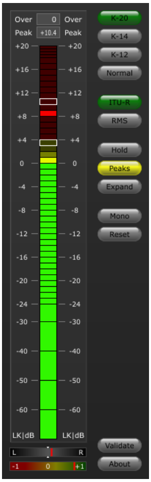
K-Meter

Free implementation of a K-System meter
according to Bob Katz' specifications



Last edited on 13th August 2012

Contents

1 The loudness race

When comparing two similar pieces of music, the louder one is perceived as sounding better (although this is only true for very short periods of time). Accordingly, the loudness of music productions has continuously grown during the last decades.

As maximum levels of records, tapes and digital media have a natural limit, however, mastering engineers have started using sophisticated dynamic compression techniques to achieve higher loudness without distorting the music (as of 2010, distortion is increasingly being used in order to achieve even higher loudness).

Unfortunately, this decrease in dynamic range does not leave the music unharmed. Current compressed music blasts away your ears and makes you turn down the volume of your amplifier. Having lowered the volume, you'll find that the "better-sounding" compressed music suddenly sounds pretty dull and boring compared to uncompressed music. In contrast, music with high dynamic range makes you turn up the volume – heck, it even sounds better when being broadcast on the radio!

2 The K-System

The K-System has been devised by mastering engineer Bob Katz in order to counteract the ongoing loudness race and to help adjusting the levels of different songs during mastering. K-System meters are level meters that do **not** place the 0 dB mark on top of the meter. Instead, 0 dB on K-System meters relates to a reference loudness. There are three K-System scales:

- K-20 (0 dB at −20 dB FS, recommended)
- K-14 (0 dB at −14 dB FS)
- K-12 (0 dB at −12 dB FS)

Using the K-System is easy. Just calibrate your monitor system so that pink noise (−20 dB FS RMS, 20 Hz to 20 kHz; chapter 6 will tell you where to find a suitable audio file) on one channel yields 83 dB SPL on a loudness meter placed at your listening position and set to *C-weighted, slow*. Then mark the monitor's gain position as "K-20".

When your mixes or masters seem to have just the right loudness, they should now yield 0 dB on a K-20 meter.

In case you want to use the K-14 meter, attenuate the monitor gain by 6 dB or repeat the above process so that pink noise yields 77 dB SPL. For K-12, attenuate the monitor gain by another 2 dB (pink noise should yield 75 dB SPL).

For more information about the K-System, please see Bob's website or his great book "Mastering Audio – The Art and the Science".

3 Installation

In order to use the pre-compiled binaries, simply extract the K-Meter files from the downloaded archive. For the VST plug-in, you'll then have to move the extracted files to your plug-in folder (`~/.vst`, `C:\ProgramFiles\Steinberg\VstPlugins\` or the like).

Loading K-Meter may take a few seconds: it checks your computer's capabilities on start-up so that FFT calculations will run at maximum speed. Depending on your computer, this little wait in the beginning may well result in lower resource usage later.

3.1 Windows

If you move the pre-compiled binaries to another directory, please make sure to also move the file `libfftw3f-3.dll` to this directory. Otherwise, you will not be able to use K-Meter.

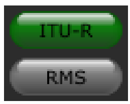
4 Controls

4.1 Meter selection

You can select the different K-System meter scales (**K-20**, **K-14** and **K-12**) by clicking on these radio buttons.

In the rare case you want to use the meter in a mixer's channel strip, click the **Normal** button which will place 0 dB FS on top. Please note, however, that the **Normal** state will be neither saved, nor recalled in your DAW and the standalone version. This is by design – the K-System meter has been explicitly designed to **not** have 0 dB FS on top!

4.2 Averaging method



The average level meters can either read unweighted levels (**RMS**) or loudness-weighted levels according to ITU-R BS.1770-1 (**ITU-R**).

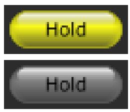
Click on the corresponding radio button to make your selection.

According to Bob Katz, the unweighted **RMS** method has been designed for stereophonic metering and calibration, while the loudness-weighted **ITU-R** method should be used for channel-summed loudness metering. To reference a meter, state both K-System meter scale and averaging method, separated by a slash, such as “K-20/ITU”.

Note: K-Meter fully implements Annex 1 of the now superseded ITU-R BS.1770-1 standard (’K’ frequency weighting, mean square calculation and channel-weighted summation), whereas the gated loudness measurement specified in ITU-R BS.1770-2 is not yet supported.

4.3 Infinite peak hold

Click on this button to toggle between infinite peak hold and “falling peaks”. This setting applies to both average and peak meters.



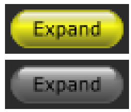
4.4 Show peak level meter

Click on this button to toggle display of the peak level meters. The original K-System meter specification demands peak level meters, but Bob Katz has asked me to hide them by default:

> *"Too many people will try to normalize the peak to full scale if they see a peak meter, and that's what we want to avoid. You can still make a K-System meter like the original, but if we meet again in 15 years I hope that peak metering will be outlawed."*

4.5 Magnify meters

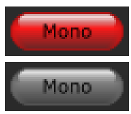
This button magnifies both average and peak level meters to 0.1 dB steps. If switched on, the 0 dB mark is placed near the centre.



<u>Hint:</u> by selecting different meter scales, you can easily magnify the whole range between −25 dB FS and 0 dB FS.

4.6 Mono mode

Click this button to easily check the mono compatibility of your stereo mix or master. In **mono** mode, audio channels will be down-mixed to mono and the meters will be linked.

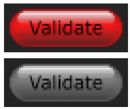


In case you insert the plug-in into a mono channel strip, **mono** mode will be selected and cannot be toggled.

4.7 Reset button

Click on this button to reset all meters, peaks and counters. You can also get rid of graphical artifacts, because all meters will be redrawn as well.

4.8 Validation button



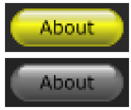
Click on this button to open the **validation window** (see chapter 6) which allows you to play an audio file (WAV, AIFF or FLAC) through K-Meter and dump internal data. During validation, the button will light up and clicking it will stop the validation.

On Linux, dumped data will be written to `stderr`, so just start the K-Meter standalone or your VST host from the shell and watch the output coming. On other systems, have a look at your VST host's log files (I have successfully used Ableton Live for this). If that doesn't work, you might have to start either the K-Meter standalone or your VST host from a debugger.

As a side note, **SMA(50)** designates the simple moving average of 50 values, a neat way to emphasise trends and eliminate short-term fluctuations.

4.9 About button

Clicking on this button will open the **about window** where you will be informed about version number, contributors, copyright and the GNU General Public License.



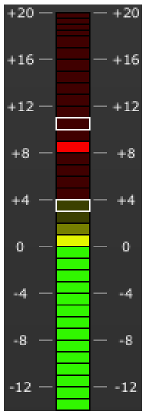
4.10 Display license

This button is located in the **about window** and does not only advertise that you are using free software licensed under the **GNU General Public License** – when clicked, it will also open the license's website in your web browser . . .

5 Meters

For 5.1 surround sound, K-Meter assumes a channel order of *L, R, C, LFE, Ls* and *Rs*. Please double-check whether this matches your host's channel order.

5.1 K-System meter



The K-System meter consists of an average level meter (graphic on the right, contiguous lit segments) and an optional peak level meter (single lit segment on top). The recommended K-20 meter has 20 dB of headroom above 0 dB, while the K-14 and K-12 meters have 14 dB and 12 dB of headroom, respectively.

Each level meter is divided into segments of 1 dB, with the exception of the top 2 dB (segments of 0.5 dB) and the bottom end (segments of 10 dB). Magnified level meters are divided into segments of 0.1 dB.

<u>*Note:*</u> *In ITU-R mode, the average level meter is graded in* LK *which stands for* Loudness, K weighted *and is by all means equivalent to dB.*

Recent maximum levels are displayed by white rectangles around the corresponding meter segments. Unless "Infinite peak hold" is switched on, maximum levels are held for 10 s and then start falling with a fall time of 8.67 dB/s.

Both stand-alone application and the plug-in only work at sampling rates between 44.1 kHz and 192 kHz and introduce a latency of 1024 samples. This latency is reported to your plug-in host so it may compensate for the introduced delay. Needless to say, the original unfiltered signal is passed to the outputs.

You can reset all meters by clicking on the "Reset" button.

5.2 Average level meter

The average level meter uses an averaging period of 1024 samples. In **RMS** mode, this meter exhibits a flat frequency response between 20 Hz and 20 kHz ($\pm$0.01 dB), whereas **ITU-R** mode implements 'K' frequency weighting and also sums all channels as specified in ITU-R BS.1770-1.

In any case, the average level meter is band-limited using a windowed-sinc low-pass filter with a cutoff frequency of 21.0 kHz. On level changes, it takes 600 ms for the meter to reach 99 % of the final reading.

Note: Unfortunately, the specifications of ITU-R BS.1770-1 clash with those for K-System meters. I have discussed this in depth with Bob Katz and we decided that it makes more sense to adhere to ITU-R BS.1770-1 in these cases.

Thus, in ITU-R mode sine waves do not *read the same on average and peak level meters and pink noise (−20 dB FS RMS, 20 Hz to 20 kHz) does* not *read 0 dB on the K-20 average level meter. So for calibration, please switch K-Meter to RMS mode.*

5.3 Peak level meter

The peak level meter displays the unfiltered peak level and thus possesses a completely flat frequency response. It has a rise time of one sample and a fall time of 8.67 dB/s.

5.4 Overload counter

The overload counter displays the number of samples that have reached or exceeded digital full scale (to be exact, the counter registers levels above −0.001 dB FS to address the granularity of 16-bit floating-point numbers). This is a very conservative approach to estimate overloads – but I'd rather have an excess warning than have my audio files clip.

Please note that this counter does not register inter-sample peaks.

5.5 Maximum peak display

This meter displays the maximum peak level encountered so far in dB. In case the level exceeds 0.0 dB FS (this can occur in hosts that do not clip levels to 0.0 dB FS), the meter will turn red.

Please note that this display does not register inter-sample peaks.

5.6 Phase correlation meter

This meter only works for stereo channels and displays the cross correlation between left and right channel. Cross correlation is a measure of how much two signals are correlated. Thus, a value of $+1$ means that both channels are *in phase*, whereas a value of -1 signals that the channels are completely *out of phase*. Please note that the meter's scale is not linear!

For the non-tech savvy musician: if you find that this meter hits the red area, you should check the mono-compatibility of your mix. But although phase correlation meters often prove helpful, you cannot always rely on their readout.

The only way to make sure that your mixes are mono-compatible is to actually listen to them in mono.

That's a universal truth, by the way. Do not mix by your eyes, mix by your ears!

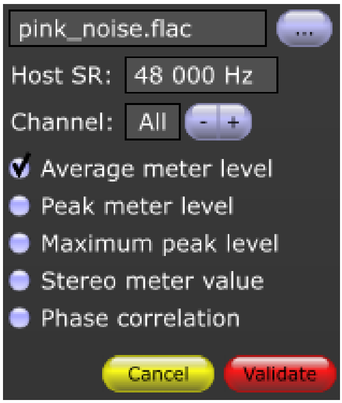
5.7 Stereo meter

The stereo meter obviously only works for stereo channels and displays the average stereo position of your mix. It may indicate a bias to one stereo channel that you might have overheard due to impaired hearing, wrong placement of your monitors or similar problems.

But please don't get the false notion that the needle should stay in the middle all time in order to achieve a good mix. Quite the contrary! As I said, you should not mix by your eyes …

6 Validation

I have gone to great lengths to ensure that all meters read correctly. You want to validate for yourself? Just download and extract the source code. The directory `validation` contains instructions and FLAC-compressed wave files. To validate **ITU-R** mode, please download ITU-R BS.2217 and follow the instructions (at the time being, the gate tests should be ignored). A word of warning: these audio files may **damage your ears** and speakers, so please watch your monitor levels!



After opening the **validation window** (see section 4.8), click on the ellipsis button (the one with the dots) to select an audio file for playback through K-Meter. Please make sure that the sample rates of your host (**Host SR**) and the audio file match, otherwise the results will not be correct.

Now, select which **variables** (if any) should be dumped. You may also restrict the dumped data to a specific audio **channel**.

Finally, click on the **validate** button to reset all meters and start playback of the selected audio file. All audio input will be discarded during playback and for an additional ten seconds. To stop playback early, simply click on the **validate** button again.

In case you want to calibrate your monitor system, head over to Bob Katz's download section, get the file labelled **−20 dB FS RMS pink noise stereo 44.1**, set K-meter to **RMS** mode and click on the **validate** button. Please ensure that all intermediate software and hardware mixers are set to the correct levels.

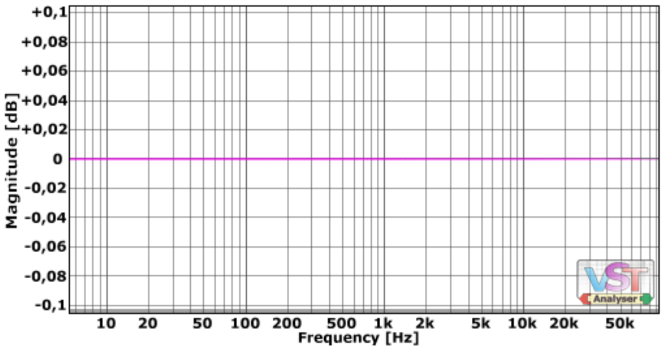
6.1 Validation status

average level meter (RMS)	readings	passed
	frequency response	passed
	meter ballistics	passed
	5.1 surround sound	—
average level meter (ITU-R)	ITU-R BS.2217	passed
peak level meter	readings	passed
	meter ballistics	passed
overload counter	readings	passed
maximum peak display	readings	passed
phase correlation meter	readings	passed
stereo meter	readings	passed

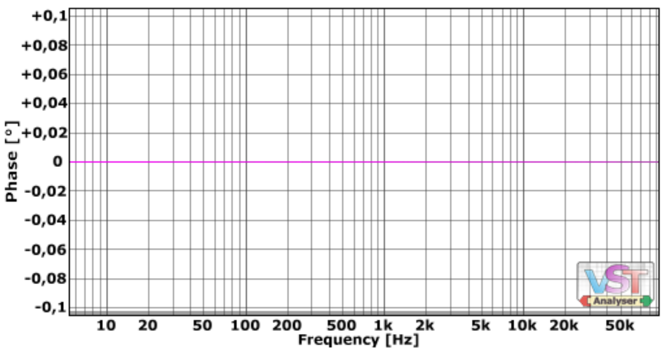
6.2 Frequency and phase response

Frequency and phase response have been determined at a sample rate of 192 kHz using VST Plugin Analyser.

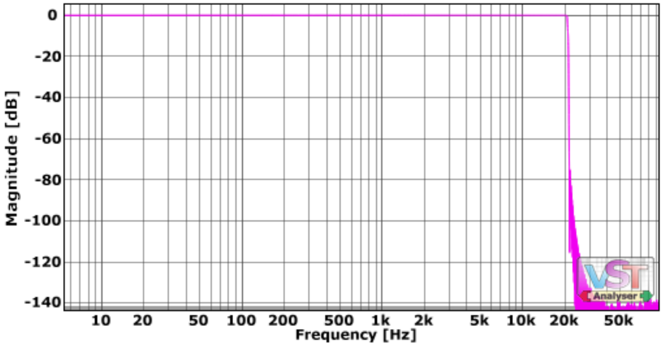
Frequency response of complete effect path (5 Hz to 96 kHz, 0 dB ±0.1 dB):



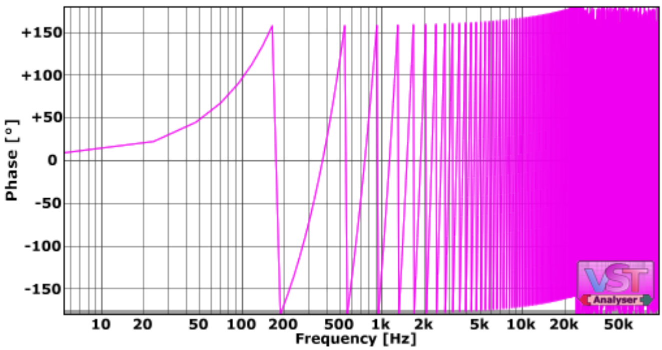
Phase response of complete effect path (5 Hz to 96 kHz, 0° ±0.1°):



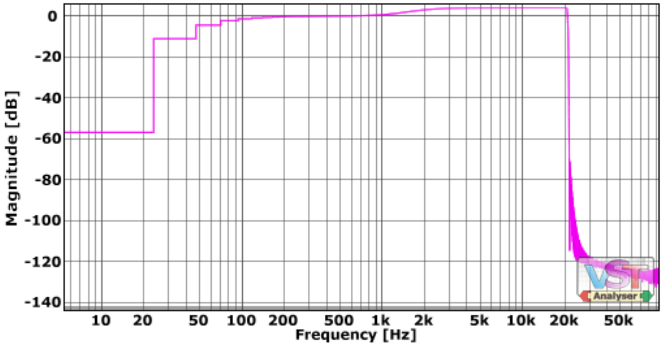
Frequency response of band-limited RMS detection stage (5 Hz to 96 kHz, -140 dB to 5 dB):



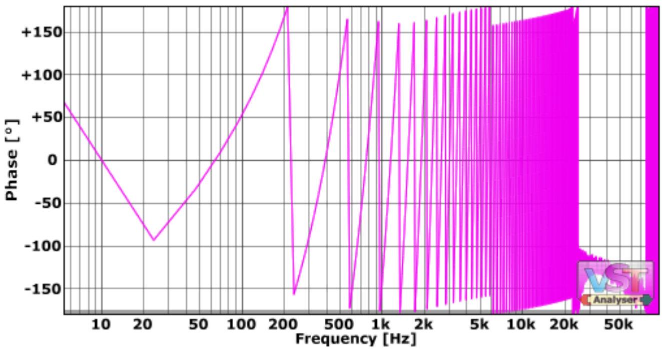
Phase response of band-limited RMS detection stage (5 Hz to 96 kHz, $-180°$ to $+180°$):



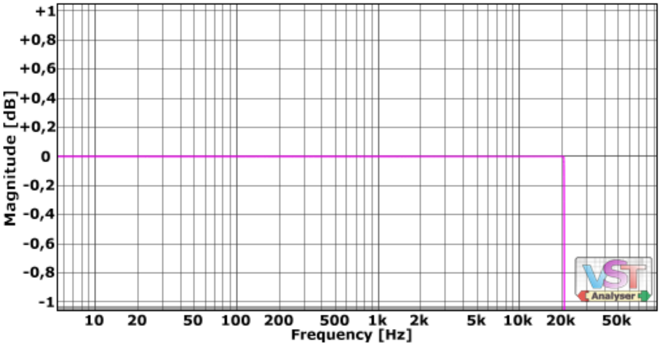
Frequency response of band-limited ITU-R BS.1770-1 detection stage (5 Hz to 96 kHz, −140 dB to 5 dB):



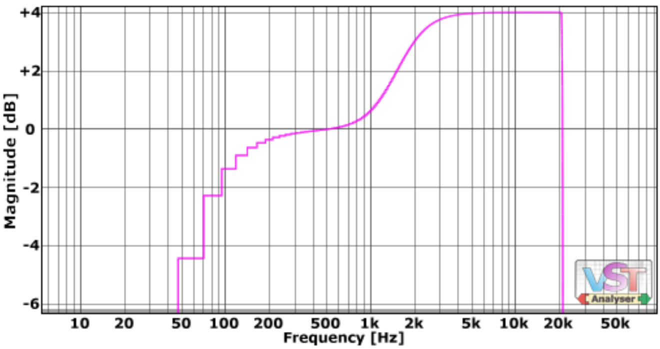
Phase response of band-limited ITU-R BS.1770-1 detection stage (5 Hz to 96 kHz, −180° to +180°):



Frequency response of band-limited RMS detection stage (5 Hz to 96 kHz, 0 dB ±1 dB):



Frequency response of band-limited ITU-R BS.1770-1 detection stage (5 Hz to 96 kHz, 0 dB -6 dB to 4 dB):



7 Help needed

As K-Meter was coded using cross-platform code, it should be easy to compile versions for Windows (64 bit) and Mac OS X. I just don't have the adequate systems and compilers.

In case you want to help, please see the next chapter for an email address. You'll need sufficient experience in coding, compiling and debugging, though, so no beginners please!

8 Final words

I want to express my gratitude to **Bob Katz** for kindly answering all of my questions regarding the K-System meter and checking this document for technical errors. I'd further like to thank **bram@smartelectronix** for his code to calculate logarithmic rise and fall times, and **Raiden** for working out the ITU-R BS.1770-1 filter specifications. I must also thank the **users of K-Meter** for sending kind words, suggestions and bug reports. Finally, I want to thank the **open source community** for making all of this possible.

Although coding K-Meter has been a lot of fun, it has also been a lot of work. So if you like K-Meter, why not send me a short email and tell me so? Write a few words about yourself, send suggestions for future updates or volunteer to create a nice theme – do whatever you like!

Here is my email address (please remove "`-nospam`"):

```
"Martin Zuther" <code-nospam@mzuther.de>
```

Thanks for using free software. I hope you'll enjoy it!

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A How to build K-Meter

A.1 Preparing GNU/Linux

To build K-Meter yourself, I recommend setting up a `chroot` environment. This is fast and easy to do on Debian-based systems and might save you a **lot** of trouble. At the time of writing, I'm using Debian 6.0 (Squeeze), but the procedure should be similar on your distribution of choice. If you aim at generic 64-bit compilation, simply change `i386` to `amd64`.

To install the necessary packages and install the `chroot` base system, execute the following statements (please change http://ftp.de.debian.org/debian/ to a mirror close to you):

```
sudo apt-get install debootstrap schroot

sudo mkdir -p /srv/chroot/squeeze_i386
sudo debootstrap --variant=buildd \
  --arch i386 squeeze \
  /srv/chroot/squeeze_i386 \
  http://ftp.de.debian.org/debian/
```

Running `debootstrap` will take some time. Meanwhile, add the following lines to `/etc/schroot/schroot.conf` (make sure you remove all preceding white space so that each line begins in the first column):

```
[squeeze-i386]
description=Debian 6 (Squeeze, i386)
directory=/srv/chroot/squeeze_i386
personality=linux
root-users=username
type=directory
users=username,another_user
```

Please make the necessary changes to `username`. You may also add additional users, like `another_user`. In case you are setting up a 32-bit `chroot` environment on a 64-bit system, you'll also have to change `linux` to `linux32`.

When `debootstrap` is done, log in as superuser:

```
schroot -c squeeze-i386 -u root
```

to install a few packages. The packages `less` and `vim` are optional, but might come in handy:

```
apt-get update
apt-get install bash-completion libasound2-dev \
  libjack-jackd2-dev mesa-common-dev xorg-dev
apt-get install less vim
apt-get clean
```

If you like `bash` completion, you might also want to open the file `/etc/bash.bashrc` and unquote these lines:

```
# enable bash completion in interactive shells
[two more lines...]
fi
```

Finally, log out and log in as normal user:

```
schroot -c squeeze-i386
```

Congratulations – after you have installed the dependencies (see below), you are ready to build K-Meter!

A.2 Dependencies

A.2.1 premake4

Importance:	required
Version:	4.3
License:	BSD
Homepage:	industriousone.com/premake

Installation

Place the binary somewhere in your `PATH`. Depending on your platform, you should run *premake* using the scripts `build/run_premake.sh` or `build/run_premake.bat`.

A.2.2 Fastest Fourier Transform in the West

Importance:	required
Version:	3.2.2
License:	GPL v2
Homepage:	www.fftw.org

Installation on GNU/Linux

Extract the archive into the directory `libraries/fftw3`, change into this directory and run:

```
./configure --enable-float --with-pic
make
mkdir -p bin/i386/
mv .libs/* bin/i386/
```

Installation on Microsoft Windows

Extract the source code archive into the directory `libraries/fftw3` and the archive containing the pre-compiled binaries into the directory `libraries/fftw3/bin`.

Please note that in order to run K-Meter on Windows, the library `libfftw3f-3.dll` **must** be located in the same directory as the standalone or plug-in. To make things a little easier for you, I have already placed `libfftw3f-3.dll` in the directories `bin` and `bin/final`.

A.2.3 JUCE library

Importance: required
Version: 1.53
License: GPL v2
Homepage: www.rawmaterialsoftware.com/juce.php

Installation

Extract the archive into the directory `libraries/juce`.

A.2.4 Virtual Studio Technology SDK

Importance: optional
Version: 2.4
License: proprietary
Homepage: ygrabit.steinberg.de

Installation

Just extract the archive into the directory `libraries/vstsdk2.4`.

A.2.5 Audio Streaming Input Output SDK

Importance:	optional
Version:	2.2
License:	proprietary
Homepage:	ygrabit.steinberg.de

Installation

Simply extract the archive into the directory `libraries/asiosdk2.2`.

A.2.6 Artistic Style

Importance:	optional
Version:	1.24
License:	LGPL v3
Homepage:	astyle.sourceforge.net

This application formats the code so it looks more beautiful and consistent. Thus, you only have to install it if you plan to help me with coding K-Meter.

Installation

Place the binary somewhere in your `PATH`. Depending on your platform, you should run *astyle* using the scripts `src/format_code.sh` or `src/format_code.bat`.

A.3 Building on GNU/Linux

After preparing the dependencies, start your `chroot` environment, change into the directory `build` and execute

```
./run_premake.sh
make config=CFG TARGET
```

where `CFG` is one of `debug32`, `debug64`, `release32` and `release64`, and `TARGET` is one of `linux_standalone_stereo`, `linux_standalone_surround`, `linux_vst_stereo` and `linux_vst_surround`.

The compiled binaries will end up in the directory `bin`.

A.4 Building on Microsoft Windows

After preparing the dependencies, change into the directory `build` and execute

```
./run_premake.bat
```

Then change into the directory `build/windows/vs20xx`, open the project file with the corresponding version of Visual C++ and build the project.

The compiled binaries will end up in the directory `bin`.

B GNU General Public License

Version 3, 29 June 2007

Preamble

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```
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