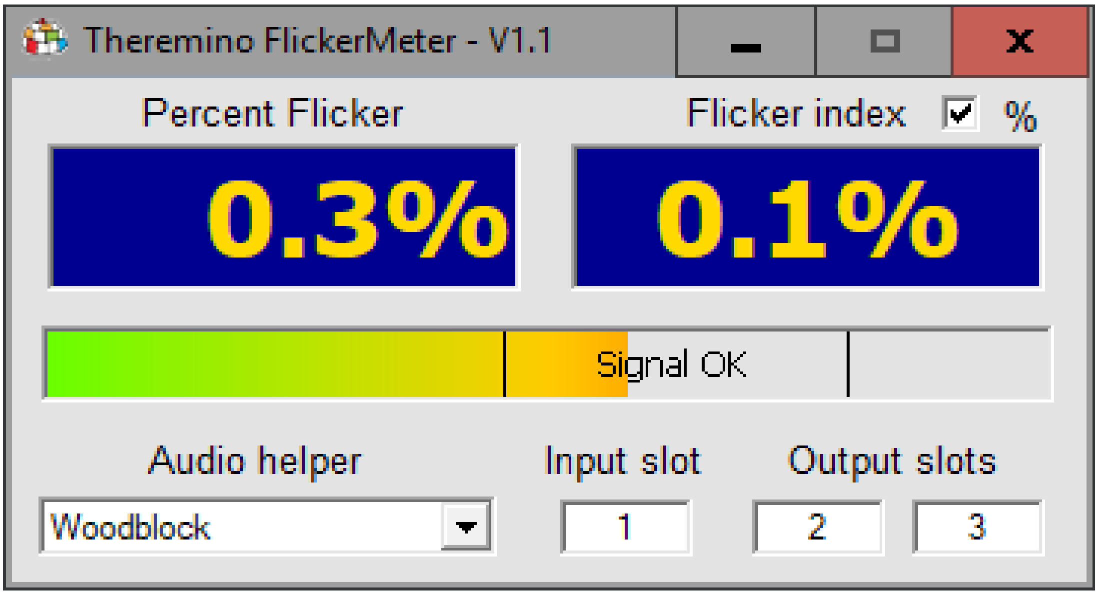
Theremino **System**



Theremino FlickerMeter

Measure the flickering of the lamps

Why measure the "Flicker" of the lamps

The "Flicker" is the instability of the light produced by the lamps.

The lamps are usually powered from the mains, with alternating current whose frequency is 50 Hz (or 60 Hz in some countries). In these systems, the voltage varies from positive to negative 50 times per second and crosses zero twice per cycle.

So incandescent, halogen or fluorescent lamps (as well as LED if poorly designed), turn on and off a hundred times a second and produce light with a flicker at 100 Hz (or 120 Hz).

Human beings do not consciously perceive flicker at frequencies above 50Hz, but the light receptors and the brain neurons are affected. To which the flashing of the light sources, although invisible, can also cause disorders and discomforts.

Health effects

Numerous studies have shown that a completely invisible flicker can cause headaches, eyestrain and nausea. Normally it is just a feeling of discomfort, but in some cases (most sensitive and prolonged exposure) the visual acuity and overall health can be affected.

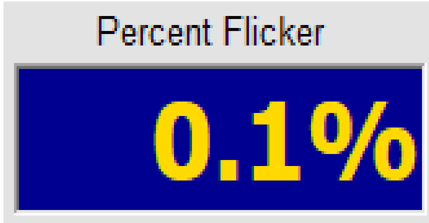
It was also shown that if the work environment has flickering lights workers get tired before and production declines. Women and children are more sensitive to these effects, men and older people are less so.

Also, pets are much more sensitive than we, to flicker effects.

Some of them, such as birds, can see variations of light up to frequencies around 200 Hz, so ten times more than what we do.

For them a movie appears as a sequence of photographs and a lamp, which to our eyes seem perfectly stable, it may look like a strong stroboscopic lamp and cause severe discomfort.

Safe values for health



In these years (2017) there are integrated circuits specially designed to provide a perfectly stabilized current to the LEDs. These ICs are also very inexpensive and can work with power ranging from 85 to 265 volts, at either 50 or 60 Hz.

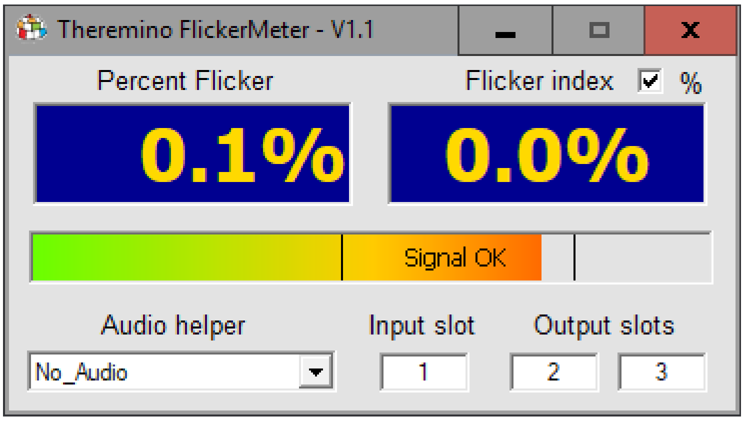
Using these integrated, in a well-designed circuit, the flicker is practically zero and the efficiency is maximum. With these integrated, and good quality led, some manufacturers can exceed 100 lumens per watt.

There is therefore no reason to produce lamps that have a measurable flicker, If not to save a few cents or for cheating on efficiency data (some manufacturers take advantage of the confusion between the light peak power and average power consumed and produce flickering lamps in order to declare very high values of lumens per watt).

So, since it is possible to produce zero flickering lamps, it makes no sense to do biological research, or arguing over them. The flicker value MUST be very low, virtually zero.

We think the only safe lighting is lighting that gives values:

- Less than 1% (with the "Percent Flicker" method)
- Less than 0.01 (with the corrected "Flicker Index")
- Less then 0.5% (with the corrected "Flicker Index" as a percentage)



In this image can be seen the values measured in Chinese led strip (60 LEDs per meter of 5050 type) powered with a Chinese stabilized power supply of 12 volts, 5 amperes. Despite being economic components, which are normally found on eBay, their flicker is almost zero.

Prehistory

At first there were only incandescent lamps (1878). Then, towards the middle of 1900, they were fluorescent lamps (neon tubes), and many noted that producing an "annoying" light.

At first the blame was given to the color of the light, but subsequent research has shown that feelings of discomfort are caused by the flickering.

For many years the only world existing light bulbs were incandescent or fluorescent. And since the fluorescent flickered so much more, all ended up thinking that fluorescent are flickering and incandescent are flicker-free".

In fact even incandescent lamps flicker, a little less than the fluorescent, but also them are flickering quite a bit. And the halogens are even worse, since they work at higher temperatures and therefore have a lower thermal inertia.

Lamp types

The incandescent and halogen lamps inevitably have an average high flicker (from 10% to 30%) And you can not reduce it in any way.

The ancient neon tubes with passive power supply (an inductor built with many copper coils wound on iron) have a flicker even higher (from 30% to 50%).

The fluorescent lamps CFL (Compact Fluorescent Lamp), also known as "energy-saving" have switching electronic ballasts. So theoretically could have zero flickering. In practice, however, due to space and cost all CFL have an average high flicker, more or less equal to traditional fluorescent and halogen (from 10% to 30%).

The LED lamps are the only with a very low flicker (up to 0.1%). But, if their power supply is poorly designed, they could flicker worse than any other lamp and get close to 100%.

Commercial measuring devices

The flickering of the lamps is measured with equipment called "**Flicker Meter** ". This is a common name for systems that measure the flicker "irksomeness".

The values measured by these units are calculated using standard formulas.

They are very precise equipment, certainly more precise than a device "do it yourself" and have only one defect, they cost an exaggeration.

For example, what you see here on the right costs more than 3000 dollars.
http://www.gamma-sci.com/product/uprtek-mf250n-flicker-meter

But actually we do not need all this precision.

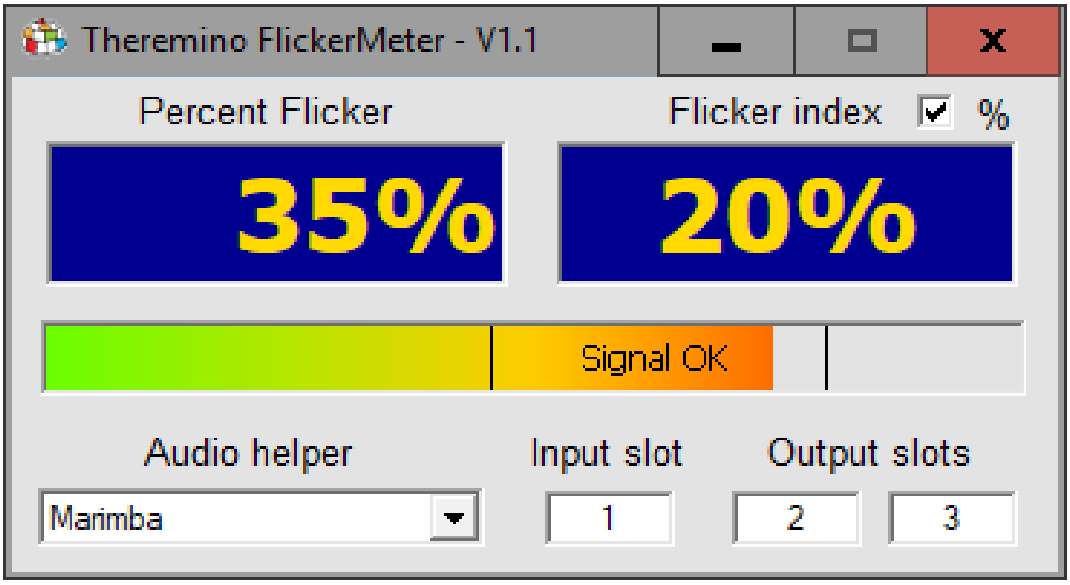
We do not care if the value is 33.5% instead of 33.6%.

And it would not matter if we were wrong, for example, from 20% to 30%.

Because if there is flickering and more than 1% is measured, the lamp is not good and is to be discarded (see the chapter "Safe safety values").

The "Flicker Meter" application

This is a simple application, the controls are few and easy to understand.



- The two upper boxes show the measurement results.
- The box to the right of "Flicker index" changes the value to percentage.
- The horizontal colored indicator adjusts the level of the light signal (if it was too high or too low the precision would be reduced).
- The "Audio helper" box lets you choose a sound. The sound can help during the adjustment of the signal level, in the case that the screen is not visible.
- "Input" slot is the slot of the Theremino system from which the signal arrives, through the measuring device and the HAL application.
- "Output slots" are slots where the two measured values are written. These values may be used by other applications, such as a spreadsheet (Excel), to collect a number of measures in a table.

Configuring the input Pin

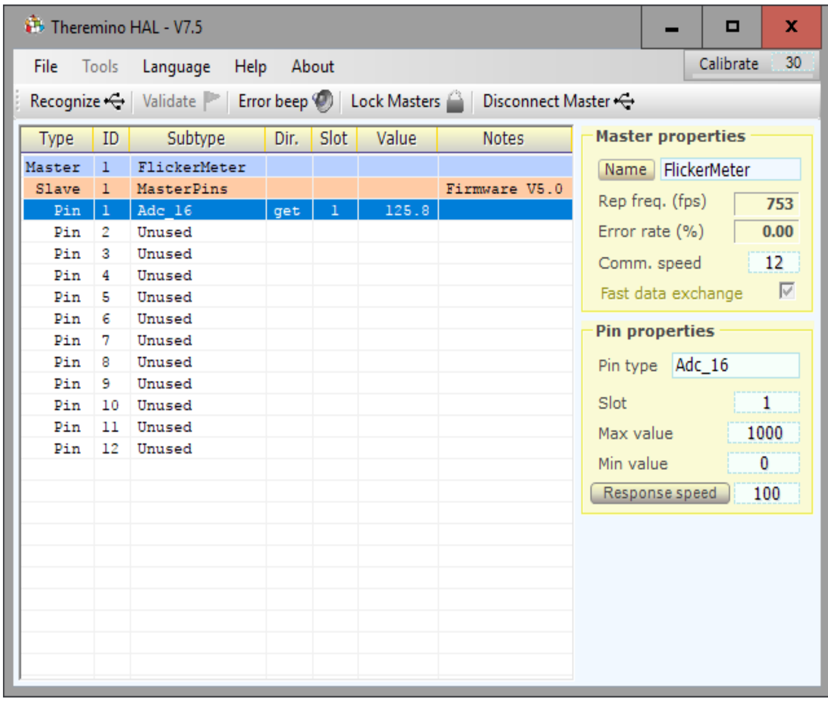
During startup, the application "Flicker_Meter" starts also the "Theremino_HAL".

The HAL handles the USB communication with the master module. With the HAL we configure the Master inputs for reading each type of sensor.

When you start Flicker Meter the HAL should already be configured. It should start minimized in the bottom bar of Windows, and should be close again at the end. You need not change its parameters except in special cases.

HAL configuration checklist

- Open it by clicking on the icon of the igloo at the bottom bar of Windows.
- Check that "Comm speed" is 12
- Click on the Pin 1 line
- Check that the "Pin Properties" box all values are like this.
- If necessary, click Pin type and set Adc_16. And the four numbers below: 1/1000/0/100
- Notice also that the "Response speed" button is switched off, ie it is not illuminated in orange.



At the end it is good to minimize the HAL before to close, so at each restart will start minimized in the Windows application area and will not take place on the desktop.

Using other modules instead of the Master

Some might think of using a NetModule with NetHAL or an Arduino with the ArduHAL, but their ADC are not precise enough. Theoretically would have the same bits of the master module, but do not have the over-sampling of sixteen times that we have implemented the HAL, so their noise is higher. We tried to use them and we have verified that you can not go below one or two percent even with the most stable lights. While the master comes to 0.1%.

Or you might think to use an Adc24. But even this idea is to be discarded because we would get no improvements. On the other hand this device would become unnecessarily expensive and also more difficult to build and configure. So for this project we must necessarily use a Master module.

Adjusting the signal level

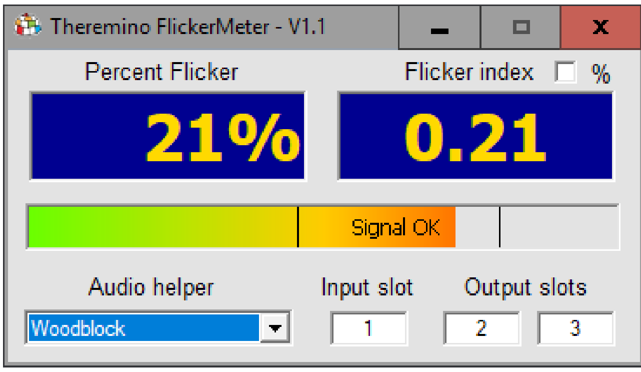
To make precise measures the amount of light must be adequate and you must place the instrument near to the lamp, so as to collect light only from it and not by any other lamp, which could distort the measurements.

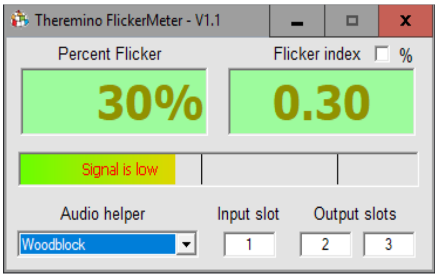
The instrument and the lamp must be very firm. Whatever vibration increases the measured value, particularly when measuring very low values.

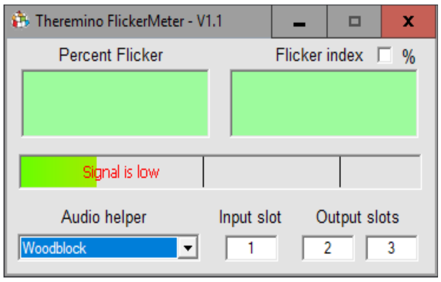
If you are using a device with the adjustment potentiometer, you will rotate it until the indicator shows that the signal is in the central area. Otherwise you will adjust the level moving the device near or away from the lamp.

In this image one sees the signal level well regulated.

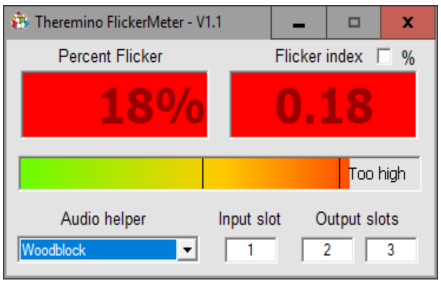
When measuring lamps with very low flicker is good to adjust the signal in the right part of the central area, to maximize accuracy.

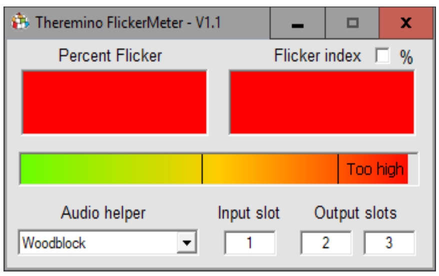






Low signal (when it is very low even disappear numbers)





High signal (when it is very high even disappear numbers)

Using sounds to adjust the signal

The measuring device must be positioned close to the lamp to be measured in such a way that its light is strong enough to minimize the effect of any other source of light.

Any other lamp, or natural light, can alter the measured value, so the more the other lights are stronger and more the meter should be placed near to the lamp to be measured.

But you must not go too close to the lamp, because the measure would become more sensitive to distance variations between the lamp and the meter and therefore also to vibrations and rocking of the lamp.

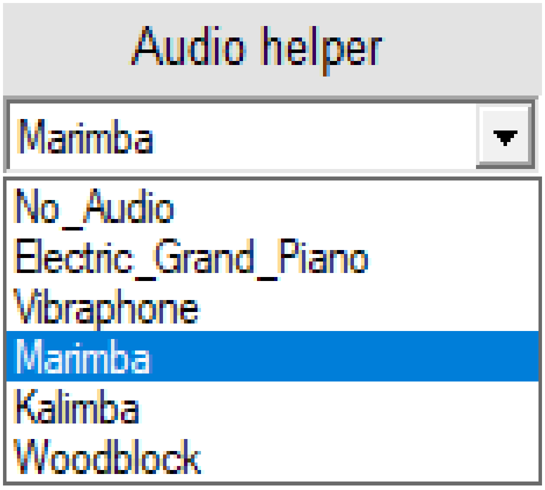
Normally the most appropriate distance is between ten centimeters and one meter.

Also important to note that both the meter and the lamp must stand well still during the measurement. Therefore it is not possible to keep the device in hand, it must lay on a surface or be fastened with a tripod or a clamp.

It may therefore happen that the right position for the meter is at the top, or at a point that makes it difficult to adjust while watching the screen.

In these cases should enable one of the sounds of "Audio Helper".

To learn how to use sounds suggest you choose "Woodblock", which highlights well the level changes.



The meter should be placed in a lighted area, but holding it close to the PC (or tablet), so it can be adjusted while watching the screen.

With a little 'training you will learn how to adjust the potentiometer (or the distance from the lamp), even based only on the sounds, without looking at the screen.

Methods to measure the "flicker"

Our application measures flicker with good precision, according to the two most commonly used methods: "Percent flicker" and "Flicker Index".

Other devices use more complex methods and try to act like the eye and the human brain. They employ a series of electrical filters to calculate the visibility of flicker for humans. The design of these Flickermeters is prescribed by protocol EN60868 (Interestingly, the PDF document costs over 100 Euro).

But recent studies have shown that even what is not noticed by the human eye can have the same harmful effects on health. For so these devices, in addition to being complex and expensive, they tend to underestimate the severity of the problem.

Even the method "Flicker Index" tends to underestimate the flickering and moreover has also been chosen a unit of measure that "makes it seem low," the measured value. Surely in meetings that have established these methods were manufacturers of fluorescent and halogen lamps.

Technology	Percent Flicker	Flicker Index
The worst LED lamps	99.0	0.45
Lamp to high pressure sodium	95.0	0.30
CFL lamp with magnetic ballast	37.0	0.11
T12 linear tube with magnetic ballast	28.4	0.07
spiral fluorescent lamp (CFL)	7.7	0.02
Incandescent lamp	6.3	0.02
Average quality LED lamp	2.0	0.00
Lamps of excellent quality LED or LEDs in adhesive strips, with power supply from 12 or 24 volts stabilized.	0.2	0.00

As seen in this table, the "Percent flicker" shows large variations between the different lamps, while the "Flicker Index" shows always low and "reassuring" values.

Many documents in recent years suggest using the "Flicker index". If you pay attention you can notice an apparent willingness not to give too much bother to manufacturers of halogen and CFL lamps. And not to point too the difference between good LED lamps (with zero flickering) and all the others.

Several measurement methods

Percent Flicker

The measured values range from 0% to 100%.

A perfectly stable light gets a value of 0%

A light that turns on and off completely gets a value of 100%

Flicker Index

The measured values range from 0 to 1 (***Note 1***)

A perfectly stable light gets the value "0"

A light that turns on and switches off completely "should" get the value "1"

Note 1

Note that many devices are using a "Flicker Index" calculation that never produces a value greater than 0.5, even with a light that flashes in the worst possible way (square wave at 100%).

So these devices, even the worst lighting, give measures around 0.45, which are much more reassuring that read "Flicker Percent = 99%".

Also some versions of Flicker Meter calculate the "Flicker Index" taking into account the visibility of flicker for humans. This correction is made assuming that you do not notice will not have biological effects. But this was refuted by studies that have shown that there is a fatigue, loss of concentration, headaches, fatigue and impaired vision, even with lighting that flashes imperceptible by a human.

The Flicker Index measured with these devices goes so far as to give a reassuring 0.02 to the classic neon tubes that seen on the oscilloscope are blinking at 50%, and mark values of around 30% when measured by the "Percent flicker" method.

It must also consider that there are not only human beings. Other animals, such as birds, see distinctly variations of light up to 200 Hz and beyond. To which a light that appears to us stops is perceived by them as a stroboscopic lamp and disturbs them very much.

In conclusion, the "Flicker Index" (as understood in some documents and measured by some commercial equipment) is not an objective measure and is misleading because it tends to classify as good, illuminations that are not.

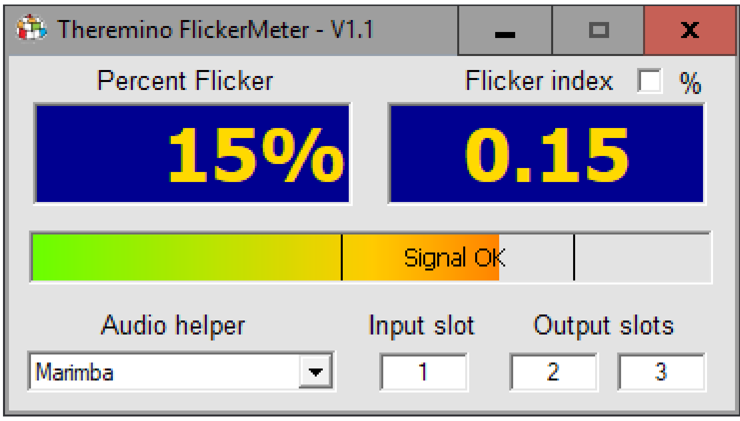
Correct measurement methods

The Flicker index calculated by our application shows the value "1" in the case of maximum variation (square wave). In practice the result of our formula is a double value with respect to that of the meters that are based on uncorrected formulas, which therefore have the "Flicker Index" that only goes up to 0.5.

Our app also allows you to multiply by 100 the "Flicker Index", so you can easily compare it with the "Percent Flicker".

In the next two images we see the measurement of a perfect square wave that produces equal values with the two methods.

In this first image you see the "Flicker Index" in the classic version. Note that it is difficult to notice that they are two identical values.

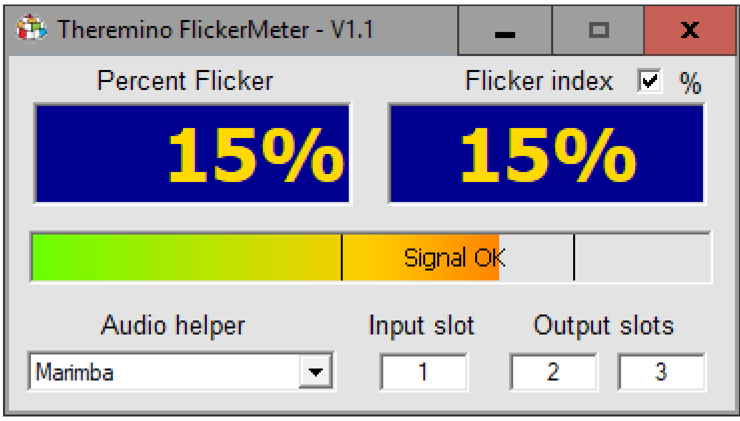


In the next image the percentage check-box has been activated.

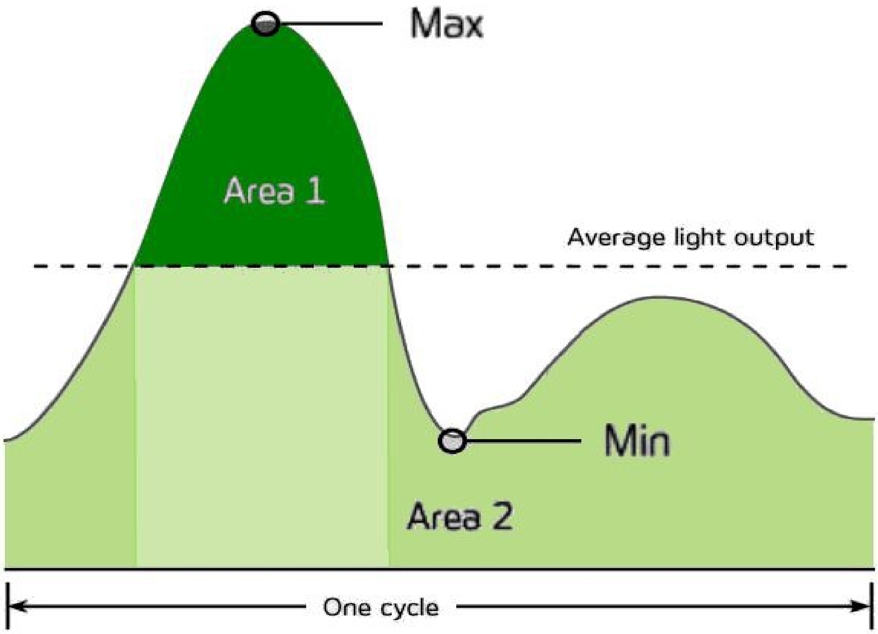
The "Flicker index" as a percentage makes it easier to compare values.

From the comparison it is possible to get an idea of the type of waveform which varies with the light.

If the two values are equal, then the waveform is square, and as they diverge, it goes towards less squared waveforms and (presumably) less harmful to health.



Appendix 1 - Calculation Formulas



Percent of Max = 100% * (Max - Min) / Max

This is the gross formula and it would be our favorite because it shows the maximum flicker. Too bad no one uses this formula so, reluctantly, we adapted.

percent Flicker = 100% * (Max - Min) / (Max + Min)

The formula used in the first indicator of our application.

Flicker Index = Area1 / (Area1 + Area2)

The "uncorrected" flicker index that ranges from 0 to 0.5 at most.

Corrected Flicker = Area1 / (Area1 + Area3)

The “corrected” flicker index that ranges from 0 to 1.

You get the area 3 from the area 2 excluding the part that is under the area 1 (highlighted with a lighter color).

Corrected Flicker Index as Percentual = 100% * Area1 / (Area1 + Area3)

The flicker index "correct" reported in percentage by values from 0% up to 100% and is therefore easily comparable with the "Percent flicker".

This is the "Flicker index" that we recommend to use. It is obtained by pressing % in the second indicator of our application.

Appendix 2 - Measurement methods comparison

Max light value	Min light value	Percent of Max	Percent flicker	Flicker Index (square wave)	Flicker Index (sinusoidal wave)	Flicker Index (triangular wave)	Flicker Index (rectified sinusoid)
100.0	0.0	100.0	100.0	1.000	0.640	0.500	0.480
100.0	1.0	99.0	98.0	0.980	0.627	0.490	0.470
100.0	5.0	95.0	90.5	0.905	0.579	0.452	0.434
100.0	10.0	90.0	81.8	0.818	0.524	0.409	0.393
100.0	15.0	85.0	73.9	0.739	0.473	0.370	0.355
100.0	20.0	80.0	66.7	0.667	0.427	0.333	0.320
100.0	25.0	75.0	60.0	0.600	0.384	0.300	0.288
100.0	30.0	70.0	53.8	0.538	0.345	0.269	0.258
100.0	35.0	65.0	48.1	0.481	0.308	0.241	0.231
100.0	40.0	60.0	42.9	0.429	0.274	0.214	0.206
100.0	45.0	55.0	37.9	0.379	0.243	0.190	0.182
100.0	50.0	50.0	33.3	0.333	0.213	0.167	0.160
100.0	55.0	45.0	29.0	0.290	0.186	0.145	0.139
100.0	60.0	40.0	25.0	0.250	0.160	0.125	0.120
100.0	65.0	35.0	21.2	0.212	0.136	0.106	0.102
100.0	70.0	30.0	17.6	0.176	0.113	0.088	0.085
100.0	75.0	25.0	14.3	0.143	0.091	0.071	0.069
100.0	80.0	20.0	11.1	0.111	0.071	0.056	0.053
100.0	81.0	19.0	10.5	0.105	0.067	0.052	0.050
100.0	82.0	18.0	9.9	0.099	0.063	0.049	0.047
100.0	83.0	17.0	9.3	0.093	0.059	0.046	0.045
100.0	84.0	16.0	8.7	0.087	0.056	0.043	0.042
100.0	85.0	15.0	8.1	0.081	0.052	0.041	0.039
100.0	86.0	14.0	7.5	0.075	0.048	0.038	0.036
100.0	87.0	13.0	7.0	0.070	0.044	0.035	0.033
100.0	88.0	12.0	6.4	0.064	0.041	0.032	0.031
100.0	89.0	11.0	5.8	0.058	0.037	0.029	0.028
100.0	90.0	10.0	5.3	0.053	0.034	0.026	0.025
100.0	91.0	9.0	4.7	0.047	0.030	0.024	0.023
100.0	92.0	8.0	4.2	0.042	0.027	0.021	0.020
100.0	93.0	7.0	3.6	0.036	0.023	0.018	0.017
100.0	94.0	6.0	3.1	0.031	0.020	0.015	0.015
100.0	95.0	5.0	2.6	0.026	0.016	0.013	0.012
100.0	96.0	4.0	2.0	0.020	0.013	0.010	0.010
100.0	97.0	3.0	1.5	0.015	0.010	0.008	0.007
100.0	98.0	2.0	1.0	0.010	0.006	0.005	0.005
100.0	99.0	1.0	0.5	0.005	0.003	0.003	0.002
100.0	99.1	0.9	0.5	0.005	0.003	0.002	0.002
100.0	99.2	0.8	0.4	0.004	0.003	0.002	0.002
100.0	99.3	0.7	0.4	0.004	0.002	0.002	0.002
100.0	99.4	0.6	0.3	0.003	0.002	0.002	0.001
100.0	99.5	0.5	0.3	0.003	0.002	0.001	0.001
100.0	99.6	0.4	0.2	0.002	0.001	0.001	0.001
100.0	99.7	0.3	0.2	0.002	0.001	0.001	0.001
100.0	99.8	0.2	0.1	0.001	0.001	0.001	0.000
100.0	99.9	0.1	0.1	0.001	0.000	0.000	0.000
100.0	100.0	0.0	0.0	0.000	0.000	0.000	0.000

Appendix 3 - Measuring frequency

The flicker frequency depends on the supply circuit of the lamp.

Theoretically, some adapters may have a single half-wave rectifier and then produce flicker at a frequency of 50 Hz (which is much more visible). But in practice all the lamps have a flicker frequency of 100 Hz, we try tens of them and all have 100 Hz flickering.

Also the fluorescent lamps with electronic reactor that works at high frequency, have a flicker at 100 Hz. This is due to an insufficient filtering of the rectified voltage. To filter it perfectly would serve a condenser expensive and too large to fit in the holder.

And even the old fluorescent tubes with the age of the stone reactor produce flicker at 100 Hz.

We also tried a Philips LED tube made to replace the old fluorescent tubes. Since its cost we assumed he had a lot of flicker zero, but actually had quite high, comparable to that of the fluorescent tubes, and invariably to 100 Hz.

Then to measure the flicker frequency is virtually useless and we have not weighed the Flicker Meter application with a frequency meter.

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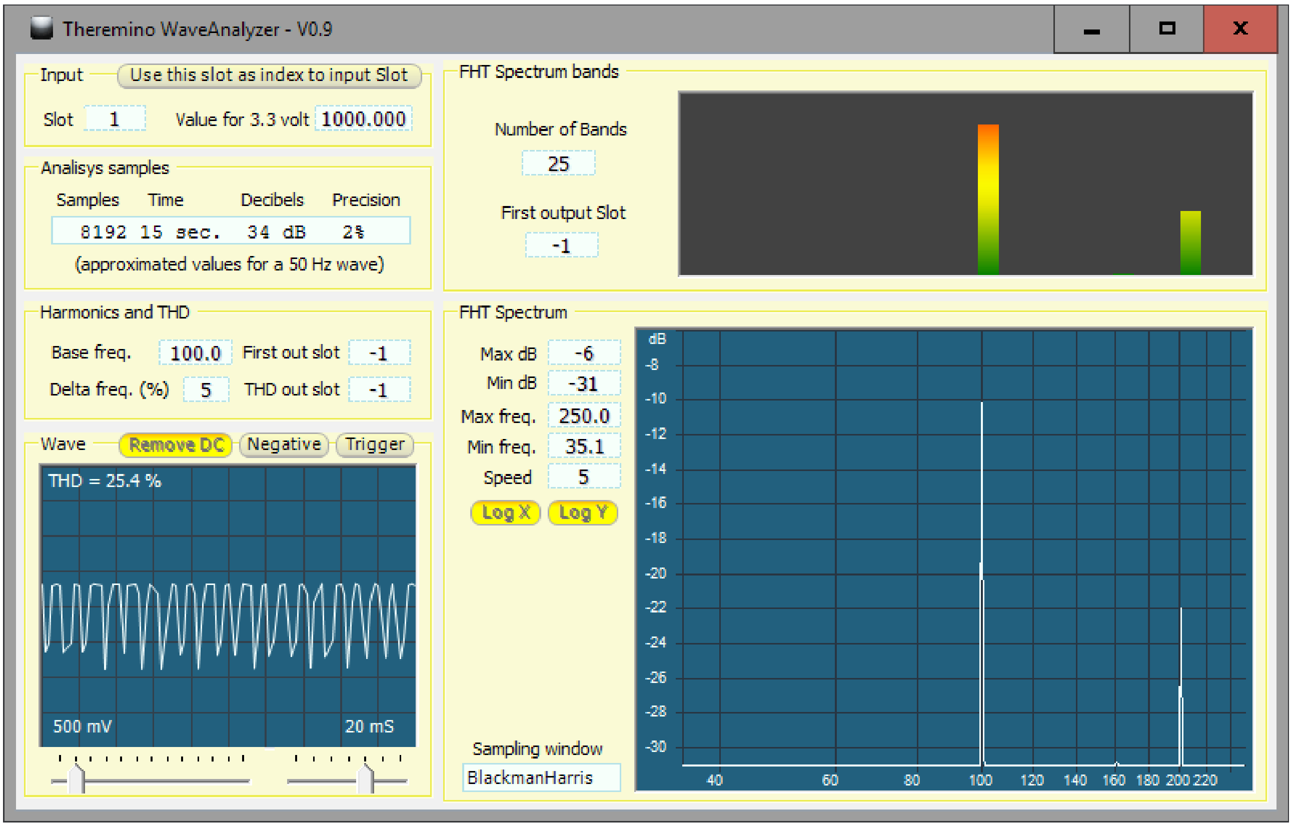
Anyone wishing to remove their doubts can use our application "Wave Analyzer", which not only measures the frequency, but also makes a spectrum analysis of all changes from zero to 250 Hz. Download "Wave Analyzer" from ***this page***.



Appendix 4 - Dimmers

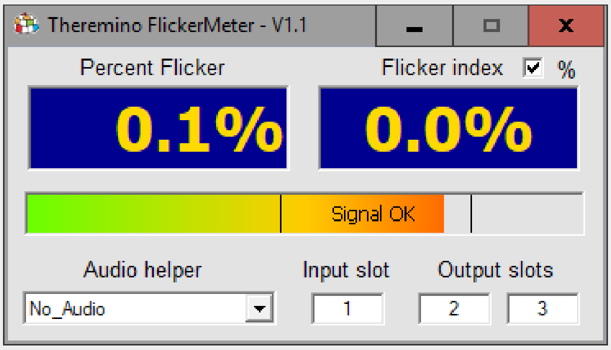
We will completely neglect the old dimmer for incandescent and halogen lamps. These lamps are not to be used because they consume six times more LEDs, and because they have a shorter life. But mainly because they have some intrinsic flicker, which can not even be decreased by modifying their power supply (fluorescent would be very difficult to correct and halogen power supply does not have its own).

We'll talk then just dimmers for LED.

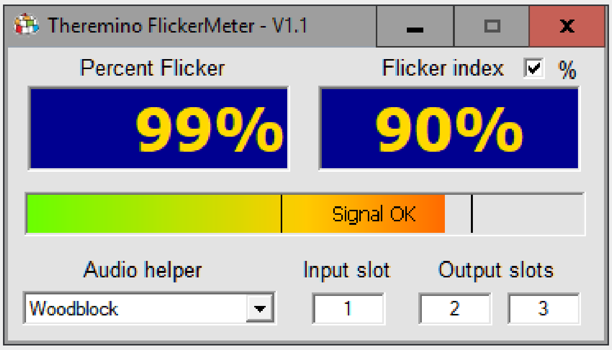
With current dimmer for LED lamps also have a very low flicker can become very bad, no matter whether they are "dimmed" or not.

We tried three different types of LED dimmer (12 or 24 volts). Two of them decreased the brightness turning on and off the lamp with a frequency of approximately 120 Hz and one with approximately 240 Hz. Perhaps you could rest assured with frequencies above 1000 Hz but who knows. The only sure lamp is a lamp that does not flicker.

Here's how a dimmer can "ruin" a good lamp:



Without dimmer



With dimmer

This however is not the only way to make a dimmer. Some of the components in more and there would be a stabilized power supply with variable output voltage or current. And a stabilized power supply would have a perfectly constant output and then the lamp would flicker very close to zero. One of the reasons why it does not produce them no one that could not be universal. They should provide a DC current to the LEDs and thus would not be placed on the cable that carries the alternating voltage.

Conclusions

Probably in these years no dimmer which produces no flickering. So our advice is to try them, make sure they have a flickering exaggerated and delete them. This will favor the emergence of new generations of well-designed dimmer.