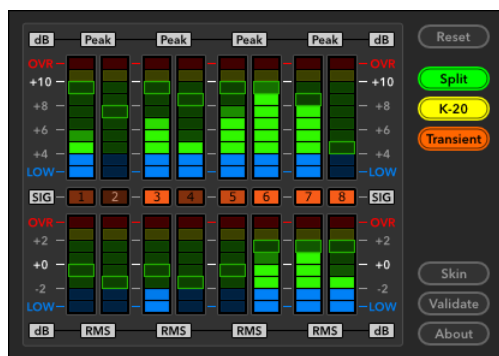


traKmeter

Loudness meter for correctly setting up
tracking and mixing levels



Last edited on 2nd February 2018



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1 Digital recordings

The digital revolution brought a lot of advantages to the field of audio processing such as higher fidelity, less noise and non-degrading copies. Unfortunately, however, digital audio also introduced some problems of its own.

Whereas the analog domain is relatively inert against very high levels (overdriving some analog equipment actually sounds pretty good), the digital domain punishes even small transgressions into forbidden territory with harsh clipping.

And while digital audio can be transferred without loss in quality, it is degraded by each and every calculation, be it a simple change in level, equalisation or a fancy effect. Crossing domains from analog to digital and *vice versa* leads to additional degradation. Finally, changes in bit depth and sample rate, jitter and inter-sample peaks are nothing for the weak of heart.

However, most of these obstacles can be overcome easily by proper gain staging, minimising the crossing of domains and choosing appropriate bit depths and sample rates. If you also learn how to properly test and operate your equipment, you're well on your way to pure audio bliss ...

1.1 Gain staging

Professional analog audio equipment is designed to be run at a nominal level of **4 dBu** ($1.23 V_{\text{RMS}}$) and leaves a headroom for peaks of about 20 dB. This in turn is consistent with the maximum crest factor of analog audio signals.

Thus, driving all analog audio equipment at 4 dBu ensures an optimal signal-to-noise ratio while preventing clipping and keeping all transients intact. The process of setting audio devices to run at optimal input and output levels is called *gain staging*.

Now let's transfer this to the digital domain. As the maximum crest factor of analog audio signals amounts to 20 dB, we'll adjust the headroom accordingly by setting our average input and output levels to **-20 dB FS RMS**.

Again, this ensures a good signal-to-noise ratio while preventing clipping. Maybe even more important, this level also drives (most of) your digital audio equipment and plug-ins at their respective "sweet spot".

Another recommendation (which many radio stations have been following for reasons outside the scope of this document) is that peak levels should not exceed **-9 dB FS**. For recording, this will leave enough space for sudden jumps in level and also for inter-sample peaks – audio peaks that lie *in between* two successive samples and may lead to unpredictable clipping during digital-to-analog conversion.

Some analog-to-digital converters also degrade audio when fed with input levels close to digital full-scale (0 dB FS), resulting in the “harshness” often attributed to digital audio – my first sound card definitely suffered from this. So lowering your input levels as described above may also improve your overall sound.

Finally, we’ll emphasise the newly designated headroom and shift the meter scales by 20 dB. Thus, the optimal average audio level is designated **0 dB RMS**, while the maximum peak audio level becomes **11 dB**. As a nice side effect, our new scale corresponds to Bob Katz’s **K-20 scale**.

1.2 Digital audio myths

I can almost hear you: you have heard that digital recordings should be performed at peak levels close to but not exceeding 0 dB FS (digital full-scale). Heck, this misinformation has ended up in the manuals of some professional audio equipment. But for the reasons given above it is plain wrong.

Let’s look at a worst-case scenario: even if your recordings *peak* at –20 dB FS and you discard the least significant bit (some people claim that it mostly consists of errors), a bit depth of 16 bit would still leave you with a signal-to-noise ratio of 70 dB. That is about what you can expect from some of the best professional analog tape machines and recording desks – and we’re not even talking of 24 bit.

If you don't believe me yet, take a look at my professional 16-bit hard disk recorder (Otari PD-80): its analog inputs and outputs are aligned to “4 dBu (–15 dB from digital full-scale)”. The manufacturer has even marked this level on the meter bridge (small triangle on the photo). Although I admit that the mark is only useful for audio alignment, given that it sits on a peak meter ...



There is also a great thread over at Gearslutz (“The Reason Most ITB mixes don’t Sound as good as Analog mixes”) well worth reading. Here are links to the [first post](#) and two other selected posts ([#1874](#) and [#3614](#)).

1.3 Introducing traKmeter

Most digital audio equipment sadly only has peak meters. This is readily understandable as you want to avoid digital clippings by all means. However, the lack of average meters makes correct gain staging almost impossible.

For gain staging, you need average meters or – even better – a combination of peak and average meters. And this is where traKmeter comes in.

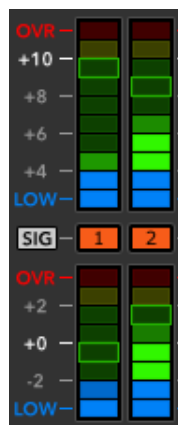
2 traKmeter

traKmeter consists of two meters, a peak meter on top and an average meter below. The meters are separated by an orange signal LED and consist of an area of green LEDs that is enclosed by either blue ones (lower levels) or yellow and then red ones (higher levels).

You may have noticed that the average meter's green area is centred around the **0 dB RMS** mark. This number should be vaguely familiar. Remember, it corresponds to -20 dB FS RMS, the level we have determined to be the optimal average audio level in the digital domain.

A fully lit yellow LED on the peak meter's top end corresponds to a level of **11 dB** (or -9 dB FS). Again, this number should be familiar: during digital recording, peak levels shouldn't exceed this level.

Thus, by keeping the meter's readout in the green areas and from entering the yellow and especially the red areas on top of each meter, you will automatically track at optimal audio levels. It's as simple as that!

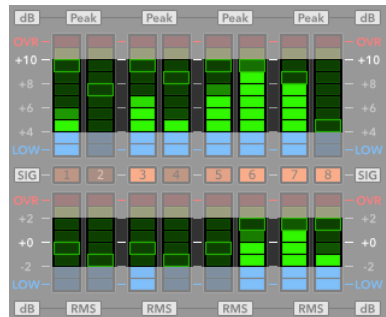


2.1 Tracking with traKmeter

Open up an instance of traKmeter and set it up so that it measures your audio input. That can be done either by starting the stand-alone version and connecting it to one or more input channels of your sound card, or by inserting a plug-in instance into an input channel of your digital audio workstation.

In the second case, take care that your digital audio workstation doesn't add additional headroom and that no processing takes place before traKmeter. This can be ascertained by feeding calibration tones into your sound card or by directly comparing the readouts of stand-alone and plug-in version.

Now, feed the signal you want to record into an audio input channel and adjust its level (in the analog domain!) using traKmeter. Try to set the input level so that transients fall into the average meter's **0 dB RMS** area. Make sure that peak levels never exceed **11 dB**. In case both conditions cannot be met simultaneously, adjust the peak level only. See the image to the right for a visual clue.



2.2 Mixing with traKmeter

When you get someone else's tracks for mixing, chances are that they have been recorded far too hot. While you can't change that, you might want to adjust them to optimal loudness so that your upcoming mix is not ruined.

*If the original recordings were made with poor equipment and you have got the time, it may well be worth to **re-record** all tracks through a really good preamp and adjust their loudness at the same time. Depending on the preamp, the results can be stunning!*

In any case, mixing levels will now be much lower than what you are used to. This can easily be corrected by either adjusting the output gain of your subgroups or by inserting a gain plug-in in your master track.

To preserve all transients, the final loudness of your mix should stay within **-20 dB FS RMS** and **-16 dB FS RMS** (or between **0 dB RMS** and **4 dB RMS** on the K-20 scale). Remember that smashed transients will be gone forever, whereas you can always bring up the volume during mastering! My plug-in **K-Meter** and its K-20 scale may help you with setting up correct mixing levels.

3 Installation

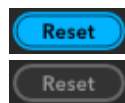
In order to use the pre-compiled binaries, simply extract the traKmeter files from the downloaded archive. For the plug-ins, you'll then have to move the extracted files to your respective plug-in folder (`~/.lv2`, `~/.vst`, `C:\Program Files\Steinberg\VstPlugins\` or the like).

Should the stand-alone version ever fail to start, you can reset its settings by deleting `trakmeter_stereo.ini` or `trakmeter_surround.ini`. These files are located in `~/.config` (GNU/Linux) or `%appdata%\config\` (Windows).

4 Controls

4.1 Reset button

Click on this button to reset all meters. You can also use it to get rid of graphical artefacts, because the current skin will be reloaded and the meters redrawn.



4.2 Crest factor button

When this button is pressed, meter readout uses the K-20 scale (crest factor of 20 dB). Disengage the button to change to decibels relative to digital full-scale (crest factor of 0 dB).



Please note that although this meter uses the K-20 scale, it is by no means a K-System meter.

4.3 Transient button

This button changes the RMS meter's ballistics from “transient” mode to “classic” mode.



I find that “transient” mode with its fast attack and slow release times is well suited to setting up levels. It works fine for both transient audio sources (drums, percussion, piano) and more “static” ones (pads, bass and so on).

If you are used to VU meters, however, “classic” mode with its equally slow attack and release times may feel more comfortable to you.

Note: I don't use “classic” mode myself, so you may find that the RMS meter scale needs adjusting. Please don't hesitate to notify me, it's really easy to change this.

4.4 Select a skin

Click on this button to select the currently used traKmeter skin. You can also set a default skin that will be loaded when new plug-ins are instantiated.



4.5 Validation button

Click on this button to open the **validation window** (see [chapter 7](#)) which allows you to play an audio file through traKmeter and dump internal data. During validation, the button will light up and clicking it will stop validation early.



On Linux, dumped data will be written to `stderr`, so just start the traKmeter stand-alone or your VST host from the shell and watch the output coming. On Windows, you can also use DebugView by Sysinternals (stand-alone) or have a look at Ableton Live's log files (VST plug-in). If none of that works, you might have to start either the stand-alone 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.

4.6 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.



4.7 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

All meters possess a completely flat frequency response. Meter scales can be adjusted using the “Crest factor” button (see [section 4.2](#)).

5.1 Average level meter

The average level meter uses an averaging period of 1024 samples. It has been calibrated according to [AES17-1998](#) so that sine wave signals read the same on both peak and average meters.



Peaks will be held for 10 s and then fall with a speed of 8.67 dB/s.

5.1.1 Transient mode

On rising levels, it takes 10 ms for the meter to reach 99 % of the final reading. On falling levels, the meter switches to a linear fall time of 6 dB/s.

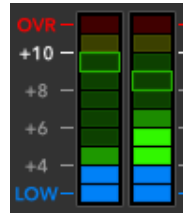
5.1.2 Classic mode

Similar to VU meters, it takes 300 ms for the meter to reach 99 % of the final reading. This meter exhibits no overshoot, however.

5.2 Peak level meter

The peak level meter has a rise time of one sample and a fall time of 8.67 dB/s. The red LED marked “OVR” detects levels exceeding -9 dB FS and should never light.

Peaks will be indefinitely held until the meter is reset.



5.3 Signal meter

The orange signal meter detects peak levels of -60 dB FS and above. It has a rise time of one sample and simply fades out if the level falls below the threshold.



6 Recording tips

Over the years, I have accumulated a couple of recording tips. You may not know some of them, so read ahead ...

Use a good preamp. “Good” doesn’t mean your preamp has to have a lot of channels or features. To the contrary! Go for a simple design and invest your money in professional quality instead. Recordings made with a good preamp make mixing much easier – the tracks simply seem to fall into place.

Use the preamp’s gain control. If necessary, crank up the preamp to yield the needed output level. Do not fear the preamp’s internal noise – making up for low gain in later stages will likely result in even more noise! Also see [section 1.1](#).

Avoid unbalanced equipment. Run all signals on balanced lines with a nominal level of 4 dBu. If you can’t, use DI boxes or transformers and read the previous sentence again ...

Use short audio chains. All equipment adds noise or may otherwise degrade audio, so keep your audio recording chains as short as possible.

For example, instead of routing your mixer between preamp and hard disk recorder, connect the mixer to your hard disk recorder's *outputs*. This simple change can lead to much better recordings (especially with cheap mixers) and you'll still be able to hear yourself and other tracks during recording.

Record at lower levels. Record digital audio at **-20 dB FS RMS** with peak levels not exceeding **-9 dB FS**. For an in-depth explanation, see [section 1.1](#).

Record in mono. Most audio sources do not contain stereo information that is useful in a mixing context (notable exceptions are audience recordings, string sections and sometimes pianos). The pseudo-stereo effects of some synthesisers may even cause phasing issues in the mixing stage.

Recording these sources in stereo will only waste space on your hard disk and make you miserable during mixing. So why not record them in mono in the first place?

Use high bit depths. Do yourself a favour and record at bit depths of 24 bit instead of 16 bit. Although most digital audio converters only provide 20 bits of *noise-free* audio, the additional bits still provide an incredible amount of extra detail and you can record at lower levels without losing information. When properly dithered, changing to a lower bit depth even preserves quite a bit of that detail.

Also, if you edit audio files or apply effects, calculation errors are inevitable. At 24 bit, however, most of these artifacts are 48 dB lower in level (and thus inaudible) compared to 16 bit audio files.

Your digital audio workstation's bus should use at least 32 bits (floating point) to avoid accumulation of the above-mentioned artifacts.

Try different sample rates. Recording at certain sample rates may sound better, so experiment and get to know your converters. But try to keep the sample rate to exact multiples of the target sample rate. For instance, it makes sense to track at 44.1 kHz or 88.2 kHz for a CD release instead of using 48 kHz.

Only use professional software for sample rate conversion. This is by no means a trivial task.

Concentrate on recording. When tracking, try to not interfere with the flow of the session. This is easily done by keeping editing and mixing to the bare minimum.

For example, I currently track using an old hard disk recorder, as digital audio workstations tend to distract me too much.

Avoid copy'n'paste. Quite a lot of today's electronic music sounds like (and actually is) one short loop that was "arranged" by occasionally muting some of its tracks. This takes away all the small inaccuracies that happen when humans play instruments. It also makes such tracks sound absolutely lifeless.

So instead of looping a track, record a couple of takes and comp the best ones. You'll be surprised at the difference it makes!

Do not fix things later. A bad recording is a bad recording is a bad recording. You can't really "fix it in the mix". So tools like Auto-Tune, extreme EQ or the edit button should be seen as a last resort. It's easy to kill all of a track's vibe in the process.

Instead, record a few more takes. Treat your room (acoustically and in terms of positive vibe). Experiment with microphone placement. Try everything you can to help the musicians perform better. Maybe you even have to look for better musicians ...

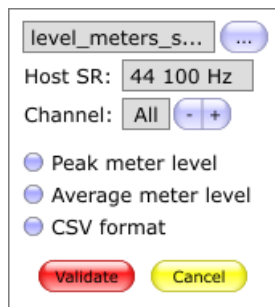
7 Validation

I have gone to great lengths to ensure that the 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. A word of warning: these audio files may **damage your ears** and speakers, so please watch your monitor levels!

Begin by starting traKmeter. If in a Bash shell, try this:

```
32 and 64 bit  
./trakmeter_stereo 2>&1 | tee /tmp/validate.log
```

After opening the **validation window** (see [section 4.5](#)), click on the ellipsis button (the one with the dots) to select an audio file for playback through traKmeter. 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 dumped data to

a specific audio **channel**. Check **CSV** if you want to feed the output to a parser.

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 twenty seconds. To stop playback early, simply click on the **validate** button again.

7.1 Validation status

	Test	Valid
Average level meter	visuals	✓
	readout	✓
Peak level meter	visuals	✓
	readout	✓
Signal meter	visuals	✓

8 Help needed

As traKmeter was coded using cross-platform code, it should be easy to compile on Mac OS X. Unfortunately, I happen to not have a Mac ...

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!

9 Final words

I want to thank **Rickard** of Interfearing Sounds for asking me how to use K-Meter for tracking. This question and the following thoughts really got traKmeter started. I'd like to thank **bram@smartelectronicx** for his code to calculate logarithmic rise and fall times. I must also thank the **beta testers** and **users of traKmeter** 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 traKmeter has been a lot of fun, it has also been a lot of work. So if you like traKmeter, 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 skin. I also really enjoy listening to music that you may have produced using my software...

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 traKmeter

A.1 Preparing GNU/Linux

To build traKmeter 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 Linux Mint 18, but the procedure should be similar on your distribution of choice.

Start by installing the necessary packages:

— 32 and 64 bit —

```
sudo apt-get install debootstrap schroot
```

Then install the chroot base system by executing the following statements:

— 32 bit —

```
sudo debootstrap --variant=builddd \  
  --arch i386 stable \  
  /srv/chroot/stable_i386 \  
  http://httpredir.debian.org/debian
```

64 bit

```
sudo debootstrap --variant=buildd \  
  --arch amd64 stable \  
  /srv/chroot/stable_amd64 \  
  http://httpredir.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):

32 and 64 bit

```
[stable-i386]  
description=Debian stable (i386)  
directory=/srv/chroot/stable_i386  
profile=default  
personality=linux32  
type=directory  
users=username  
  
[stable-amd64]  
description=Debian stable (amd64)  
directory=/srv/chroot/stable_amd64  
profile=default  
personality=linux  
type=directory  
users=username
```

Please make the necessary changes to `username`. If you experience problems, you can try to change `stable` to a release name such as `wheezy`.

When debootstrap is done, log in as superuser:

32 bit

```
schroot -c stable-i386 -u root
```

64 bit

```
schroot -c stable-amd64 -u root
```

You'll have to install a few packages – less and vim are optional, but might come in handy:

32 and 64 bit

```
apt-get update
apt-get -y install bash-completion clang \
    libasound2-dev libjack-jackd2-dev \
    mesa-common-dev xorg-dev 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:

32 and 64 bit

```
# enable bash completion in interactive shells
if [...]
    [a couple of lines...]
fi
```

Finally, log out and log in as normal user:

32 bit

```
schroot -c stable-i386
```

```
64 bit  
schroot -c stable-amd64
```

In this chroot shell, install the dependencies (see below).
Congratulations – you are now ready to build traKmeter!

A.2 Dependencies

A.2.1 premake

Importance: required
Version: 5.0.0 (alpha11)
License: BSD
Homepage: premake.github.io

Installation

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

To change the premake file using the provided Jinja templates, install the necessary dependencies and run the Python script `Builds/create_premake.py`.

A.2.2 JUCE library

Importance: required

Version: 5.1.2

License: ISC and GPL v3 (among others)

Homepage: www.juce.com

Installation

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

If you want to build the LV2 plug-in, please extract the archive `distrho_lv2-xxxxxxxx.tar.gz` into the same directory.

A.2.3 Virtual Studio Technology SDK

Importance: optional

Version: 3.6.8

License: GPL v3 (yay!)

Homepage: ygrabit.steinberg.de

Installation

Just extract the archive into the directory `libraries/vst`.

A.2.4 Audio Streaming Input Output SDK

Importance: optional

Version: 2.3

License: proprietary

Homepage: ygrabit.steinberg.de

Installation

Simply extract the archive into the directory `libraries/asio`.

A.2.5 Python

Importance: optional

Version: 3.5 (or higher)

License: Python Software Foundation License

Homepage: www.python.org

You'll only need Python if you want to change the premake file (see [section A.2.1](#)) using Jinja templates.

Installation (Windows)

You can download an installer from the website.

A.2.6 Jinja

Importance: optional

Version: 2.8 (or higher)

License: BSD

Homepage: jinja.pocoo.org

You'll only need Jinja if you want to change the premake file using templates (see [section A.2.1](#)).

A.2.7 Artistic Style

Importance: optional

Version: 2.05.1

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 traKmeter.

Installation

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

A.3 Building on GNU/Linux

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

```
32 and 64 bit  
./run_premake.sh  
make config=CFG TARGET
```

where `CFG` is one of `debug_x32`, `debug_x64`, `release_x32` and `release_x64`, and `TARGET` is the version you want to compile, such as `linux_standalone_stereo`.

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

```
32 and 64 bit  
./run_premake.bat
```

Then change into the directory `Builds/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 Licenses

B.1 GNU General Public License

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Version 3, 29 June 2007

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