not specified, the default location is `/tmp/tmp_cfg.txt`.
- `-f / --frame_size (default=10)` specifies the frame size (10 or 20) that will be used (in milliseconds).

  If the frame size is not specified, the default value is `10`.
- `-h / --help` prints the parameters that are supported by this script.

3.3.1.2.2. Directly Running the Sample Application

To directly run the sample application, run the following command:

```
./effects_demo -c config-file
```

where -c config-file specifies the path of the sample config file, for example, t4_denoise48k_1_cfg.txt. Sample config files are provided with the sample application.

> **Note:** Config files that are used by the sample app can be generated by using the run_effects.sh script, which accepts a path specified by the -c or the --cfg-file flag. If this path is specified, the script writes a config file with the specified configuration parameters to that path. This config file can be reused by the effects_demo sample app.
>
> For example, the following command will write the configuration to the t4_aec.cfg:./run_effect.sh -e aec -s 48 -g t4 -c t4_aec.cfg file.

For example, to denoise a 48kHz stream on a T4 GPU with a batch size of 1, run:

```
./effects_demo -c t4_denoise48k_1_cfg.txt
```

The configuration files contain pairs of parameters and their values, with one pair per line. Currently, the following parameters are supported:

reset *list-of-stream-ids*
Specifies the stream identifiers to reset, starting with 1. Multiple identifiers are separated by spaces.

effect *effect-name*
Specifies the name of the effect to apply. Supported effects are denoiser, dereverb, dereverb_denoiser, aec, and superres.

sample_rate *audio-sample-rate*
Specifies the sample rate of the audio in Hz. Supported values are 8000, 16000, and 48000.

model *model-file*
Specifies the path of the model file to be used in the sample application, for example, models/sm_70/denoiser_48k_1152.trtpkg. The model file should match the audio sample rate that was specified in the sample_rate parameter and the number of input wav files specified in input_wav_list parameter (see Setting the Parameters of an Audio Effect for more information).

frame_size *frame-size-value-in-milliseconds*
Specifies the input frame size (in milliseconds) to be used in the NvAFX_Run() call. The supported values are 10 and 20.

input_wav_list *input-audio-file-list*

Specifies a list of paths to input noisy audio .wav files to use. Each file should contain mono channel audio in signed 16-bit or 32-bit float format with a basic WAV header. Multiple files are separated by a space. The number of input files must match the number of streams/ batch size. In a stream, the files that are separated by a semicolon (;) are processed one after another in the same stream. In addition, if the stream ID exists in the reset list, NvAFX_Reset is called on the stream identifiers when switching between files.

For example, the following configuration specifies that streams 1, 2 and 4 use file1.wav, file2.wav and file6.wav as the input to the stream, and stream 3 uses multiple files (file3.wav, file4.wav, file5.wav) as the input to the stream:

```
input_wav_list file1.wav file2.wav file3.wav;file4.wav;file5.wav file6.wav
```

> **Note:** Sample input audio files are included with the sample application in the samples/input_files/16k and in the samples/input_files/48k directory.

`input_farend_wav_list` ***`input-farend-audio-file-list`***

(**AEC only**) Specifies a list of paths to input noisy audio .wav files to be used as far-end audio. Each entry in this list matches a near-end input that was specified in the input_wav_list, and the number of audio samples in this file must be the same as the number of samples in the corresponding nearend input file.

`output_wav_list` ***`output-audio-file-list`***

Specifies the files to which the output audio will be written. Output files contain mono audio in 32-bit float format. Multiple files are separated by spaces. In a stream, if multiple input files are specified (separated using semicolon), multiple output files will be created with the same name followed by `_1`, `_2`, and so on.

For example, in the following configuration, the output will be written to `out1.wav` (output of `file1.wav`), `out2.wav` (output of `file2.wav`), `out3.wav` (output of `file3.wav`), `out3_1.wav` (output of `file4.wav`), `out3_2.wav` (output of file5.wav), and `out4.wav` (output of `file6.wav`).

```
input_wav_list file1.wav file2.wav file3.wav;file4.wav;file5.wav file6.wav
output_wav_list out1.wav out2.wav out3.wav out4.wav
```

> **Note:** In input/output `.wav` files, only the basic WAV header is supported.

`real_time` ***`enable`***

Simulates real-time audio input, set to 1 to enable, or 0 to disable (disabled by default). When this option is enabled, each audio frame is passed to the SDK with a delay, like how audio is received from a physical device or stream. For example, if the frame size is 10ms, each frame is passed in every 10ms, like how audio is received from a microphone (10ms audio received from the mic approximately every 10ms).

`intensity_ratio` ***`ratio`***

Specifies the denoising intensity ratio. The value of this parameter ranges from `0.0` to `1.0` (inclusive), where a higher value indicates a stronger suppression of noise/reverb. A value of `0.0` is equivalent to passing out input audio without applying noise removal/dereverb.

3.3.1.3. Chaining Effects

This sample application also supports chaining multiple effects (refer to Running Multiple Effects in a Chain for more information).

To run the application in chaining mode, use `run_effect_chained.sh`:

```
./run_effect_chained.sh  -g gpu -e1 effect1 -s1
input_sample_rate_1 -o1 output_sample_rate_1 -e2 effect2 -s2
input_sample_rate_2 -o2 output_sample_rate_2 [-c
path_to_save_config_file] [-i input_file_or_folder]
```

This script generates a config file that can be used with the `effects_demo` sample to run multiple effects in a chain and runs the application with this file.

For example, to run the application on A16, with the Denoiser 16k + Superresolution 16k->48k chain with batch size of 20, use the following command:

```
./run_effect_chained.sh  -g a16 -e1 denoiser -s1 16 -o1 16 -e2 superres -s2 16 -o2
 48 -b 20
```

Refer to Creating a Chained Audio Effect for the list of supported combinations of chaining effects.

The config file that is used for chaining follows the same format and parameters as `effects_demo`, with the following modifications:

`effect` ***`effect-name-1 effect-name-2`***

Specifies the names of the effects to apply to input audio (effect-name-1 will be applied to input audio first, and effect-name-2 will be applied to this output). For more information about possible chaining combinations, refer to Creating a Chained Audio Effect.

> **Note:** Chaining effects only support combination of Superres and Denoiser/Dereverb and Combined Denoiser+Dereverb effect. Other effect chains are not supported. If you combine the Denoiser effect and Dereverb effect, use the combined Denoiser+Dereverb model (refer to About the Room Echo Cancellation + Background Noise Suppression Effect for more information).

`sample_rate` ***`audio-sample-rate-1 audio-sample-rate-2`***

Specifies the input sample rate of the audio in Hz for the effects. The supported values are 8000, 16000, and 48000.

`model` ***`model-file-1 model-file-2`***

Specifies the path of the model file to be used by the effects, for example, models/sm_70/denoiser_48k_1152.trtpkg. The model file should match the audio sample rate that was specified in the `sample_rate` parameter and the number of input wav files specified in `input_wav_list` parameter (see Setting the Parameters of an Audio Effect for more information).

`intensity_ratio` ***`intensity-ratio-1 intensity-ratio-2`***

Specifies the intensity ratio for the effects. The value of this parameter ranges from 0.0f to 1.0f, where a higher value indicates a stronger suppression of noise/reverb. A value of 0.0f is equivalent to a passthrough of input audio.

`chained_effect_gpu_list` ***`gpu-1 gpu-2`***

In a multi-GPU system, specifies the GPU device ID that will be used for the first and the second effect in the chain.

`-i/--input-file (default: Not specified)`

Specifies the input files/folder on which to run the effect.

The helper script will use the sample files distributed with the SDK by default (in `samples/input_files`). The user can also optionally provide a files/folder that contains the files to be processed by using this parameter.

The supported value for this parameter is a path to the input file in correct format (refer to Directly Running the Sample Application for more information), or a folder that contains multiple input files in the correct formats. If a folder is specified, only the files present in the top level of the folder will be processed. For example, if the input folder is `folder1`, then `folder1/a.wav`, folder1/b.wav, and so on will be processed, but `folder1/subfolder/a.wav` will not be processed.

3.3.2. effects_delayed_streams_demo Application

This application demonstrates the use-case for handling delayed streams (refer to Running an Audio Effect on Delayed Streams for more information about delayed streams). In this sample, each of the input streams falls under one of the following categories:

one_step_delay_streams

These streams have a delay of 1 frame. For example, if the frame size is 10ms, these streams will have a delay of 10ms. This means that these streams will be active every alternate iteration, and when the streams are active, they will receive data for both frames (20ms). As a result, when data from these streams arrive, `NvAFX_Run` should be called two times, once with the delayed data and once with the current data.

two_step_delay_streams

These streams have a delay of 2 frames. For example, if the frame size is 10ms, these streams will have a delay of 20ms. This means that these streams will be active after every two iterations, and when the streams are active, they will receive data for three iterations (30ms). As a result, when data from these streams arrive, `NvAFX_Run` should be called three times, twice with the delayed data and once with the current data.

always_active_streams

These streams have no delay and are always active, with one `NvAFX_Run` call per iteration.

`NvAFX_Run()` calls are made based on the description above to generate processed audio output. The configuration files provide a parameter to specify `one_step_delay_streams` and `two_step_delay_streams` (refer to Running the Application for more information). These values and the batch size are used to infer the list of `always_active_streams`.

3.3.2.1. (Optional) Building the Application

To build the application:

1. Navigate to the `samples/effects_delayed_streams_demo` directory.
2. To compile the application, run the `make` command.

```
:/Audio Effects SDK/samples/effects_delayed_streams_demo$ make
```

3.3.2.2. Running the Application

The sample application can be run using the `run_effect.sh` helper script or directly by using the `effects_delayed_streams_demo` executable file.

3.3.2.2.1. Running the Sample Application with the Helper Script

The `run_effect.sh` helper script is a wrapper around the `effects_delayed_streams_demo` application and runs like the helper script in `effects_demo` (refer to Running the Sample Application Using the Helper Script for more information).

This script supports 10 streams that are always preconfigured into active streams, streams with a one-step delay, and streams with a two-step delay. In addition to the parameters in run_effects.sh that were specified (refer to Running the Sample Application Using the Helper Script), this script also supports the `-t / --all_streams_active` parameter, which specifies that all 10 streams are always active. If this parameter is not specified, several streams are configured with a one-step or a two-step delay.

For example, to run the sample application on T4 with the 16k denoiser effect, a batch size of 10, and with all streams active, run the following command:

```
./run_effect.sh -g t4 -s 16 -b 10 -e denoiser -a
```

3.3.2.2.2. Directly Running the Sample Application

To run the sample application, run the following command:

```
./effects_delayed_streams_demo -c config-file
```

where `-c config-file` specifies the path of the config file, for example, `t4_denoise48k_10_cfg.txt`.

For example:

```
./effects_delayed_streams_demo -c t4_denoise48k_10_cfg.txt
```

Note: Sample config files for 16kHz and 48kHz audio are provided with the application.

Like `effects_demo`, the configuration files contain pairs of parameters and their values, with one pair per line. In addition to the configuration parameters used by `effects_demo`, `effects_delayed_streams_demo` requires the following parameters:

`one_step_delay_streams` ***`list-of-stream-id`***

Specifies the stream identifiers that belong to the `one_step_delay_streams` category as mentioned in the previous section. If none of the streams are in this category, this value should be set to none.

`two_step_delay_streams` ***`list-of-stream-id`***

Specifies the stream identifiers that belong to the `two_step_delay_streams` category as mentioned in the previous section. If none of the streams are in this category, this value should be set to `none`.

3.3.2.3. Chaining Effects

This sample application also supports chaining multiple effects (refer to Creating a Chained Audio Effect for more information).

To run the application in chaining mode, use `run_effect_chained.sh`:

```
./run_effect_chained.sh  -g gpu -e1 effect1 -s1
input_sample_rate_1 -o1 output_sample_rate_1 -e2 effect2 -s2
input_sample_rate_2 -o2 output_sample_rate_2 [-c path_to_save_config_file]
```

For example, to run the application on A100, with the Denoiser 16k + Superresolution 16k->48k chain, use the following command:

```
./run_effect_chained.sh  -g a100 -e1 denoiser -s1 16 -o1 16 -e2 superres -s2 16 -o2
 48
```

Refer to Creating a Chained Audio Effect for the list of supported combinations of chaining effects.

The configuration used for this script is the same as the configuration that is used for `effects_demo` (refer to Chaining Effects for more information). The script also uses the same parameters that are used by `effects_delayed_streams_demo` (refer to Running the Application for more information).

Chapter 4. Using the Audio Effects SDK in Applications

The Audio Effects API is a C API but can also be used with applications that are built using C++.

4.1. Workflow in the SDK Application

The following section describes the typical workflow for using an effect in applications.

This flow is a simplified version of the sample program (`effects_demo`/ `effects_delayed_streams_demo` (**Linux only**)). The same flow is also used for chained effects, with a few differences in API calls.

1. Create an effect handle for the effect.

   ```
   NvAFX_Handle handle;
   // Single effect
   NvAFX_Status status = NvAFX_CreateEffect(NVAFX_EFFECT_DENOISER, &handle);
   // OR, create a chained effect
   NvAFX_CreateChainedEffect(NVAFX_CHAINED_EFFECT_SUPERRES_8k_TO_16k_DENOISER_16k,
    &handle);
   ```

2. Set the required parameters (model, batch size (**Linux only**), input sample rate (**Linux only**)).

   ```

   // Set model name
   // Single effect (can also use SetStringList with size 1)
   NvAFX_SetString(handle, NVAFX_PARAM_MODEL_PATH, "denoiser_48k.trtpgk");
   // Chained effect
   NvAFX_SetStringList(handle, NVAFX_PARAM_MODEL_PATH, model_files,
    num_model_files);

   // Linux only: Set input sample rate, number of streams
   NvAFX_SetU32(handle, NVAFX_PARAM_INPUT_SAMPLE_RATE, 48000);
   NvAFX_SetU32(handle, NVAFX_PARAM_NUM_STREAMS, 20);
   ```

3. Set optional parameters, such as intensity ratio, use default GPU, VAD enable, Cuda Graph enable/disable (Windows only) and the delayed streams enable/disabled (Linux only), by using the `NvAFX_SetU32/NvAFX_SetFloat` parameters.

   a). (Linux only) Optionally, set input samples per frame.

      A list of supported input sample rates can be queried using `NvAFX_GetU32List` (refer to Getting the Parameters of an Effect).

   Refer to Using the Audio Effects SDK in Applications for more information.

4. (**Optional**) Set the GPU on which the model will be loaded.

   Refer to Using Multiple GPUs for more information.

5. Load the model.

```
NvAFX_Load(handle);
```

6. After a successful load, query the input/output sample rate, channels, and samples per frame for the effect.

```
// Sample rate
NvAFX_GetU32(handle, NVAFX_PARAM_INPUT_SAMPLE_RATE, &input_sample_rate_);
NvAFX_GetU32(handle, NVAFX_PARAM_OUTPUT_SAMPLE_RATE, &output_sample_rate_);

// Channels
NvAFX_GetU32(handle, NVAFX_PARAM_NUM_INPUT_CHANNELS, &num_input_channels_);
NvAFX_GetU32(handle, NVAFX_PARAM_NUM_OUTPUT_CHANNELS, &num_output_channels_);

// Samples per frame
// Windows only
NvAFX_GetU32(handle, NVAFX_PARAM_NUM_INPUT_SAMPLES_PER_FRAME,
 &num_input_samples_per_frame_);
NvAFX_GetU32(handle, NVAFX_PARAM_NUM_OUTPUT_SAMPLES_PER_FRAME,
 &num_output_samples_per_frame_);
// Linux only
NvAFX_GetU32(handle, NVAFX_PARAM_NUM_SAMPLES_PER_INPUT_FRAME,
 &num_input_samples_per_frame_);
NvAFX_GetU32(handle, NVAFX_PARAM_NUM_SAMPLES_PER_OUTPUT_FRAME,
 &num_output_samples_per_frame_);
```

7. For each input sample, process the audio by using `NvAFX_Run`.

```
NvAFX_Run(handle, input, output, num_input_samples_per_frame_,
 num_input_channels_);
```

8. If there is a disconnection in audio processing (for example, a batch was reused for a different audio source), use `NvAFX_Reset` to reset internal effect states.

```
// Windows only
NvAFX_Reset(handle);
// Linux only
NvAFX_Reset(handle, states_array, input_wav_list.size());
```

9. (Linux only) During batching, to temporarily pause streams (for example, if data is not ready for that stream but is available for processing for other streams) use `NVAFX_PARAM_ACTIVE_STREAMS` as required.

   Refer to Running an Audio Effect on Delayed Audio Streams (**Linux SDK only**) for more information.

10. After audio processing is complete, to free resources, use `NvAFX_Destroy(handle)`.

4.1.1. Building Applications with the SDK

The SDK includes dependent libraries in external/cuda/lib, which are required to compile and run applications and do not require libraries to be separately installed. Refer to Getting Started with the Audio Effects SDK for Windows or Hardware and Software Requirements (Linux) for runtime requirements for applications that use the SDK.

4.1.1.1. Building Applications with the Windows SDK

To build applications with SDK on Windows, use one of the following methods:

- Statically link the library in Visual Studio by using `lib(NVAudioEffects.lib)`.

Refer to Building the Sample Application for more information.

- Load the SDK DLL at runtime by using LoadLibrary/GetProcAddress.

  For example, NvAFX_CreateEffect can be called in the following way:

```
typedef NvAFX_Status(*NVAFX_CREATEEFFECT)(NvAFX_EffectSelector, NvAFX_Handle*);
HINSTANCE h = LoadLibraryW(L"NVAudioEffects.dll");
_NvAFX_CreateEffect = (NVAFX_CREATEEFFECT)GetProcAddress(h,
 "NvAFX_CreateEffect");
void *nv_handle;
_NvAFX_CreateEffect(“denoiser”, &nv_handle);
// Similarly for other APIs
FreeLibrary(h);
```

Previous releases of TensorRT might have a bug where cuBLAS is not unloaded after you unload the SDK DLL, which might cause a memory leak.

To workaround this issue, run the following workaround:

```
int maxLoopCount = 5;
while (maxLoopCount--) {
HMODULE cublas_handle = GetModuleHandle(L"cublasLt64_11");
if (!cublas_handle) break;
if (FreeLibrary(cublas_handle) == false) break;
}
```

4.1.1.2. Building Applications with the Linux SDK

To build applications with SDK on Linux, use either of the following methods:

- At compile time, link to `libnv_audiofx.so`.

  For example, with gcc:

```
gcc -L"../../nvafx/lib" -l"nv_audiofx" -L"../../external/cuda/lib/"
-I"../../nvafx/include" source.c
```

- Dynamically load `libnv_audiofx.so` by using `dlopen`/`dlsym` with the correct library paths set (using `LD_LIBRARY_PATH`/similar).

  Refer to the `dlopen(3)`/`dlsym(3)` man pages for more information.

Note: Some versions of TensorRT may attempt to dynamically load `libcublas.so`. This library is not installed by newer versions of CUDA by default (installs only `libcublas.so.11`). Hence, if **not** using the libraries in `external/cuda/lib`, **and** if previous versions of CUDA are installed, SDK may load an incompatible version of `libcublas.so` and fail to load effects completely. This can be verified using `ltrace`/`strace`/similar to check the libraries loaded by the SDK - note that `ldd`/similar would not show this as the library is dynamically loaded.

To resolve this issue, either use the libraries under `external/cuda/lib` (by setting `LD_LIBRARY_PATH`/similar), or correct/create a symlink to the correct `libcublas.so` (for example, by executing `ln -s /usr/local/cuda-11.8/lib64/libcublas.so.11 libcublas.so` and exporting the current directory in `LD_LIBRARY_PATH` using `export LD_LIBRARY_PATH=$(pwd):$LD_LIBRARY_PATH` or equivalent)

For example:

```
// Typedefs for functions, similarly define for other functions as required
typedef NvAFX_Status (*fnNvAFX_CreateEffect)(NvAFX_EffectSelector code,
 NvAFX_Handle* effect);

// Load library and bind
// Note: ensure that external/cuda/lib is in library path, or fix via RPATH/
similar
void* handle = dlopen("libnv_audiofx.so", RTLD_LAZY);
assert(handle);
fnNvAFX_CreateEffect f = (fnNvAFX_CreateEffect) dlsym(handle,
 "NvAFX_CreateEffect");
assert(f);

// Call functions
NvAFX_Handle effect;
auto ret = f(NVAFX_EFFECT_DENOISER, &effect);
assert(ret == NVAFX_STATUS_SUCCESS);
```

4.2. Creating an Audio Effect

Call the `NvAFX_CreateEffect()` function with the following parameters:

- The `NvAFX_EffectSelector` type `NVAFX_EFFECT_DENOISER`, `NVAFX_EFFECT_DEREVERB`, `NVAFX_EFFECT_DEREVERB_DENOISER`, `NVAFX_EFFECT_AEC`, or `NVAFX_EFFECT_SUPERRES`.
- The pointer to the location that stores the handle to the newly created audio effect.

The `NvAFX_CreateEffect()` function creates a handle to the audio effect instance for use in additional API calls.

The following example creates a denoiser audio effect:

```
NvAFX_Status err = NvAFX_CreateEffect(NVAFX_EFFECT_DENOISER, &handle);
```

4.3. Creating a Chained Effect

The SDK supports running multiple effects in a chain where the output from one effect is passed as the input to the second effect without performing unnecessary pre and post-processing computations. For example, the SDK can chain the Denoiser and Superresolution effects, which will take in 16kHz input data, remove the noise from this audio, and upsample the audio to 48kHz.

This process is more efficient than creating two stand-alone audio effect objects and passing the output of the first object to the second object, and the process also avoids creating unnecessary device-to-host and host-to-device copies.

The following effect chains are supported by the SDK models:

- Superresolution effect (8kHz to 16kHz) + Background Noise Removal effect (16kHz)
- Superresolution effect (8kHz to 16kHz) + Room Echo Removal effect (16kHz)
- Superresolution effect (8kHz to 16kHz) + Combined Background Noise Removal/Room Echo Removal effect (16kHz)
- Background Noise Removal effect (16kHz) + Superresolution effect (16kHz to 48kHz)
- Room Echo Removal effect (16kHz) + Superresolution effect (16kHz to 48kHz)

- Combined Background Noise Removal/Room Echo Removal effect (16kHz) + Superresolution effect (16kHz to 48kHz)

> **Important:** No other effect chains are supported by the SDK models. Using an unsupported chain by manually chaining individual effects might result in degraded audio quality.
>
> If you combine the Denoiser effect and the Dereverb effect, use the combined Denoiser +Dereverb model (refer to About the Room Echo Cancellation + Background Noise Suppression Effect for more information).

To create a chained effect, call NvAFX_CreateChainedEffect with one of the following effect selectors:

- **One** of the following effect selectors:
    - `NVAFX_CHAINED_EFFECT_DENOISER_16k_SUPERRES_16k_TO_48k`
    - `NVAFX_CHAINED_EFFECT_DEREVERB_16k_SUPERRES_16k_TO_48k`
    - `NVAFX_CHAINED_EFFECT_DEREVERB_DENOISER_16k_SUPERRES_16k_TO_48k`
    - `NVAFX_CHAINED_EFFECT_SUPERRES_8k_TO_16k_DENOISER_16k`
    - `NVAFX_CHAINED_EFFECT_SUPERRES_8k_TO_16k_DEREVERB_16k`
    - `NVAFX_CHAINED_EFFECT_SUPERRES_8k_TO_16k_DEREVERB_DENOISER_16k`
- The pointer to the location that stores the handle to the newly created audio effect.

  The following example creates a chained audio Background Noise Removal effect (16kHz) + Superresolution effect (16kHz to 48kHz) effect:

```
NvAFX_Status err =
 NvAFX_CreateChainedEffect(NVAFX_CHAINED_EFFECT_DENOISER_16k_SUPERRES_16k_TO_48k,
                                                             &handle);
```

- In the Linux SDK, this effect has the following maximum throughput (# batches supported in real-time):

Table 3. **Denoiser + Superresolution Effect chain**

Architecture	Maximum Throughput for Superresolution (8kHz to 16kHz) + Denoiser(16kHz) chain	Maximum Throughput for Denoiser (16kHz) + Superresolution (16kHz to 48kHz) chain
T4	162	75
V100	350	200
A100	750	400
A10	350	150

Table 4. **Dereverb + Superresolution Effect chain**

Architecture	Maximum Throughput for Superresolution (8kHz to 16kHz) + Dereverb (16kHz) chain	Maximum Throughput for Denoiser (16kHz) + Superresolution (16kHz to 48kHz) chain
T4	160	73
V100	350	150
A100	800	400
A10	350	150

Table 5. **Dereverb + Denoiser + Superresolution Effect chain**

Architecture	Maximum Throughput for Superresolution (8kHz to 16kHz) + Dereverb (16kHz) chain	Maximum Throughput for Denoiser (16kHz) + Superresolution (16kHz to 48kHz) chain
T4	144	68
V100	300	150
A100	750	400
A10	300	150

Note: Running effects in a chain might impact the performance and latency of the audio pipeline.

4.4. Setting the Parameters of an Audio Effect

An audio effect requires a model to transform the input audio. Each model supports a specific audio sample rate. The path to the model file and input audio sample rate (Linux SDK only) must be set in the SDK. After required parameters for the effect are set, the effect can be loaded using `NvAFX_Load`.

The Linux SDK also supports several frame sizes (the number of samples per frame), which can be queried and set in the SDK (refer to Getting the Parameters of an Effect for more information).

To set U32 values, call the `NvAFX_SetU32()` function with the following parameters:

- Previously created effect handle.
- The selector string for the parameter to be set:

  - **(Linux SDK Only)** To set the sample rate, specify:

    ```
    NVAFX_PARAM_INPUT_SAMPLE_RATE
    ```

  - To set the number of audio streams, specify:

    ```
    NVAFX_PARAM_NUM_STREAMS
    ```

  - To set the number of samples per input frame, specify:

    - **For Linux**

      ```
      NVAFX_PARAM_NUM_SAMPLES_PER_INPUT_FRAME
      ```

    - **For Windows**

      ```
      NVAFX_PARAM_NUM_INPUT_SAMPLES_PER_FRAME
      ```

  - In a Multi-GPU setup, to have SDK automatically select the GPU compatible with the model set in SDK, set the following parameter to 1:

    > **Note:** The default value is 0.

    ```
    NVAFX_PARAM_USE_DEFAULT_GPU
    ```

    This parameter is not supported by chained effects.

  - (**Windows SDK Only**) To allow users to create and manage their own CUDA context, set the following parameter to 1:

    > **Note:** The default value is 0.

    ```
    NVAFX_PARAM_USER_CUDA_CONTEXT
    ```

  - **(Windows SDK only)** To disable CUDA graphs, set the following parameter to 1.

    > **Note:** The default value is 0.

    ```
    NVAFX_PARAM_DISABLE_CUDA_GRAPH
    ```

- In a Multi-GPU setup, to have SDK automatically select the GPU compatible with the model set in SDK, set the following parameter to 1:

  ```
  NVAFX_PARAM_USE_DEFAULT_GPU
  ```

  The default value is 0, and this parameter is not supported by chained effects.

- The Noise Removal and Room Echo Removal/Room Echo Cancellation effect supports VAD, which indicates whether the audio data frame supplied to the SDK through `NvAFX_Run` contains speech data.

  When enabled, this feature also removes low-volume noise and all non-speech data from the `NvAFX_Run` output without degrading performance. To enable this feature, set the following parameter to 1:

  ```
  NVAFX_PARAM_ENABLE_VAD
  ```

  > **Note:** This parameter can only be set **before** the model is loaded (before the `NvAFX_Load` call). Setting the parameter **after** the model is loaded has no effect.

The default value is 0, and this parameter is not supported by chained effects.

The VAD status for the last `NvAFX_Run` call can also be queried by using the `NvAFX_GetBoolList()` function. This query can be helpful when the audio output pipeline has an alternative packet loss concealment algorithm. For more information about querying the list, refer to Getting the Parameters of an Effect.

- An unsigned integer value that specifies the value for the selector.

To set the model, call the `NvAFX_SetString()` function with the following parameters:

- Previously created effect handle.
- A null-terminated string specifying the path to the model file.
  - **For the Linux SDK**
    - Each model file supports a specific sample rate and a maximum number of audio streams.
    - Model files for specific GPU compute versions are located in the `models/<compute_version>` directory in the SDK.

      The following GPU compute versions can be used for the following GPUs:

      - Volta (V100): `models/sm_70`
      - Turing (T4): `models/sm_75`
      - Ampere:
        - A100 (`ga100` based GPUs): `models/sm_80`
        - A10 (`ga102` or later GPUs): `models/sm_86`
      - The specified model should match the sample rate and a specified number of audio streams.
      - The model file name uses the following naming convention:

        ```
        <effect>_<samplerate>_<max-streams>.trtpkg
        ```

        - For the Superresolution effect, the model file name follows the following naming convention:

          ```
          <effect>_<input_rate>_<output_rate>_<max-streams>.trtpkg
          ```
      - Each folder also includes a symlink, which points to the actual model, for example `denoise_16k.trtpkg` and `denoiser_48k.trtpkg`.
      - `samplerate` can be 8k, 16k, or 48k.
      - The number of audio streams should be within the range 1 and `max-streams` (both inclusive).
      - Models give the best throughput performance when the number of audio streams is set to 64 or a multiple of 256 (256, 512, 768, and so on).

    For example, the `denoiser_48k_1152.trtpkg` model can be used for 48kHz and between 1 to 1152 audio streams but will be optimal for 64, 256, 512, 768, and 1024 streams. Code that uses this model can also directly use the symlink denoiser_48k.trtpkg in the same folder, which allows the underlying model to be changed without code changes.

> **Note:** The maximum number of batches supported by some of the models included in the Linux SDK might be less than the maximum throughput supported by the effect.
>
> In case your use case requires a model with larger batch size, please contact us at maxinesdk-support@nvidia.com.

- **For the Windows SDK**
    - Each model file supports a specific sample rate.
    - Model files for specific GPU compute versions are located in the models directory in the SDK.
- For chained effects, call the NvAFX_SetStringList function with the following parameters:
    - The previously created effect handle.
    - An array of null-terminated strings, each specifying the path to the model file of the effect to be chained.

      For example, for a Denoiser 16k + Superres 16k to 48k chain, an array that contains two paths should be passed in the following paths:
        - To the 16k Denoiser model.
        - To the 16k to 48k Superres model.

      The model paths should follow the same conventions as the conventions of the standalone effect.
- The length of the array.

  For example, the following code sets the sample rate to sample_rate and the path to the model specified by the model_file.c_str().

```
NvAFX_Status err;

// Set sample rate (Linux only)
err = NvAFX_SetU32(handle, NVAFX_PARAM_INPUT_SAMPLE_RATE, sample_rate);

// Set model path
err = NvAFX_SetString(handle, NVAFX_PARAM_MODEL_PATH, model_file.c_str());
err = NvAFX_SetU32(handle, NVAFX_PARAM_NUM_STREAMS, num_streams);
```

4.5. Getting the Parameters of an Effect

The number of channels in input/output audio are fixed for the Audio Effect and cannot be changed. Before running an audio effect, the number of channels that are supported by the effect must be queried. The Linux SDK also supports several frame sizes (number of samples per frame), which can be queried and set by using the set API (refer to Setting the Parameters of an Audio Effect for more information). The application can also query and use the default frame size supported by the SDK, as demonstrated in the following sample.

The Linux SDK also supports several frame sizes (number of samples per frame), which can be queried and set by using the set API (refer to Setting the Parameters of an Audio Effect for more information). The application can also query and use the default frame size supported by the SDK, as demonstrated in the following sample.

Chained effects currently **only** support a 10ms frame size.

> **Note:** Effect parameters, except for supported frame size list (Linux only), can be queried only after the effect is loaded. Querying parameters before the model is loaded might return invalid values, and the function might fail with an error code.
>
> To ensure that the sample rate of the input audio is compatible with the Audio Effect, the sample rate should be queried first.

To query these parameters, call the `NvAFX_GetU32()` function with the following parameters:

- Previously created effect handle.
- The selector string for the parameter to be queried:
  - To get the default number of samples per input frame, specify:
    - **For Linux**

      ```
      NVAFX_PARAM_NUM_SAMPLES_PER_INPUT_FRAME
      ```
    - **For Windows**

      ```
      NVAFX_PARAM_NUM_INPUT_SAMPLES_PER_FRAME
      ```
  - To get the default number of samples per output frame per channel, specify:
    - **For Linux**

      ```
      NVAFX_PARAM_NUM_SAMPLES_PER_OUTPUT_FRAME
      ```
    - **For Windows**

      ```
      NVAFX_PARAM_NUM_OUTPUT_SAMPLES_PER_FRAME
      ```
  - To get the number of channels in input/output audio, specify:

    ```
    NVAFX_PARAM_NUM_INPUT_CHANNELS/NVAFX_PARAM_NUM_OUTPUT_CHANNELS
    ```
  - To get the input/output sample rate, specify:

    ```
    NVAFX_PARAM_INPUT_SAMPLE_RATE/NVAFX_PARAM_OUTPUT_SAMPLE_RATE
    ```
- A pointer to the location where the value will be stored.

To query lists, the user must query the list size, allocate memory for the output, and then pass the newly allocated memory and size to `NvAFX_GetU32List()` or `NvAFX_GetBoolList`.

To query the list size, call the `NvAFX_GetU32List()` or the `NvAFX_GetBoolList()` function with the following parameters:

- Previously created effect handle.
- The selector string for the parameter to be queried.

  To get the list of the number of supported samples per frame (Linux only), specify `NVAFX_PARAM_SUPPORTED_NUM_SAMPLES_PER_FRAME`.
- An output pointer, set to nullptr (or NULL) to query size.

- A pointer to the location where the size of the list is to be stored.

  The size should be initialized to zero and will be updated with the actual size when this function is called.

  The `NvAFX_GetU32List()` call retrieves the size of the list for the corresponding parameter selector with an `NVAFX_STATUS_OUTPUT_BUFFER_TOO_SMALL` error status. To query the list, allocate memory for the list with the returned size and call the `NvAFX_GetU32List()` function with the following parameters:

  - The selector string for the parameter to be queried.

    To get the list of supported number of samples per frame, specify:

    ```
    NVAFX_PARAM_SUPPORTED_NUM_SAMPLES_PER_FRAME.
    ```
  - A pointer to a U32 array of size at least of the list size retrieved from the above call.

    The list values are written to this array.
  - A pointer to a location where the value of the size of the list is stored.

The following example queries an effect for the supported number of samples per frame, the number of channels in input/output audio, the sample rate, and the supported frame sizes.

```
uunsigned num_samples_per_frame, num_channels, sample_rate;
NvAFX_Status err;
// Linux only
std::unique_ptr<unsigned int[]> supported_list = nullptr;
int list_size = 0;
err = NvAFX_GetU32List(handle, NVAFX_PARAM_SUPPORTED_NUM_SAMPLES_PER_FRAME,
 supported_list.get(), &list_size);
if (err != NVAFX_STATUS_OUTPUT_BUFFER_TOO_SMALL) {
   // This indicates API failure
   return;
}
supported_list.reset(new unsigned int[list_size]);
err = NvAFX_GetU32List(handle, NVAFX_PARAM_SUPPORTED_NUM_SAMPLES_PER_FRAME,
 supported_list.get(), &list_size);

// Load model
err = NvAFX_GetU32(handle, NVAFX_PARAM_NUM_SAMPLES_PER_INPUT_FRAME,
 &num_samples_per_frame);
err = NvAFX_GetU32(handle, NVAFX_PARAM_NUM_INPUT_CHANNELS, &num_channels);
err = NvAFX_GetU32(handle, NVAFX_PARAM_OUTPUT_SAMPLE_RATE, &sample_rate);
// Querying VAD results
// VAD must be supported and enabled on the handle
NvAFX_Run(...); // Process input first

// Query results for last input
// Note: If no voice is detected, output audio is zeroed by the effect
// However, result is also returned (in case custom packet loss concealment is
 desired) - returns NVAFX_TRUE if input audio had voice, NVAFX_FALSE otherwise
std::vector<NvAFX_Bool> out(num_streams, 0);
uint32_t s = out.size();
auto status = NvAFX_GetBoolList(handle, NVAFX_PARAM_VAD_RESULT, out.data(), &s);
assert(status == NVAFX_STATUS_SUCCESS);
// Use VAD result
```

4.6. Getting Supported Devices (Windows SDK Only)

The `NvAFX_GetSupportedDevices()` function can be used to determine the GPUs that are supported by the currently selected model.

> **Note:** This method must be called **after** you set the model path.

Call this function with the following parameters:

- The effect handle.
- The size of the input array.

  If the call succeeds, this value will be set by the function.
- Array of size num.

The function will fill the array with the CUDA device indices of devices that are supported by the model, in descending order of preference, where the first device is the most preferred device.

This example fetches the list of supported GPUs by the model:

```
int numSupportedDevices = 0;
NvAFX_GetSupportedDevices(handle, &numSupportedDevices, nullptr);

std::vector<int> ret(num);
NvAFX_GetSupportedDevices(handle, &numSupportedDevices, ret.data();
```

4.7. Loading an Audio Effect

Loading an effect involves validating the parameters that were set for the effect and loading the specified model into GPU memory.

To load an audio effect, set the parameters for the effect described in the previous section and call `NvAFX_Load()` with the effect handle.

```
NvAFX_Status err = NvAFX_Load(handle);
```

4.8. Running an Audio Effect

Once the effect is loaded, it can be applied to input audio using the `NvAFX_Run()` function. When the effect is run, the contents of the input memory buffer are read, the audio effect is applied, and the output is written to the output memory buffer.

> **Note:** Input/Output memory buffers are in CPU memory. Copying to/from GPU memory is handled internally by the SDK.

> **Note:** Except for the Acoustic Echo Cancellation effect, which has two input channels, the SDK supports **only** mono-channel processing. The number of channels that are supported by the effect can be obtained by querying `NVAFX_PARAM_NUM_INPUT_CHANNELS`. Refer to Getting the Parameters of an Effect for more information.

To run an audio effect, call the `NvAFX_Run()` function with the following parameters:

- Previously created effect handle.
- The input memory buffer.

  For the AEC effect, specify two channels, where the first channel is the batched near-end audio, and the second channel is the batched far-end audio.
- The output memory buffer.

  For Super Resolution effect, the size of input and output memory buffer will differ and should be queried by the user using the following:

  - `NVAFX_PARAM_NUM_OUTPUT_SAMPLES_PER_FRAME`
  - `NVAFX_PARAM_NUM_INPUT_SAMPLES_PER_FRAME`
- The number of samples per frame per stream of input/output data.
- The number of channels in input/output audio.

  Refer to Getting the Parameters of an Effect for more information.

The following example runs an audio effect:

```
NvAFX_Status err = NvAFX_Run(handle, input, output, num_samples, num_channels);
```

4.9. Running Multiple Audio Effects in a chain

The following example demonstrates running two effects in a chain:

```
NvAFX_Status err;
err = NvAFX_API
 NvAFX_CreateChainedEffect(NVAFX_CHAINED_EFFECT_DENOISER_16k_SUPERRES_16k_TO_48k,
 &effect);
// Set effect parameters & load effect
...
```

```
NvAFX_Status err = NvAFX_Run(chained_handle, input_audio, intermediate_output,
 num_samples, num_channels);
```

Note: Running effects in a chain might impact the performance and latency of the audio pipeline.

4.10. Running an Audio Effect on Delayed Audio Streams (Linux SDK Only)

The Linux SDK supports cases where some streams do not arrive at the expected time. These streams are referred to as delayed streams. To support handling these streams, the SDK allows applications to specify a list that indicates whether the corresponding stream is currently active or delayed/inactive.

The list can be set by calling `NvAFX_SetBoolList()` with the following function parameters:

- Previously created effect handle.
- The `NVAFX_PARAM_ACTIVE_STREAMS` selector string.
- An array of type `NVAFX_BOOL` where each element represents the status of the corresponding audio stream.

  `NVAFX_TRUE` indicates an active stream, and `NVAFX_FALSE` indicates an inactive stream
- Length of the above array, which is equal to the number of audio streams.

For delayed audio streams, the effect can be initially applied on all delayed audio streams by setting them as active and setting the on-time audio streams as inactive. This should be followed by one or more `NvAFX_Run()` calls to apply the effect on the delayed audio streams. After the delayed audio streams are processed, the on-time audio streams are set to active, and `NvAFX_Run()` is executed once to apply the effect.

The following example demonstrates how to process four streams:

1. Consider an effect that accepts 10ms audio inputs.
2. Audio streams 1 and 3 are delayed by 10ms each and arrive with 20ms worth of data.
3. Audio streams 2 and 4 are on time and arrive with 10ms of data.
4. Streams can be processed in one of the following ways:

   - **Option 1**

     Process the extra 10ms **only** in the delayed streams and then process on-time 10ms data for **all** streams. Initially, by using `NvAFX_SetBoolList`, streams 1 and 3 are set as active, and 2 and 4 are set as inactive.

     a). An `NvAFX_Run` call is executed where 10ms of data from streams 1 and 3 is populated in the input while the rest of the input is set to 0.

     This step processes the extra 10ms of data in streams 1 and 3.

     b). A second `NvAFX_SetBoolList` call is executed to set all streams (1, 2, 3, and 4) as active.

c). An NvAFX_Run call is executed with the real-time 10ms data from all four streams.

- **Option 2**

  Process 10ms in all streams and then process the extra 10ms data only in delayed streams:

  a). Process 10ms of data from all streams (stale data from stream 1 and 3 and new data from stream 2 and 4 by calling NvAFX_Run.

  b). Set streams 1 and 3 to active and 2 and 4 to inactive by calling NvAFX_SetBoolList.

  c). Process the extra 10ms from stream 1 and 3 by calling NvAFX_Run.

The following example runs an audio effect after setting some of the audio streams as inactive:

```
NvAFX_Status err = NvAFX_SetBoolList(handle, NVAFX_PARAM_ACTIVE_STREAMS,
 stream_active_list, num_streams);

NvAFX_Status err = NvAFX_Run(handle, input, output, num_samples, num_channels);
```

The internal state of each stream is updated during each NvAFX_Run call only for active streams. Setting a stream to inactive will disable updating this state. If required, this state can also be reset using NvAFX_Reset, as described in NvAFX_Reset.

4.11. Destroying an Audio Effect

When an audio effect is no longer required, it should be destroyed to free the resources and memory used by the effect.

To destroy an audio effect, call NvAFX_DestroyEffect() and specify the effect handle to the effect to be destroyed.

```
NvAFX_Status err = NvAFX_DestroyEffect(handle);
```

4.12. Using Multiple GPUs

Applications that are developed with the Audio Effects SDK can be used with multiple GPUs. By default, the SDK assumes that the application will set the GPU. Optionally, the SDK can select the best GPU to run the effect(s).

4.12.1. Selecting the GPU for Audio Effects Processing in a Multi-GPU Environment

The GPU that will be used to run audio effect(s) in a multi-GPU environment can be controlled by using the cudaSetDevice() and cudaGetDevice() CUDA functions. The device should be set **before** NvAFX_Load() is called because NvAFX_Load() will succeed only when the currently selected GPU supports the SDK.

```
int chosenGPU = 0; // or whichever GPU you want to use
cudaSetDevice(chosenGPU);
NvAFX_Handle effect;
err = NvAFX_API NvAFX_CreateEffect(code, &effect);
err = NvAFX_Set...; // set parameters
…
err = NvAFX_API NvAFX_Load(effect);
…
err = NvAFX_API NvAFX_Run(effect, ...);
```

4.12.2. Selecting GPUs for Chained Audio Effects (Linux Only)

When using chained effects in a multi-GPU environment, the SDK can optionally run the effects in the chain on separate GPUs. For example, in a Denoiser 16k + Superres 16k to 48k chain, the denoiser effect can be run entirely on one GPU and the Superres effect on another GPU.

To use this feature, create the chained effect and set `NVAFX_PARAM_CHAINED_EFFECT_GPU_LIST` to an array that specifies the GPU IDs using `NvAFX_SetU32List`. This parameter must be set before you call `NvAFX_Load` on the effect.

The following sample demonstrates use of this parameter:

```
NvAFX_Handle effect;
err = NvAFX_API NvAFX_CreateChainedEffect(code, &effect);
…
// Run first effect on GPU id 3, second on GPU id 4
uint32_t gpus[] = { 3, 4};
err = NvAFX_API SetU32List(effect, NVAFX_PARAM_CHAINED_EFFECT_GPU_LIST, gpus,
                           sizeof(gpus));

…
err = NvAFX_API NvAFX_Load(effect);
```

4.12.3. Offloading GPU Selection to the SDK for Audio Effects Processing in a Multi-GPU Environment

In a multi-GPU environment, the SDK can optionally determine the optimal GPU on which to run the audio effect(s). To use this feature, call `NvAFX_SetU32` with the `NvAFX_SetU32(effect , NVAFX_PARAM_USE_DEFAULT_GPU, 1)` parameters before loading effects. If `NvAFX_SetU32` is called after an audio effect is loaded, the function will not have any effect.

If the application sets `NVAFX_PARAM_USE_DEFAULT_GPU` to 0, or does not set this parameter, the SDK will explicitly not select the GPU to run the effect. The application can set the device on which SDK calls are to be executed by using the `cudaSetDevice` API. If this parameter is not set or is set to 0, the SDK will use the default device (device 0).

If the application sets `NVAFX_PARAM_USE_DEFAULT_GPU` to `1`, the application should not call `cudaSetDevice()`, and the other effects (or multiple instances of an effect) will use the GPU that was determined by the SDK. If the application explicitly calls `cudaSetDevice()` before `NvAFX_Load()`, the SDK might override the application's device preference. If the client calls `cudaSetDevice()` to set the GPU to a different GPU just before calling `NvAFX_Run()`, the `NvAFX_Run()` call will fail.

```
NvAFX_Handle effect;
err = NvAFX_API NvAFX_CreateEffect(code, &effect);
err = NvAFX_API SetU32(effect, NVAFX_PARAM_USE_DEFAULT_GPU, 1);
…
err = NvAFX_API NvAFX_Load(effect);
…
```

Note: `NVAFX_PARAM_USE_DEFAULT_GPU` and `NVAFX_PARAM_USER_CUDA_CONTEXT` **cannot** be used at the same time.

This parameter is not supported for chained effects.

4.12.4. Selecting Different GPUs for Different Tasks

The applications that use the SDK might be designed to perform multiple tasks in a multi-GPU environment in addition to applying the audio effect filter. In this situation, the best GPU for each task should be selected before calling NvAFX_Load and be set before each NvAFX_Run call.

The application is responsible for switching to the appropriate GPU before executing SDK calls. If the application does not switch to the appropriate GPU before calling NvAFX_Run, the call will fail with an error.

The following steps demonstrate how to complete CUDA tasks and SDK calls on different GPUs.

1. Call `cudaGetDeviceCount()` to determine the number of available GPUs.

   ```
   // Get the number of GPUs
   cuErr = cudaGetDeviceCount(&deviceCount);
   ```
2. Determine the best GPU for the task.

   For example, this can be determined by iterating over the available GPUs and selecting the GPU with the highest number of SMs by using `cudaGetDeviceProperties()`.
3. In the loop that completes the application's tasks, select the best GPU for each task **before** performing the task by calling `cudaSetDevice()` to select the GPU for the task.
4. Before executing SDK calls, call `cudaSetDevice()` again to set the GPU back to the Audio Effects GPU.

   ```
   // Select the best GPU for each task and perform the task.
   while (!done) {
     …
     cudaSetDevice(gpuOtherTask);
     PerformOtherTask();
     cudaSetDevice(gpuAFX);
     err = NvAFX_Run(effect, ...)
   ```

4.12.5. CUDA Graph Support (Windows Only)

The Windows SDK supports using CUDA graphs, which improve performance by reducing the CPU overheads that are seen with short-lived CUDA kernels.

By default, graphs are enabled in the Windows SDK, but this can cause issues if the SDK runs in parallel with other applications that are using CUDA graphs. The following example shows you how to disable CUDA graphs:

```
// Call before loading model (NvAFX_Load) Windows only
  err = NvAFX_API SetU32(effect, NVAFX_PARAM_DISABLE_CUDA_GRAPH, 1);
```

```
  ...
```

Chapter 5. Audio Effects SDK API Reference

This section provides detailed information about the APIs in the Audio Effects SDK.

5.1. Type Definitions

The Audio Effects SDK type definitions provide selector strings for the audio effect and the parameters of an audio effect.

5.1.1. NvAFX_EffectSelector

This type definition provides selector strings for the audio effect types.

```
typedef const char* NvAFX_EffectSelector;
```

The currently supported selectors are:

NVAFX_EFFECT_DENOISER : "denoiser"

Denoiser audio effect (refer to About the Background Noise Suppression Effect).

NVAFX_EFFECT_DEREVERB "dereverb"

De-reverb effect (refer to About the Room Echo Cancellation Effect).

NVAFX_EFFECT_DEREVERB_DENOISER "dereverb_denoiser"

Combined De-reverb and Denoiser effects (refer to About the Noise Removal and Room Echo Removal/Room Echo Cancellation + Background Noise Suppression Effect).

NVAFX_EFFECT_AEC "aec"

AEC effect (refer to About the Acoustic Echo Cancellation Effect).

NVAFX_EFFECT_SUPERRES

Audio Super-resolution effect (see About the Audio Super-Resolution Effect).

NVAFX_CHAINED_EFFECT_DENOISER_16k_SUPERRES_16k_TO_48k

Chained effect (Denoiser 16k + Superres 16k to 48k)

NVAFX_CHAINED_EFFECT_DEREVERB_16k_SUPERRES_16k_TO_48k

Chained effect (Dereverb 16k + Superres 16k to 48k)

NVAFX_CHAINED_EFFECT_DEREVERB_DENOISER_16k_SUPERRES_16k_TO_48k

Chained effect (Dereverb+Denoiser 16k + Superres 16k to 48k)

NVAFX_CHAINED_EFFECT_SUPERRES_8k_TO_16k_DENOISER_16k

Chained effect (Superres 8k to 16k + Denoiser 16k)

NVAFX_CHAINED_EFFECT_SUPERRES_8k_TO_16k_DEREVERB_16k

Chained effect (Superres 8k to 16k + Dereverb 16k)

NVAFX_CHAINED_EFFECT_SUPERRES_8k_TO_16k_DEREVERB_DENOISER_16k
Chained effect (Superres 8k to 16k + Dereverb+Denoiser 16k)

5.1.2. NvAFX_ParameterSelector

This type definition provides selector strings for audio effect parameters.

```
typedef const char* NvAFX_ParameterSelector;
```

The currently supported selectors are:

NVAFX_PARAM_MODEL_PATH: "model_path"
A character string that specifies the path to the model file for the audio effect.

NVAFX_PARAM_INPUT_SAMPLE_RATE: "input_sample_rate"
An unsigned integer that specifies the audio input sample rate for the audio effect.

NVAFX_PARAM_OUTPUT_SAMPLE_RATE: "output_sample_rate"
An unsigned integer that specifies the audio output sample rate for the audio effect.

(Linux SDK only) NVAFX_PARAM_NUM_SAMPLES_PER_INPUT_FRAME: "num_samples_per_input_frame"
An unsigned integer that specifies the number of samples per input frame per audio stream for the audio effect.

(Windows SDK only) NVAFX_PARAM_NUM_INPUT_SAMPLES_PER_FRAME: "num_input_samples_per_frame"
An unsigned integer that specifies the number of samples per input frame per audio stream for the audio effect.

(Linux SDK only) NVAFX_PARAM_NUM_SAMPLES_PER_OUTPUT_FRAME: "num_samples_per_output_frame"
An unsigned integer that specifies the number of samples per output frame per audio stream for the audio effect.

(Windows SDK only) NVAFX_PARAM_NUM_OUTPUT_SAMPLES_PER_FRAME: "num_output_samples_per_frame"
An unsigned integer that specifies the number of samples per output frame per audio stream for the audio effect.

NVAFX_PARAM_NUM_INPUT_CHANNELS: "num_input_channels"
An unsigned integer that specifies the number of audio channels for the audio effect.

NVAFX_PARAM_NUM_OUTPUT_CHANNELS: "num_output_channels"
An unsigned integer that specifies the number of output audio channels for the audio effect.

NVAFX_PARAM_NUM_STREAMS: "num_streams"
An unsigned integer that specifies the number of audio streams to be processed by the audio effect.

NVAFX_PARAM_INTENSITY_RATIO: "intensity_ratio"
A float value that specifies the factor that ranges from 0.0 to 1.0. Setting the factor to 0.0 is identical to a pass through, and a value of 1.0 provides the maximum possible impact of the effect.

(Linux SDK only) NVAFX_PARAM_ACTIVE_STREAMS: "active_streams"
A list of `NvAFX_Bool` values that specify whether the corresponding stream is active.

(Linux SDK only) NVAFX_PARAM_SUPPORTED_NUM_SAMPLES_PER_FRAME: "supported_num_samples_per_frame"
A list of U32 values that specifies the supported values for the number of samples per frame. This value can be queried before model load after the input sample rate is set.

`NVAFX_PARAM_CHAINED_EFFECT_GPU_LIST`

A list of U32 values specifying the GPUs to be used in chained effects. Each effect in the chain will use the corresponding GPU from the list.

(Windows SDK Only) `NVAFX_PARAM_USER_CUDA_CONTEXT: "user_cuda_context"`

An unsigned integer value that allows SDK users to disable the SDK internal context management. To disable the internal context management, set this value to 1. This value cannot be changed after the model is loaded for that particular session.

`NVAFX_PARAM_DISABLE_CUDA_GRAPH : "disable_cuda_graph"`

An unsigned integer value that specifies whether to enable CUDA graphs (enabled by default):

- To disable CUDA graphs, set this value to 1.
- To enable CUDA graphs, set this value to zero.

For more information about CUDA Graphs, refer to Getting Started with CUDA Graphs.

> **Note:** `NVAFX_PARAM_USE_DEFAULT_GPU` and `NVAFX_PARAM_USER_CUDA_CONTEXT` cannot be used at the same time.

The following selectors have been deprecated:

- `NVAFX_PARAM_NUM_CHANNELS: "num_channels"`
- `NVAFX_PARAM_SAMPLE_RATE: "sample_rate"`
- `NVAFX_PARAM_NUM_SAMPLES_PER_FRAME: "num_samples_per_frame"`

5.1.3. NvAFX_Handle

An opaque handle that is associated with an instance of an audio effect.

```
typedef void* NvAFX_Handle;
```

5.1.4. NvAFX_Bool (Linux SDK Only)

This type definition is set to `NVAFX_TRUE` to represent `true` and `NVAFX_FALSE` to represent `false`.

```
typedef char NvAFX_Bool;
```

5.1.5. logging_cb_t (Linux SDK Only)

A callback function type that is used in the `NvAFX_InitializeLogger` API.

```
typedef void(*logging_cb_t)(LoggingSeverity level, const char* log, void* userdata);
```

5.1.6. LoggingSeverity (Linux SDK Only)

The levels of the `LoggingSeverity` that are used in the `NvAFX_InitializeLogger` API.

```
typedef enum LoggingSeverity_t {
  LOG_LEVEL_ERROR,
  LOG_LEVEL_WARNING,
  LOG_LEVEL_INFO,
} LoggingSeverity
```

5.1.7. LoggingTarget (Linux SDK Only)

The logging target used in the `NvAFX_InitializeLogger` API.

```
typedef enum LoggingTarget_t
{
  LOG_TARGET_NONE = 0x0,
  LOG_TARGET_STDERR = 0x1,
  LOG_TARGET_FILE = 0x2,
  LOG_TARGET_CALLBACK = 0x4,
} LoggingTarget;
```

5.2. Functions

This section provides information about the functions in the Audio Effects SDK.

5.2.1. NvAFX_GetEffectList

This function retrieves a list of supported audio effects.

```
NvAFX_Status NvAFX_GetEffectList(
  int* num_effects,
  NvAFX_EffectSelector* effects[]
);
```

Parameters

num_effects [out]

Type: `int*`

Pointer to an integer that contains the number of effects returned.

effects [out]

Type: `NvAFX_EffectSelector* []`

Address to a list of effect selection strings that are supported by the SDK. This list is statically allocated by the SDK, so the caller should not allocate memory for this parameter or free it after use. Refer to NvAFX_EffectSelector for more information about the selection strings.

Return Value

`NVAFX_STATUS_SUCCESS` on success.

Remarks

This function retrieves the list of audio effects that are supported by the SDK. The selection strings for the Audio Effects SDK are populated in the `effects` output parameter. The number of available effects are written to the `num_effects` output parameter.

5.2.2. NvAFX_CreateEffect

This function creates an audio effect instance.

```
NvAFX_Status NvAFX_CreateEffect(
  NvAFX_EffectSelector code,
  NvAFX_Handle* effect
);
```

Parameters

code [in]

Type: `NvAFX_EffectSelector`

The selection string for the type of audio effect to be created. Refer to NvAFX_EffectSelector for more information about the allowed selection strings.

effect [out]

Type: `NvAFX_Handle*`

The pointer to the location where the handle to the newly created audio effect instance will be stored.

Return Value

`NVAFX_STATUS_SUCCESS` on success.

Remarks

This function creates an instance of the specified type of audio effect and returns the handle via this effect to the `effect` output parameter.

5.2.3. NvAFX_CreateChainedEffect

This function creates a chained effect instance.

```
NvAFX_Status NvAFX_CreateChainedEffect(
  NvAFX_EffectSelector code,
  NvAFX_Handle* effect
);
```

Parameters

code [in]

Type: `NvAFX_EffectSelector`

The selection string for the type of chained audio effect to be created. Refer to NvAFX_EffectSelector for more information about the allowed selection strings.

effect [out]

Type: `NvAFX_Handle*`

The pointer to the location where the handle to the newly created chained audio effect instance will be stored.

Return Value

`NVAFX_STATUS_SUCCESS` on success.

Remarks

This function creates an instance of the specified type of chained audio effect and returns the handle to this effect instance by using the `effect` output parameter.

5.2.4. NvAFX_DestroyEffect

This function destroys an effect instance.

```
NvAFX_Status NvAFX_DestroyEffect(
  NvAFX_Handle effect
);
```

Parameters

effect [in]

Type: `NvAFX_Handle`

The handle to the audio effect instance to be destroyed.

Return Value

`NVAFX_STATUS_SUCCESS` on success.

Remarks

This function destroys the audio effect instance with the specified handle and frees all resources and memory that were used by that instance.

5.2.5. NvAFX_SetString

This function sets a string parameter of the specified effect.

```
NvAFX_Status NvAFX_SetString(
  NvAFX_Handle effect,
  NvAFX_ParameterSelector param_name,
  const char* val
);
```

Parameters

effect [in]

Type: `NvAFX_Handle`

The handle to the audio effect instance.

param_name [in]

Type: `NvAFX_ParameterSelector`

Refer to Setting the Parameters of an Audio Effect for a list of the allowed options.

val [in]

Type: `char*`

Pointer to the character string to be set.

Return Value

`NVAFX_STATUS_SUCCESS` on success.

Remarks

This function sets the value of the specified character string parameter for the specified audio effect to the `val` parameter.

5.2.6. NvAFX_SetStringList

This function sets a string parameter of the specified effect.

```
NvAFX_Status NvAFX_SetStringList(
  NvAFX_Handle effect,
  NvAFX_ParameterSelector param_name,
  const char** list, unsigned int list_size
);
```

Parameters

effect [in]

Type: `NvAFX_Handle`

The handle to the audio effect instance.

param_name [in]

Type: `NvAFX_ParameterSelector`

Refer to Setting the Parameters of an Audio Effect for a list of the allowed options.

list[in]

Type: `char**`

Pointer to the character array.

list_size[in]

Type: `unsigned int`

Size of the character array to be set.

Return Value

`NVAFX_STATUS_SUCCESS` on success.

Remarks

This function sets the value of the specified character string parameter for the specified audio effect to the `val` parameter.

5.2.7. NvAFX_SetU32

This function sets a UInt parameter of the specified effect.

```
NvAFX_Status NvAFX_SetU32(
  NvAFX_Handle effect,
  NvAFX_ParameterSelector param_name,
  unsigned int val
);
```

Parameters

effect [in]

Type: `NvAFX_Handle`

The handle to the audio effect.

Param_name [in]

Type: `NvAFX_ParameterSelector`

Refer to Setting the Parameters of an Audio Effect for the list of allowed options.

Any other selector string returns an error.

> **Note:** For the Linux SDK, the valid values for the `NVAFX_PARAM_NUM_SAMPLES_PER_INPUT_FRAME` setting can be queried by using the `NvAFX_GetU32List()` function with `NVAFX_PARAM_SUPPORTED_NUM_SAMPLES_PER_FRAME` as the selector.
>
> Setting any other value will result in an error.

val [in]

Type: `unsigned int`

Value to be set for the parameter.

Return Value

`NVAFX_STATUS_SUCCESS` on success.

Remarks

This function sets the value of the specified 32-bit unsigned integer parameter for the specified audio effect to the `val` parameter.

5.2.8. NvAFX_GetString

This function gets the current value of the `set` string parameter of the specified effect.

```
NvAFX_Status NvAFX_GetString(
  NvAFX_Handle effect,
  NvAFX_ParameterSelector param_name,
  char* val,
  int max_length
);
```

Parameters

effect [in]

Type: `NvAFX_Handle`

The handle to the audio effect instance.

Param_name [in]

Type: `NvAFX_ParameterSelector`

Refer to Setting the Parameters of an Audio Effect for a list of the allowed options.

val [out]

Type: `char*`

The address of the buffer where the requested character string will be stored. This buffer must be allocated and freed by the caller.

max_length [in]

Type: `int`

The length in bytes of the buffer that is specified by the `val` parameter.

Return Value

`NVAFX_STATUS_SUCCESS` on success.

Remarks

This function gets the value of the character string parameter for the specified audio effect and writes the retrieved string to the buffer at the location specified by the `val` parameter.

5.2.9. NvAFX_GetU32

This function gets the value of a uint parameter of the specified effect.

```
NvAFX_Status NvAFX_GetU32(
  NvAFX_Handle effect,
  NvAFX_ParameterSelector param_name,
  unsigned int* val
);
```

Parameters

effect [in]

Type: `NvAFX_Handle`

The handle to the audio effect instance.

param_name [in]

Type: `NvAFX_ParameterSelector`

Refer to Setting the Parameters of an Audio Effect for a list of the allowed options.

> **Note:** Effect parameters, except for supported frame size list (Linux only), can be queried only after the effect is loaded. Querying parameters before model load might return invalid values, or the function might fail with an error code.
>
> For the Linux SDK, although `NVAFX_PARAM_NUM_SAMPLES_PER_INPUT_FRAME` can be queried by using this API to get the default number of samples per frame, you should use `NvAFX_GetU32List()` with the `NVAFX_PARAM_SUPPORTED_NUM_SAMPLES_PER_FRAME` parameter to get the list of supported values.
>
> You can then use `NvAFX_SetU32()` with the `NVAFX_PARAM_NUM_SAMPLES_PER_FRAME` parameter to set the value.

val [out]

Type: `unsigned int*`

The address of the buffer where the retrieved 32-bit unsigned integer parameter value will be written.

Return Value

`NVAFX_STATUS_SUCCESS` on success.

Remarks

This function gets the value of the specified 32-bit unsigned integer parameter for the specified audio effect and writes the retrieved value to the buffer that is specified by the `val` parameter.

5.2.10. NvAFX_GetU32List (Linux SDK Only)

This function gets the uint list parameter values for the specified effect.

```
NvAFX_Status NvAFX_GetU32List(
  NvAFX_Handle effect,
  NvAFX_ParameterSelector param_name,
  unsigned int* list[],
  int* list_size
);
```

Parameters

effect [in]

Type: `NvAFX_Handle`

The handle to the audio effect instance.

param_name [in]

Type: `NvAFX_ParameterSelector`

The following selector:

`NVAFX_PARAM_SUPPORTED_NUM_SAMPLES_PER_FRAME`

Any other selector string returns an error.

Note: Values returned for `NVAFX_PARAM_SUPPORTED_NUM_SAMPLES_PER_FRAME` as the selector depends on the sample rate. You must ensure that `NvAFX_SetU32()` is called with `NVAFX_PARAM_SAMPLE_RATE` selector to set the sample rate before making this call.

list [out]

Type: `unsigned int* []`

The address to a list that contains the 32-bit unsigned values for the given selector.

Note: The application needs to call this API with `list_size` initialized to zero, and `list` set to `nullptr` to get the size of list to be allocated. The size will be returned in `list_size` parameter. The application can then allocate an U32 array of at least `list_size` and call the API again with list pointing to the array. Refer to Creating an Audio Effect for an example.

list_size [out]

Type: `int*`

Pointer to an integer that contains the number of values that were returned in the list.

Return Value

- `NVAFX_STATUS_SUCCESS` on success.
- `NVAFX_STATUS_OUTPUT_BUFFER_TOO_SMALL` when the `list_size` is less than the minimum required size of the list array.

Remarks

This function gets the list of 32-bit unsigned integer values for the specified audio effect, writes the retrieved values to a buffer specified by `list` and writes the size of the returned list in the buffer specified by `list_size`.

5.2.11. NvAFX_GetBoolList

This function gets the uint list parameter values for the specified effect.

```
NvAFX_Status NvAFX_GetBoolList(
  NvAFX_Handle effect,
  NvAFX_ParameterSelector param_name,
  NvAFX_Bool list*[]
  int* list_size
);
```

Parameters

effect [in]

Type: `NvAFX_Handle`

The handle to the audio effect instance.

param_name [in]

Type: `NvAFX_ParameterSelector`

The following selector:

`NVAFX_PARAM_VAD_RESULT`

Any other selector string returns an error.

list [out]

Type: `NvAFX_Bool* []`

The address to a list that contains the boolean values for the given selector.

> **Note:** The application needs to call this API with `list_size` initialized to zero, and `list` set to `nullptr` to get the size of list to be allocated. The size will be returned in `list_size` parameter. The application can then allocate an array of at least `list_size` and call the API again with `list` pointing to the array. Refer to Creating an Audio Effect for an example.

list_size [out]

Type: `int*`

Pointer to an integer that contains the number of values that were returned in the list.

Return Value

- `NVAFX_STATUS_SUCCESS` on success.

- NVAFX_STATUS_OUTPUT_BUFFER_TOO_SMALL when the list_size is less than the minimum required size of the list array.

Remarks

This function gets the list of boolean values for the specified audio effect, writes the retrieved values to a buffer specified by list, and writes the size of the returned list in the buffer specified by list_size.

5.2.12. NvAFX_GetSupportedDevices (Windows SDK Only)

The function gets a list of compatible devices that are supported by the currently set model file.

```
NvAFX_Status NvAFX_GetSupportedDevices(
  NvAFX_Handle effect,
  int *num,
  int *devices
);
```

Parameters

effect [in]

Type: NvAFX_Handle

The handle to the audio effect instance to load.

num [in, out]

Type: int*

The size of the input array. If the call succeeds, this value will be set by the function.

devices [in, out]

Type: int*

Array of size num. The function will fill the array with CUDA device indices of devices that are supported by the model in descending order of preference, where the first device is the most preferred device.

Return Value

NVAFX_STATUS_SUCCESS on success.

Remarks

This function gets the devices supported by the model.

5.2.13. NvAFX_Load

This function validates effect parameters and loads the specified effect.

```
NvAFX_Status NvAFX_Load(
  NvAFX_Handle effect
);
```

Parameters

effect [in]

Type: NvAFX_Handle

The handle to the audio effect instance to load.

Return Value

NVAFX_STATUS_SUCCESS on success.

Remarks

This function validates the parameters that are set for the effect and loads the specified audio effect.

5.2.14. NvAFX_Run

This function runs the specified effect.

```
NvAFX_Status NvAFX_Run(
  NvAFX_Handle effect,
  const float** input,
  float** output,
  unsigned num_samples,
  unsigned num_channels
);
```

Parameters

effect [in]

Type: NvAFX_Handle

The handle to the audio effect instance to run.

input [in]

Type: const float**

Pointer to a user-allocated array of buffers where each buffer holds the audio data for one channel. The size of the array must be equal to the number of input samples in the input frame (set via NVAFX_PARAM_NUM_SAMPLES_PER_INPUT_FRAME) and multiplied by the number of streams for which the effect is configured (set via NVAFX_PARAM_NUM_STREAMS, is always 1 for the Windows SDK).

The number of channels must be equal to the value of the NVAFX_PARAM_NUM_INPUT_CHANNELS parameter that was obtained by the NvAFX_GetU32() function. This value is 2 for the Acoustic Echo Cancellation effect and 1 for all other effects.

The sample rate of the audio data must be equal to the sample rate that was preset for the effect. For example, for the Audio Effect, the sample rate must be equal to the value of the NVAFX_PARAM_INPUT_SAMPLE_RATE parameter that was obtained by the NvAFX_GetU32() function.

output [out]

Type: float**

Pointer to a user-allocated array of buffers to which the output of the effect will be written.

The size of the array must be equal to the number of output samples in frame (set via NVAFX_PARAM_NUM_SAMPLES_PER_OUTPUT_FRAME) multiplied by the number of streams the effect is configured for (set via NVAFX_PARAM_NUM_STREAMS).

> **Note:** The buffers must be allocated, and later freed, by the calling program.
>
> Internally, NvAFX_Run copies the input/output to/from the GPU, so pinning input/output buffers does not have any effect.

num_samples [in]

Type: unsigned

The number of samples in the input buffer.

num_channels [in]

Type: unsigned

The number of input channels.

Return Value

NVAFX_STATUS_SUCCESS on success.

Remarks

This function runs the specified audio effect by reading the contents of the input buffer, applying the audio effect, and writing the output to the output buffer.

5.2.15. NvAFX_Reset

This function resets the internal state and flushes the internal history for specified batches in the effect.

Windows SDK

```
NNvAFX_Status NvAFX_Reset(
  NvAFX_Handle effect
);
```

Linux SDK

```
NvAFX_Status NvAFX_Reset(
  NvAFX_Handle effect,
  NvAFX_Bool* list,
  int length
);
```

Parameters

effect [in]

Type: `NvAFX_Handle`

The handle to the audio effect instance to run.

list [in] (Linux SDK Only)

Type: `NvAFX_Bool *`

Pointer to a memory location that indicates the streams to be reset. The `i`-th element in this array should be set to `NVAFX_TRUE` to reset the `i`-th stream and to `NVAFX_FALSE` otherwise.

length [in] (Linux SDK Only)

Type: `int`

Number of elements in the array specified. The value should be equal to the number of streams (batches).

Return Value

`NVAFX_STATUS_SUCCESS` on success.

Remarks

Allows the state of an effect to be reset.

5.2.16. NvAFX_SetBoolList (Linux SDK Only)

This function sets a list parameter of the specified effect.

```
NvAFX_Status NvAFX_SetBoolList(
  NvAFX_Handle effect,
  NvAFX_ParameterSelector param_name,
  const NvAFX_Bool* list,
  unsigned int list_size
);
```

Parameters

effect [in]

Type: `NvAFX_Handle`

The handle to the audio effect.

Param_name [in]

Type: `NvAFX_ParameterSelector`

The following:

`NVAFX_PARAM_ACTIVE_STREAMS`

Any other selector string returns an error.

list [in]

Type: `NvAFX_Bool*`

Array of Boolean values to be set for the parameter.

list_size [in]

Type: `unsigned int`

Size of the Boolean array that was passed as the input.

Return Value

`NVAFX_STATUS_SUCCESS` on success.

Remarks

This function sets the boolean values of the list parameter for the specified audio effect to the values from `list`.

5.2.17. NvAFX_SetU32List (Linux SDK only)

This function sets a list parameter of the specified effect.

```
NvAFX_Status NvAFX_SetU32List(
  NvAFX_Handle effect,
  NvAFX_ParameterSelector param_name,
  const unsigned int* list,
  unsigned int list_size
);
```

Parameters

effect [in]

Type: `NvAFX_Handle`

The handle to the audio effect.

Param_name [in]

Type: `NvAFX_ParameterSelector`

The following:

`NVAFX_PARAM_CHAINED_EFFECT_GPU_LIST`

Any other selector string returns an error.

list [in]

Type: `unsigned int*`

Array of U32 values to be set for the parameter.

list_size [in]

Type: `unsigned int`

Size of the array that was passed as the input.

Return Value

`NVAFX_STATUS_SUCCESS` on success.

Remarks

This function sets the U32 values of the list parameter for the specified audio effect to the values from `list`.

5.2.18. NvAFX_InitializeLogger (Linux SDK Only)

This function initializes the SDK logger.

```
NvAFX_Status NvAFX_InitializeLogger(
  LoggingSeverity level,
  int target,
  const char *filename,
  logging_cb_t cb,
  void* userdata
);
```

Parameters

level [in]

Type: `LoggingSeverity`

The logging level to enable. When you enable a level, it includes the levels before the current level. For example, `LOG_LEVEL_INFO` also includes `LOG_LEVEL_WARNING` and `LOG_LEVEL_ERROR`.

The following levels can be used:

- `LOG_LEVEL_ERROR`
- `LOG_LEVEL_WARNING`
- `LOG_LEVEL_INFO`

Target [in]

Type: `int`

Logging targets to write logs to `LoggingTarget` can be binary OR'd to enable multiple targets.

The following targets can be used:

- `LOG_TARGET_NONE = 0x0`
- `LOG_TARGET_STDERR = 0x1`
- `LOG_LEVEL_FILE = 0x2`
- `LOG_LEVEL_CALLBACK = 0x4`

filename [in]

Type: `const char*`

The path of the file to write logs. This parameter is used only when `LOG_TARGET_FILE` is enabled.

Note: The directory in which the log file resides should exist. For example, if the filename is `/foo/bar/log.txt`, the `/foo/bar` directory must already exist. If the `log.txt` file exists, it will be overwritten.

cb [in]

Type:`const char *`

Callback to use if `LOG_TARGET_CALLBACK` is enabled. A null value can be passed when not using a callback target.

userdata [in]

Type: `void *`

Data passed back with log callback and is used only when `LOG_TARGET_CALLBACK` is enabled.

A null value can also be passed.

Return Value

`NVAFX_STATUS_SUCCESS` on success.

Remarks

This API enables logging in the SDK. Depending on the flags that were passed, logs are redirected to `stderr`, a file, or a callback. Logging can be disabled by using the `NvAFX_UninitializeLogger` API.

5.2.19. NvAFX_UninitializeLogger (Linux SDK Only)

This function uninitializes the SDK logger.

```
NvAFX_Status NvAFX_UninitializeLogger(void);
```

Parameters

`NvAFX_UninitializeLogger` requires no parameters.

Return Value

`NVAFX_STATUS_SUCCESS` on success.

Remarks

This API disables all logging targets. Logging can be started again by using the `NvAFX_InitializeLogger` API.

5.3. Return Codes

The `NvAFX_Status` enumeration defines the following values that the Audio Effects functions might return to indicate an error or success:

NVAFX_STATUS_SUCCESS
Successful execution.

NVAFX_STATUS_FAILED
Generic error code, which indicates that the function failed to execute for an unspecified reason.

NVAFX_STATUS_INVALID_HANDLE
An invalid effect handle has been supplied.

NVAFX_STATUS_INVALID_PARAM
An invalid parameter value has been supplied for this combination of effect and selector string.

NVAFX_STATUS_IMMUTABLE_PARAM
User tried to modify an immutable parameter.

NVAFX_STATUS_INSUFFICIENT_DATA
There is insufficient data to process.

NVAFX_STATUS_EFFECT_NOT_AVAILABLE
The specified effect is not supported.

NVAFX_STATUS_OUTPUT_BUFFER_TOO_SMALL
The output buffer length is too small to hold the requested data.

NVAFX_STATUS_MODEL_LOAD_FAILED
The specified model file cannot be loaded.

NVAFX_STATUS_MODEL_NOT_LOADED
Model is not loaded, and it has to be loaded for this operation.

NVAFX_STATUS_INCOMPATIBLE_MODEL
Selected model is incompatible.

NVAFX_STATUS_GPU_UNSUPPORTED
The GPU is unsupported. Audio effects SDK requires Turing or later GPU with Tensor cores.

NVAFX_STATUS_NO_SUPPORTED_GPU_FOUND
No supported GPU found on the system.

NVAFX_STATUS_WRONG_GPU
Current GPU is not the one selected.

NVAFX_STATUS_CUDA_ERROR

CUDA operation failure.

NVAFX_STATUS_INVALID_OPERATION

Invalid operation performed.

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