WAVES
WLM
LOUDNESS METER
USER GUIDE

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Chapter 1 – Introduction

1.1 Welcome

Thank you for choosing Waves! In order to get the most out of your new Waves plugin, please take a moment to read this user guide.

To install software and manage your licenses, you need to have a free Waves account. Sign up at www.waves.com. With a Waves account you can keep track of your products, renew your Waves Update Plan, participate in bonus programs, and keep up to date with important information.

We suggest that you become familiar with the Waves Support pages: www.waves.com/support. There are technical articles about installation, troubleshooting, specifications, and more. Plus, you'll find company contact information and Waves Support news.

1.2 Product Overview

The Waves WLM Loudness Meter plugin provides precision loudness measurement and metering for broadcast, movie trailers, games, packaged media and more. Fully compliant with all current ITU, EBU and ATSC specifications, the WLM offers comprehensive Momentary, Short Term, Long Term, Loudness Range, and True Peak readouts, plus a unique warning and logging system that keeps track of your levels, and lets you know when you've exceeded them—or fallen short. The WLM Plus expands upon these powerful metering capabilities with the addition of an ITU compliant True Peak Limiter including Gain and Trim controls to easily normalize your program loudness. Ideal for content creators, post production houses and cable head-end facilities, the WLM is an affordable, all-in-one loudness metering software solution.

1.3 Concepts and Terminology

Loudness Metering

Loudness metering measures signal loudness using special weight filtering and averaging techniques which allow perceived loudness levels to be expressed numerically, using a variety of measurement scales:

• LU = Loudness Units

• LUFS = Loudness Units relative to Full Scale

• LKFS = Loudness, K-weighted, relative to Full Scale

• dBFS = Decibels relative to Full Scale

• dBTP = Decibels True Peak

Measurement Standards

WLM is fully compliant with all contemporary loudness measurement standards:

• ITU-R BS.1770-3

• EBU R 128

• ATSC A/85

Measurement Methods

WLM allows the user to choose one of three measurement methods:

• EBU uses foreground audio as the loudness anchor.

• LM1 measures and averages loudness across the whole program.

• DIAL uses dialog as the loudness anchor, measuring and averaging loudness only when dialog is detected.

Timescales

WLM provides readouts for four timescales:

• Momentary

• Short Term

• Long Term

• True Peak

Weighting

WLM provides readouts for the following weighting types:

• ITU-R B.S.1770 – K-Weighting
• Leq(a)
• Leq(b)
• Leq(c)
• Leq(m)

For in-depth information about measurement methods, measurement standards, timescales, and weighting, please see the Appendix at the end of this manual.

1.4 Components

The WLM has eight components:

- WLM Mono
- WLM Stereo
- WLM Multichannel 5.0
- WLM Multichannel 5.1
- WLM Plus Mono
- WLM Plus Stereo
- WLM Plus Multichannel 5.0
- WLM Plus Multichannel 5.1

In all components, measurements are summed into a single number. To view measurements for a single channel or combination of channels, use the Channels control.

Chapter 2 – Using the WLM

2.1 Quick Start Guide

The WLM's default preset is designed to check levels as per both EBU and ATSC specs. As both specifications allow some tolerance, the target is set to -24 dB, 1 dB lower than the EBU standard; however, -1 dB is not considered a violation.

1. Identify your loudness requirements.
2. Insert WLM or WLM Plus on your program output.
3. Select the appropriate preset.
4. If you would like to create a log file, click the Export CSV button.
5. Play your program through WLM.
6. Watch the meters to view the loudness measurements.

After playing the entire program, check the Long Term meter to ascertain that your program complies with the required target.

To normalize the loudness measurement and ensure the program material does not exceed True Peak levels, you may use the WLM Plus component in the following manner after the initial measurement described above:

1. Click the Trim button.
2. Click Reset button.
3. Activate the True Peak Limiter.
4. If you would like to create a log file, click the Export CSV button.
5. Play your program through WLM Plus to re-measure.

2.2 Usage Notes

The following are a few of the WLM features designed to enhance your workflow.

Presets

WLM presets fulfill most of the requirements commonly encountered by post production engineers and content providers.

- The WLM factory default is designed to cover most cases, and its results will meet both EBU and ATSC recommendations for most programs.

- The "EBU R 128 18 dB" preset complies with the recommendations specified in the EBU R 128 and its accompanying technical papers including tech 3341 – 3343 and ITU-R B.S. 1770-2

- The "ATSC A85" preset features follows recommendations specified by the Advanced Television Systems Committee.

Set As Default Preset

To save a particular setup as the WLM default, click Save and choose Set As Default Preset. (You can still load factory presets or saved presets.)
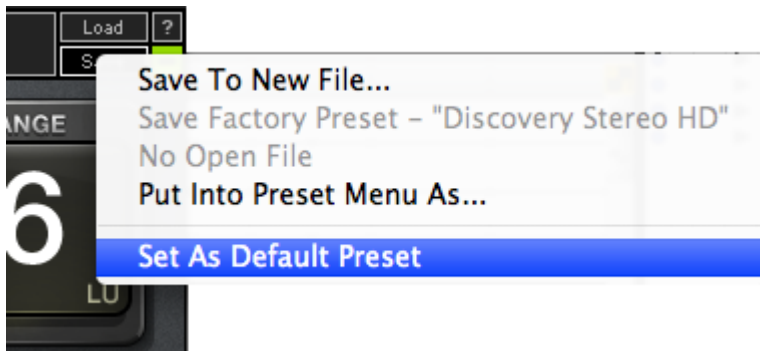
Logging

To document your metering history, the WLM can generate CSV log files that document the readings of all three measurement methods (EBU, LM1, DIAL) simultaneously. The CSV file can then be imported into a spreadsheet using Microsoft Office Excel or Open Office Calc.

To create a log, click Export CSV and choose from the following:

- **Select Real-Time CSV File** – Choose this option if you need ongoing infinite logging over a real-time audio stream. Remember to create the CSV log file in advance and the logging will take place in real time during measurements. *(Recommended for Pro Tools RTAS.)*
- **Select Off-Line CSV File** – Choose this option when you want to scan a premixed file and draw a log. This file is written only when the WLM plugin is closed, and logs up to four hours of measurements. So, in case you forget to set a real-time log file, you can save an Off-Line CSV which will contain loudness information of the first 4 hours of measurements carried out by that plugin instance. *(Recommended for Pro Tools Audiosuite.)*

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
94	15:43:25	00:01:28	-27	*	-17	No Anchor		-120	-41.8	*	-17	-19.9		
95	15:43:26	00:01:29		*	-17			-120	-38.8	*		-140		
96	15:43:27	00:01:30		*	-17			-120	-38.8	*		-61.1		
97	15:43:28	00:01:31	-48.9	*	-17.1	No Anchor		-120	-41.5	*	-17	-37.1		
98														
99	Realtime Log Reset: Sun Dec 11 15:43:29													
100														
101	System Time	WLM Time	Short LM1	LM1 Warn	Long LM1	Short Dialog	Dialog Warn	Long Dialog	Short EBU	EBU Warn	Long EBU	TruePeak	TP Warnings	
102	15:43:30	00:00:01	-42.2		-42.2	No Anchor		-120	-44.3	*	-42.3	-19.9		
103	15:43:31	00:00:02	-42.4		-42.4	No Anchor		-120	-42.6	*	-42.4	-19.9		
104	15:43:32	00:00:03	-43.2		-43.2	No Anchor		-120	-44.7	*	-43.2	-19.9		
105	15:43:33	00:00:04	-41.1		-41.1	No Anchor		-120	-40.7	*	-41.2	-19.9		
106	15:43:34	00:00:05	-35.1	*	-35.1	No Anchor		-120	-32.8	*	-33.7	-15.4		
107	15:43:35	00:00:06	-32.1	*	-32.1	No Anchor		-120	-28.8		-30	-14.7		
108	15:43:36	00:00:07	-31.4		-31.4	No Anchor		-120	-27.6		-29.3	-15.7		
109	15:43:37	00:00:08	-30.9		-30.9	No Anchor		-120	-27.6		-29.2	-14.3		
110	15:43:38	00:00:09	-30.3		-30.3	No Anchor		-120	-27.9		-28.5	-14.5		
111	15:43:39	00:00:10	-29.8		-30.1	No Anchor		-120	-27.8		-28.5	-16.8		
112	15:43:40	00:00:11	-29.2		-29.9	No Anchor		-120	-27.8		-28.4	-13.6		
113	15:43:41	00:00:12	-28.6		-29.7	No Anchor		-120	-27.9		-28.3	-12.2		
114	15:43:42	00:00:13	-28.3		-29.7	No Anchor		-120	-28.3		-28.4	-16.3		
115	15:43:43	00:00:14	-27.8		-29.4	No Anchor		-120	-28.2		-28.4	-14.5		
116	15:43:44	00:00:15	-28.1		-29.6	No Anchor		-120	-29.2		-28.5	-19.5		
117	15:43:45	00:00:16	-28.5		-29.6	No Anchor		-120	-29.4		-28.6	-19.3		
118	15:43:46	00:00:17	-28.5		-29.6	No Anchor		-120	-29.7		-28.6	-17.4		
119	15:43:47	00:00:18	-28.6		-29.5	No Anchor		-120	-29.3		-28.7	-19.4		
120	15:43:48	00:00:19	-28.5		-29.3	No Anchor		-120	-28.1		-28.5	-13.1		
121	15:43:49	00:00:20	-28.4		-29.2	No Anchor		-120	-27.7		-28.4	-13.1		
122	15:43:50	00:00:21	-27.8		-28.8	No Anchor		-120	-26		-28	-13.4		

WLM Output

Warnings

The WLM issues warnings when loudness targets are not met or exceeded.

Short Term Min – When short term loudness falls below the minimum value, the display appears in light blue until loudness is back above the minimum for 5 seconds. This warning is also registered by the Unders counter and in the CSV log file.

Short Term Max – When short term loudness exceeds the maximum value, the display appears in red until loudness falls back below the maximum for 5 seconds. This warning is also registered by the Overs counter and in the CSV log file.

True Peak Max – When True Peak loudness exceeds the maximum value, the display appears in red until the peak hold numeric display is reset.

Whenever a warning is issued, an asterisk (*) will appear in the corresponding warning column of the CSV log.

Automation Warning

The WLM registers Overs and Unders in the counters below the Short Term numeric display. If you would like to know when these readings occurred, you can either refer to your log, or use the Automation Warning feature.

The WLM includes a special control that does not appear on the plugin interface, but does show up in the automation parameters. When the host is set to write automation for the Automation Warnings control, it will display a line in the middle of the lane indicating compliant loudness levels. When an Over is detected, it will write a step to the maximum value; conversely, it will display a downward step when an Under is detected:
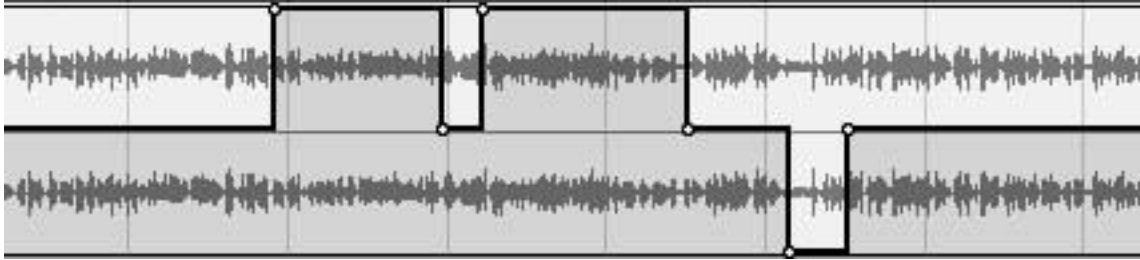
You can use this automation lane to identify parts of the program that require further attention. Adjust the loudness immediately preceding and during the event; once you have fixed the problem area, ascertain the warning does not re-occur by resetting the WLM and measuring the section again, starting a bit before the Over appears.

Chapter 3 – Interface and Controls

3.1 Interface

WLM

WLM Plus

3.2 Controls and Displays

Meters Section

1. Short Term Displays (in LUFS/LKFS) perceived short term loudness.

2. Long Term Displays (in LUFS) perceived loudness averaged across the program signal that passes through the plugin during the period specified by the Integration Time Counter.

3. Range Displays (in LU) the overall loudness range across the program signal that passes through the plugin.

4. Momentary Displays (in LUFS) momentary loudness levels, according to the Momentary scale control settings. A peak value indicator displaying maximum momentary loudness is located to the right of the bar meter, and can be reset by clicking on it.

Range: -53 to -8

5. True Peak Displays (in dBTP) inter-sample peaks which do not register in the sample data but may occur during reproduction of the digital signal. A peak value indicator displaying maximum True Peak is located to the right of the bar meter, and can be reset by clicking on it.

Range: -58 to +6

6. Unders Displays the number of times the signal goes below the specified Short Term Min value indicated in the settings panel.

7. Overs Displays the number of times the signal exceeds the specified Short Term Max value indicated in the settings panel.

8. Measurements Play/Pause Determines if program loudness is registered in the WLM memory for averaging long term loudness range. When Play is activated, loudness is registered and averaged.

9. Follow Transport Determines if measurement starts and stops according to host application transport controls. When engaged, the timer also starts and stops according to host application transport controls.

10. Timer Indicates the amount of time measurements have been taken and integrated.

11. Reset Resets the Long Term, Range, Overs and Unders counters and returns the integration timer to 00:00:00.

Processing Panel

The Processing Panel is available in the WLM Plus components

12. True Peak Limiter Activates the True Peak Limiter compliant with ITU 1770-3. The threshold is automatically defined by the "True Peak Max" value located in the "Settings Panel". The True Peak Limiter is independent of the "Channels" setting and affects all channels. The limiter does not introduce make-up gain.

Range: On /Off

Default: Off

13. GR Meter Displays the amount of gain attenuation being applied by the Limiter. A peak value indicator displaying maximum gain reduction is located to the right of the bar meter, and can be reset by clicking on it.

14. Gain Fader / Slider control allowing to boost or cut (Linear Gain) the meter's input by 18 dB. This affects the signal before all measurements available in the plug-in. The Gain is independent of the "Channels" setting and affects all channels.

Range: +/-18 dB

Default: 0 dB

15. Trim A clickable button combined with a value indicator. The value indicator displays in real time the difference between the Target Level and Long Term Loudness measurement (higher resolution figure). Clicking the "Trim" will apply the calculated value to the Gain Fader. It is recommended to use this feature once completing a measurement and not during playback. The Trim can boost the Gain by a maximum of 12 dB and cut the gain by it's maximum available range. Once "Trim" has been applied the control is unavailable until a new long term measurement has been calculated.

Default: 0 dB

Settings Panel

The Settings Panel is collapsible, hiding it from view when not in use.

16. Method Determines the measurement method.

- **EBU** Uses foreground audio as the loudness anchor, as per the EBU R 128 standard, and all current specifications incorporated in ITU-R BS.1770-2.
- **LM1** Measures and averages loudness across the whole program.
- **DIAL** Uses the dialog as the anchor element, measuring and averaging loudness only when dialog is detected.

17. Channel Determines the channels being measured.

18. Weighting Determines the type of weighting filter.

Range: ITU-R B.S.1770 (default), Leq(a), Leq(b), Leq(c), Leq(m), none

19. Short Time Determines the duration of the Short Term measurement in LM1 and Dial modes. *(In EBU mode, duration is fixed to 3 sec.)*
Range: 400 ms, 1 sec, 2 sec, 3 sec, 10 sec, 30 sec, 1 min, 2 min

20. Short Term Max Determines the maximum short term level. When short term loudness exceeds the maximum value, the display appears in red until loudness falls back below the maximum for 5 seconds.
Range: Off, -12 to -36; in Leq(m) 70 to 92 dB

21. Short Term Min Determines the minimum short term level. When short term loudness falls below the minimum value, the display appears in light blue until loudness is back above the minimum for 5 seconds.

Range: -12 to -90, Off; In Leq(m), 42 to 83 dB

Please note: When Leq(m) is selected, Short Term Max and Min controls scale to dBSPL positive values.

22. True Peak Max Determines the maximum true peak level. When True Peak loudness exceeds the maximum value, the display appears in red until the peak hold numeric display is reset. This control also defines the True Peak Limiter's threshold in the WLM Plus components.

Range: 0 to -25 dBTP

23. Target Determines the target level.

Range: Off, -33 to -9 dB

24. Custom Pre Filtering Provides low pass (LPF) and high pass (HPF) filters that pre-filter the audio prior to loudness measurement, useful when checking content intended for playback on devices with limited frequency ranges, such as handheld gaming consoles.

- **LPF On**

    Range: On, Off

    Default: Off

- **LPF Frequency**

    Range: 2000 Hz to 18000 Hz

    Default: 10000 Hz

- **LPF Slope**

  Range: 12 dB/Oct, 6 dB/Oct

  Default: 12 dB/Oct

- **HPF On**

  Range: On, Off

  Default: Off

- **HPF Frequency**

  Range: 20 Hz to 2000 Hz

  Default: 120 Hz

- **HPF Slope**

  Range: 12 dB/Oct, 6 dB/Oct

  Default: 12 dB/Oct

25. **Momentary Scale** Determines the scale displayed in the momentary bar meter.

- LKFS: -6 to -54

- LU 18 dB: 17 to -31

- LUFS 18 dB: -6 to -54

- LU 9 dB: 9 to -18

- LUFS 9 dB: -14 to -41

26. Logging Displays CSV logging file options.

- **Select Real-Time CSV File** – Choose this option if you need ongoing infinite logging over a real-time audio stream. Remember to create the CSV log file in advance and the logging will take place in real time during measurements. *(Pro Tools RTAS should choose this method.)*

- **Select Off-Line CSV File** – Choose this option when you want to scan a premixed file and draw a log. This file is written only when the WLM plugin is closed, and logs up to four hours of measurements. So, in case you forget to set a real-time log file, you can save an Off-Line CSV which will contain loudness information of the first 4 hours of measurements carried out by that plugin instance. *(Pro Tools Audiosuite users should choose this method.)*

Please note: You must create your log file prior to measuring your program. Off-line logs are generated only upon termination of the plugin instance.

3.3 WaveSystem Toolbar

Use the bar at the top of the plugin to save and load presets, compare settings, undo and redo steps, and resize the plugin. To learn more, click the icon at the upper-right corner of the window and open the WaveSystem Guide.

Appendix

Audio Loudness Metering

Loudness is the perception of audio level as perceived by humans. In broadcast, it is especially important that transmitted audio levels are consistent; otherwise, listeners would need to adjust the volume for every song, movie scene, commercial advertisement, and so on.

Loudness metering measures signal loudness using special weight filtering and averaging techniques which allow perceived loudness levels to be expressed numerically.

These numbers can be used by broadcasters to identify the loudness of a particular program or advertisement to determine if it is consistent with station or network regulations. Many countries enact laws legislating permissible loudness levels, and empower broadcast authorities to monitor levels and impose fines on broadcasters who violate these guidelines.

Broadcast networks typically provide loudness specifications to their contractors, post production and mixing facilities. These specifications indicate acceptable loudness target values, as well as which weighting filters and timescale need to be taken into consideration. In many cases, they will even recommend a specific device that measures program loudness according to their specifications.

Loudness Theory and Practice

The WLM was created to comply with contemporary loudness measurement standards, as described in a number of technical papers as listed herein:

ITU-R BS.1770-3 (August 2012) - *Algorithms to measure audio programme loudness and true-peak audio level*.
https://www.itu.int/dms_pubrec/itu-r/rec/bs/R-REC-BS.1770-4-201510-I!!PDF-E.pdf

This recommendation by the International Telecommunication Union is a staple in contemporary loudness measurements. It is a second generation revision, after the original specification created widely-accepted measurement guidelines which utilized a special weighting curve (K weighting) and established the LKFS measurement unit: Loudness K-Weighted relative to Full Scale.

EBU R 128 (August 2011rev.) - *Loudness normalisation and permitted maximum level of audio signals.*
http://tech.ebu.ch/docs/r/r128.pdf

This recommendation by the European Broadcasting Union is gaining wide acceptance as standard loudness practice across Europe. The EBU R 128 is a guideline paper which considers the ITU recommendations and expands upon them, referencing to specifications described in another 4 technical papers:

EBU Tech 3341   Metering Specification
EBU Tech 3342   Loudness Range Descriptor
EBU Tech 3343   Practical Guidelines
EBU Tech 3344   Distribution Guidelines

The EBU spec takes into account that voice and dialog loudness can miss certain loud passages, and uses the "Foreground" sound as the basis for loudness, Using a special gating scheme with an absolute and a relative gate to identify background sound and not include it in the averaged long term loudness.

ATSC A/85 (July 2011) - *Techniques for Establishing and Maintaining Audio Loudness for Digital Television.*
https://www.atsc.org/wp-content/uploads/2015/03/Techniques-for-establishing-and-maintaining-audio-loudness.pdf

This recommendation paper from the Advanced Television Systems Committee is gaining wide acceptance from US broadcast networks, especially with regard to digital TV. This latest revision approaches the EBU recommendations, but maintains that Dialog be used as the anchor for loudness measurements. While using a dialog anchor has proven highly accurate for talk and narration-based programs, for action and musical programs, measuring all audio provides better results.

Measurement Method

WLM allows the user to choose from three measurement methods:

- **EBU** – As per the EBU recommendation, WLM displays three different timescales: Momentary, Short and Long/Integrated, as well as True Peak and Loudness Range, which are also part of the EBU recommendation. The Momentary scale can show 2 resolutions, 18 dB and 9 dB in either LUFS or LU. With EBU selected as the measurement method, WLM uses foreground audio as the loudness anchor and, while it will measure short term loudness across the whole program, it will average and integrate only the foreground loudness to the long term measurement, gating out sections that fall more than 8 dB below the normal foreground audio. (The exact specification may be found online.)

  The WLM was tested using qualification material supplied by PLoud and EBU. To be fully compliant with the EBU recommendation, the weighting has to be per ITU-R BS 1770 and the target loudness is always -23 LUFS = 0 LU. Factory presets marked "EBU" ensure that its settings are fully EBU-compliant.

- **LM1** – This method sometimes called "All" measures and averages loudness across the whole program, without selecting any single element as an anchor.

- **DIAL** – This method uses dialog as the loudness anchor, measuring and averaging loudness only when dialog is detected. It uses the same specifications as the LM1 but uses the Dialog as the anchor element, effectively measuring and averaging loudness only when dialog is detected, gating out any sections that do not include dialog.

Weighting and Timescales

One of the basic concepts of loudness measurement theory is *weighting.* Essentially human hearing is profiled with a curve that describes our sensitivity to frequencies. The general rule is that all frequencies generated at the same energy will seem louder in the mid-range frequencies, and lower in very high and very low frequencies. This rule has

different specific results at different general SPL levels. i.e., the lower the overall energy, the bigger these differences will become, and at low levels, the ear will focus on mid and high mid frequencies and completely lose perception of the ultra high and very low frequencies.

The basis of this theory is well known as the Fletcher Munson equal loudness curves, which describe frequency response "Filters" that enable humans to perceive equal loudness across the audible frequency range. Additionally, the "opposites" of these filters were used to filter audio content and weigh its relative loudness to the human ear. Most common among these "weighting filters" is the A weighting, used in Leq(a) based loudness measurements for acoustic measurements. The refinement of weighting lead to the success of K-Weighting, which is the contemporary loudness curve recommended in the ITU-R B.S.1770 as well as the EBU and ATSC specifications.

Another critically important concept in loudness metering is the *timescale* of the measurement. Psychoacoustic theory stresses that we perceive loudness from the average, rather than the momentary peaks, i.e., a very short and loud transient peak won't make as big an impression on our perception of loudness, but a similar event lasting around half a second can cause discomfort. The same amount of energy lasting for several seconds or more will have an impact on our longer term perception of loudness we hear. Several timescales that affect our perception of loudness have been established and documented in the ITU and EBU recommendations:

- **Momentary** measures 400 ms of signal, sufficient for the shortest loudness timescale. As this measurement is quite fast, WLM displays it using a bar meter with smoothed release ballistics.

- **Short Term or Short** averages loudness over a period of 1 to several seconds, with some overlap between the time slices. WLM shows this number in a large numeric display; dB is rounded to the nearest whole number; the same short term value with 1 decimal space is visible within the same window in a smaller font.

- **Long Term or Integrated** relates to ongoing averaging of the whole program. This is very often the basic value that interests loudness users. Over time, the program averages to the required target.

- **True Peak** provides sub-sample accuracy for measuring inter-sample peaks in digital audio. Depending on the current wave front, two consecutive samples may interpolate to a higher one that is missed in quantization.