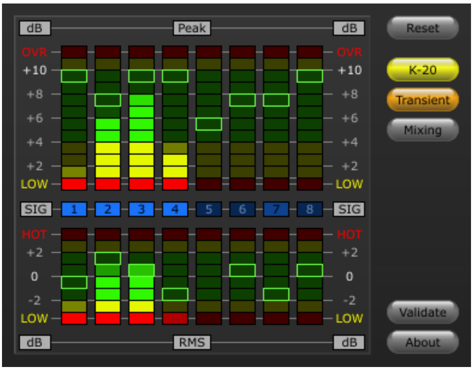
traKmeter

Loudness meter for correctly setting up tracking and mixing levels



Last edited on 30th May 2013

Contents

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_{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".

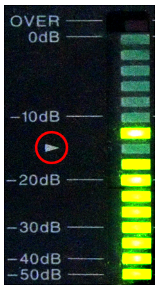
Another recommendation is that peak levels should not exceed **−9 dB FS** (EBU R68-2000) during tracking. This will leave enough space for sudden jumps in level and also for inter-sample peaks, audio peaks that lie *in between* two successive samples and may lead to unpredictable clipping during digital-to-analog 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 certainly 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 …

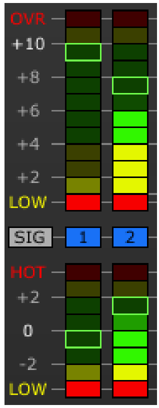
There is also a great thread over at Gearslutz ("The Reason Most ITB mixes don't Sound as good as Analog mixes") well worth reading. Here are links to the first post and two other selected posts (#1874 and #3614).

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 were **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 a blue signal LED and consist of an area of green LEDs that is enclosed by first yellow and then red LEDs.

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.

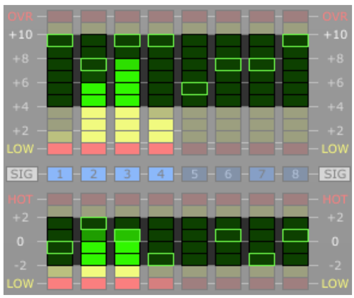
A fully lit yellow LED on the peak meter's top end corresponds to a level of **+11 dB** (or −9 dB FS). Again, this number should be familiar: peak levels in the digital domain shouldn't exceed this level.

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

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 standalone 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 standalone 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 the time, it may 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!

Another option is to insert **traKmeter** on each channel as first plug-in, enable the "Mixing" button (see section 4.4) and adjust volume using the gain knob.

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

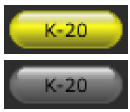
In order to use the pre-compiled binaries, simply extract the **traKmeter** files from the downloaded archive. For the plug-ins, you'll then have to move the extracted files to your respective plug-in folder (`~/.lv2`, `~/.vst`, `C:\Program Files\Steinberg\VstPlugins\` or the like).

4 Controls

4.1 Reset button

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

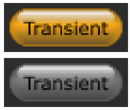
4.2 Crest factor button



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.

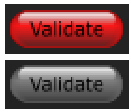
4.4 Mixing button

You can use **traKmeter** as a gain plug-in – just enable this button and adjust the gain knob.

When the plug-in is closed, its meters aren't updated, so it uses less system resources. On slow computers, however, use **traKmeter** to find the correct gain and then exchange it against a simple gain plug-in.

Please keep in mind that this setting should only be used for **pre-recorded material**. The gain stage sits *before* the meter and thus affects the meter's read-out. So if you apply a negative gain during recording, your analog input stage might clip without the meters hitting the red area!

4.5 Validation button



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

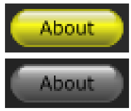
*Unfortunately, the underlying JUCE library does not seem to support multi-channel audio files. You may load such audio files into your DAW of choice and insert **traKmeter** as a plug-in instance.*

On Linux, dumped data will be written to `stderr`, so just start the **traKmeter** 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 **traKmeter** 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.

4.6 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.



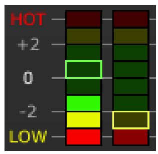
4.7 Display license

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.

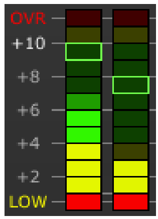
5.1.1 Transient mode

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.

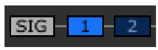
5.2 Peak level meter



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 blue signal meter detects peak levels of −60 dB FS and above. It has a rise time of one sample and falls to 99 % of the final reading in 1.2 s.

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 unballanced 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.

Avoid sample rate conversion. Sample rate conversion usually degrades audio (especially small changes of a few kHz), so try to record at the target sample rate. For instance, tracking for a CD release should be carried out at 44.1 kHz instead of 48 kHz.

There are of course exceptions to the rule, for instance you may prefer to track on a professional DAT machine (48 kHz) when your only other choice is using a consumer audio interface.

For tracking at higher sample rates, it pays to use exact multiples of your target sample rate (such as 88.2 kHz instead of 96 kHz) if your hardware and software permit. Please note that some professionals actually advise against using higher sample rates due to the possible build-up of noise beyond 20 kHz. It is also much more demanding on your computer, audio equipment and plug-ins – and may not be worth the hassle. Try changing from recording at 16 bit to 24 bit first.

Finally, 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.

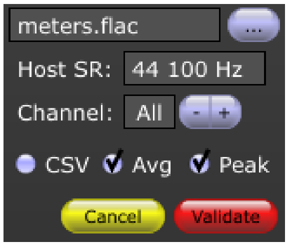
So instead of looping a track, record a couple of takes and comp the best ones. You'll be surprised at the difference it makes!

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!



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 ten 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. I just don't 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@smartelectronix** 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 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 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 13 (Maya), 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 -y install bash-completion libasound2-dev \
  libjack-jackd2-dev mesa-common-dev xorg-dev
apt-get -y 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 **traKmeter**.

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 JUCE library

Importance:	required
Version:	2.0.40
License:	GPL v2
Homepage:	www.rawmaterialsoftware.com/juce.php

Installation

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

A.2.3 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.2.4 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.2.5 Python

Importance:	optional
Version:	3.2 (or higher)
License:	Python Software Foundation License
Homepage:	www.python.org

You'll only need Python if you want to build 64-bit versions of **traKmeter** using Visual Studio Express.

Installation (Windows)

You can download an installer from the website. Please also install the Windows SDK and change `run_premake.bat` to reflect the SDK's version number.

A.2.6 Artistic Style

Importance:	optional
Version:	2.01
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 `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_multi`, `linux_vst_stereo` and `linux_vst_multi`.

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

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Terms and Conditions

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   "Copyright" also means copyright-like laws that apply to other kinds of works, such as semiconductor masks.

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   A "covered work" means either the unmodified Program or a work based on the Program.

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To “convey” a work means any kind of propagation that enables other parties to make or receive copies. Mere interaction with a user through a computer network, with no transfer of a copy, is not conveying.

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1. Source Code.

The “source code” for a work means the preferred form of the work for making modifications to it. “Object code” means any non-source form of a work.

A “Standard Interface” means an interface that either is an official standard defined by a recognized standards body, or, in the case of interfaces specified for a particular programming language, one that is widely used among developers working in that language.

The “System Libraries” of an executable work include anything, other than the work as a whole, that (a) is included in the normal form of packaging a Major Component, but which is not part of that Major Component, and (b) serves only to enable use of the work with that Major Component, or to implement a Standard Interface for which an implementation is available to the public in source code form. A "Major Component", in this context, means a major essential component (kernel, window system, and so on) of the specific operating system (if any) on which the executable work runs, or a compiler used to produce the work, or an object code interpreter used to run it.

The "Corresponding Source" for a work in object code form means all the source code needed to generate, install, and (for an executable work) run the object code and to modify the work, including scripts to control those activities. However, it does not include the work's System Libraries, or general-purpose tools or generally available free programs which are used unmodified in performing those activities but which are not part of the work. For example, Corresponding Source includes interface definition files associated with source files for the work, and the source code for shared libraries and dynamically linked subprograms that the work is specifically designed to require, such as by intimate data communication or control flow between those subprograms and other parts of the work.

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   b) The work must carry prominent notices stating that it is released under this License and any conditions added under section 7. This requirement modifies the requirement in section 4 to "keep intact all notices".

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You may convey a covered work in object code form under the terms of sections 4 and 5, provided that you also convey the machine-readable Corresponding Source under the terms of this License, in one of these ways:

a) Convey the object code in, or embodied in, a physical product (including a physical distribution medium), accompanied by the Corresponding Source fixed on a durable physical medium customarily used for software interchange.

b) Convey the object code in, or embodied in, a physical product (including a physical distribution medium), accompanied by a written offer, valid for at least three years and valid for as long as you offer spare parts or customer support for that product model, to give anyone who possesses the object code either (1) a copy of the Corresponding Source for all the software in the product that is covered by this License, on a durable physical medium customarily used for software interchange, for a price no more than your reasonable cost of physically performing this conveying of source, or (2) access to copy the Corresponding Source from a network server at no charge.

c) Convey individual copies of the object code with a copy of the written offer to provide the Corresponding Source. This alternative is allowed only occasionally and noncommercially, and only if you received the object code with such an offer, in accord with subsection 6b.

d) Convey the object code by offering access from a designated place (gratis or for a charge), and offer equivalent access to the Corresponding Source in the same way through the same place at no further charge. You need not require recipients to copy the Corresponding Source along with the object code. If the place to copy the object code is a network server, the Corresponding Source may be on a different server (operated by you or a third party) that supports equivalent copying facilities, provided you maintain clear directions next to the object code saying where to find the

Corresponding Source. Regardless of what server hosts the Corresponding Source, you remain obligated to ensure that it is available for as long as needed to satisfy these requirements.

e) Convey the object code using peer-to-peer transmission, provided you inform other peers where the object code and Corresponding Source of the work are being offered to the general public at no charge under subsection 6d.

A separable portion of the object code, whose source code is excluded from the Corresponding Source as a System Library, need not be included in conveying the object code work.

A "User Product" is either (1) a "consumer product", which means any tangible personal property which is normally used for personal, family, or household purposes, or (2) anything designed or sold for incorporation into a dwelling. In determining whether a product is a consumer product, doubtful cases shall be resolved in favor of coverage. For a particular product received by a particular user, "normally used" refers to a typical or common use of that class of product, regardless of the status of the particular user or of the way in which the particular user actually uses, or expects or is expected to use, the product. A product is a consumer product regardless of whether the product has substantial commercial, industrial or non-consumer uses, unless such uses represent the only significant mode of use of the product.

"Installation Information" for a User Product means any methods, procedures, authorization keys, or other information required to install and execute modified versions of a covered work in that User Product from a modified version of its Corresponding Source. The information must suffice to ensure that the continued functioning of the modified object code is in no case prevented or interfered with solely because modification has been made.

If you convey an object code work under this section in, or with, or specifically for use in, a User Product, and the conveying occurs as part of a transaction in which the right of possession and use of the User Product is transferred to the recipient in perpetuity or for a fixed term (regardless of how the transaction is characterized), the Corresponding Source conveyed under this section must be accompanied by the Installation Information. But this requirement does not apply if neither you nor any third party retains the ability to install modified object code on the User Product (for example, the work has been installed in ROM).

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```
<one line to give the program's name and a brief idea
of what it does.>

Copyright (C) <textyear> <name of author>

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Public License as published by the Free Software
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```

Also add information on how to contact you by electronic and paper mail.

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```
<program> Copyright (C) <year> <name of author>

This program comes with ABSOLUTELY NO WARRANTY; for
details type 'show w'.  This is free software, and
you are welcome to redistribute it under certain
conditions; type 'show c' for details.
```

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