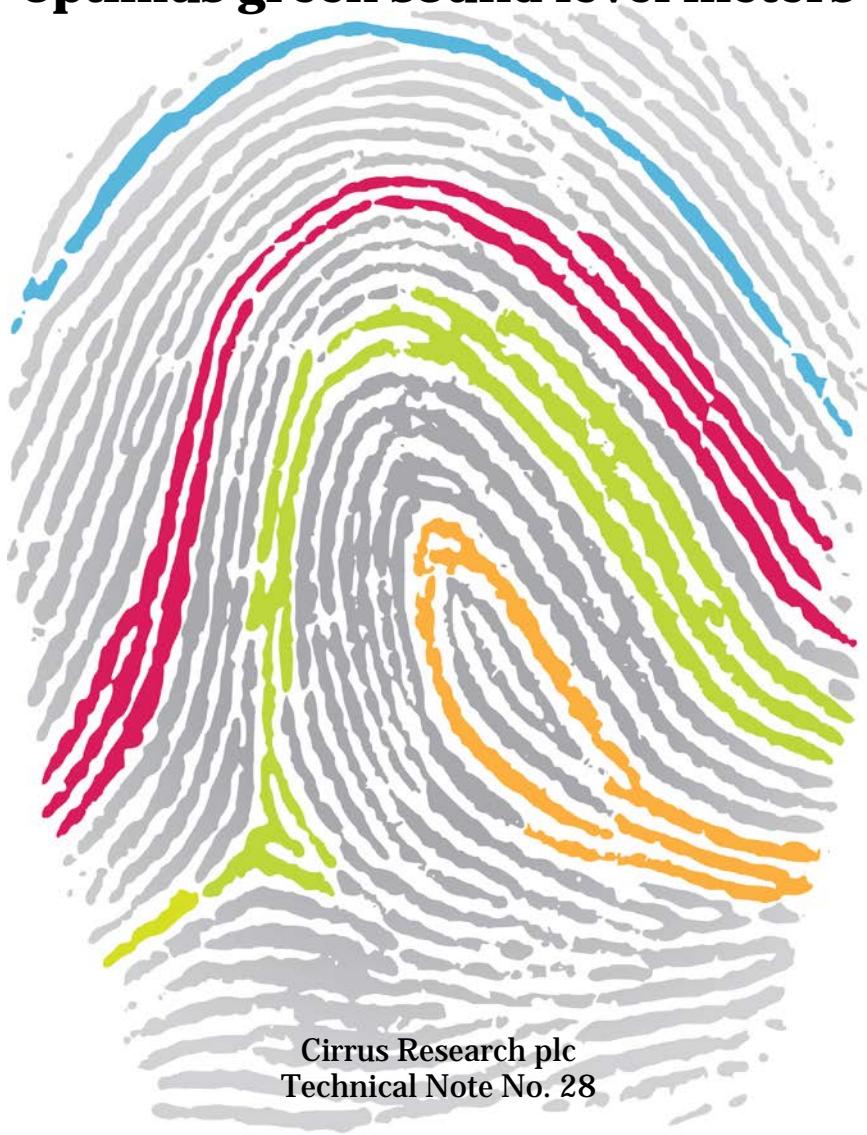


Acoustic Fingerprint™

Recording Audio with the optimus green sound level meters



Cirrus Research plc
Technical Note No. 28



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1 Introduction

The optimus green sound level meters can record and store audio information during a measurement. These recordings can be started manually, automatically or by both of these methods.

- Manual Recordings are started by pressing the Audio soft key during a measurement.
- Automatically triggered audio recordings are controlled by a set of templates which contain rules that determine when the recordings are triggered.

The audio recording feature is a very useful optimus feature that can be used to record noise events while unattended.

To avoid the tedious analysis of hours of audio, the optimus lets you set some conditions to automatically trigger audio recording when something interesting is happening.

A wise use of triggers has two main advantages:

1. The user will only have a few small audio files to listen instead of hours of audio
2. It will save a lot of memory space on the instrument which means that more measurements can be stored.

The instruments can hold up to 5 different templates with up to 20 individual rules available between the templates.

Rules can be used individually or combined to give a sophisticated set of triggering options and each template can be named for identification with up to 14 characters.

Rules can use one of three methods, these being threshold triggering, rate of change triggering or tonal noise triggering.

The tonal noise triggering (see section 7) option is only available in the CR:171C and CR:172C instruments.

The optimus green instruments are supplied with a default threshold based template which can be used to try different scenarios or can be used to create a simple threshold based trigger. Information about this option is covered on page 8

To use the full set of configuration options, the optimus must be connected to the NoiseTools software.

This technical note describes the operation of the audio recording capability of the optimus green instruments.

2 Manual audio recording

Manual audio recording is the simplest way to make an audio recording. Recordings can be started and stopped using the Audio soft key when a measurement is running.

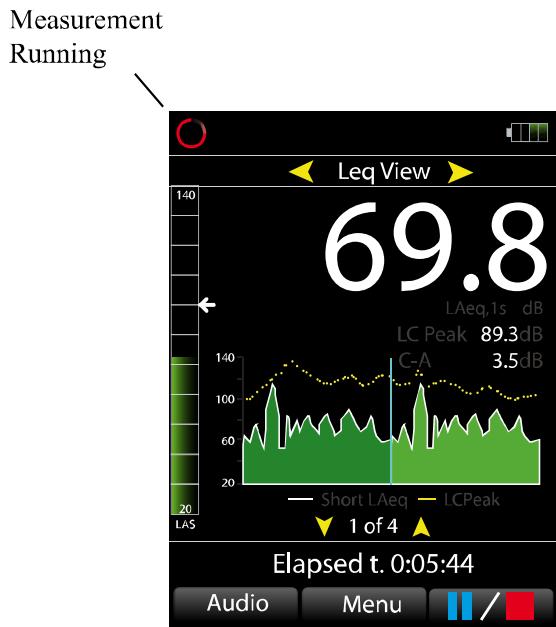


Figure 1

When the Audio key is pressed, a number of items on the display will change:

1. The Audio button will change colour from grey to green
2. The Analog Bar on the left side of the display will change from green to blue
3. The time history display will change from green to blue
4. The Audio Recording icon will be displayed in the status bar at the top of the screen

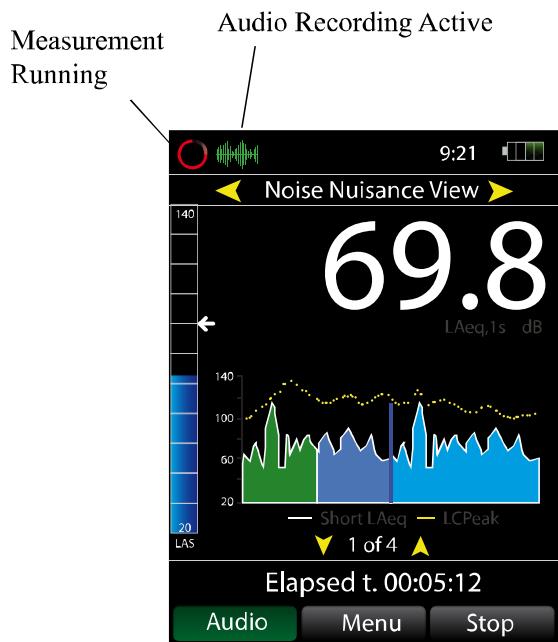


Figure 2

When the audio quality is set to Standard, the instrument provides a 10 second back-buffer or pre-trigger time.

The effect of this can be seen in the time history display. The darker blue colour shows the pre-trigger has been activated and will show 10 seconds prior to when the audio soft key was pressed. The image above shows the pre-trigger section (darker blue) followed by the lighter blue.

Pressing the Audio button again will end the audio recording. The measurement will continue.

2.1 Configuration options for manual audio recordings

The NoiseTools software allows the maximum duration of any single audio recording to set.

3 Triggered audio recordings

The second method to start and stop audio recordings within the optimus green sound level meters is to use the automatic triggers. These use a combination of templates and rules and can be used to create very simple triggers using a single rule or more complex and sophisticated triggers using multiple simultaneous rules.

At the top of the display in the status bar will be a grey icon of an ear. This shows that the audio triggering system is active, as shown below in Figure 3 below.

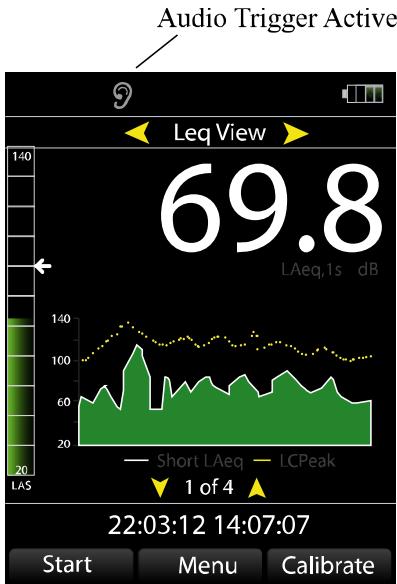


Figure 3

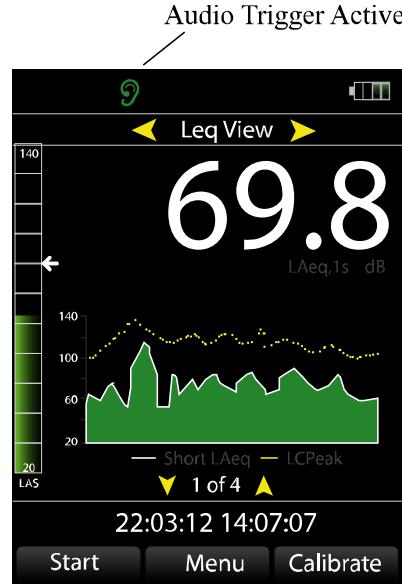


Figure 4

To test that the trigger is operating, simply make a noise that will meet the criteria. When the conditions for the rule are met, the icon will turn green as shown in figure 4 above.

When the instrument is running but no audio triggers are active, the grey ear icon is shown (see figure 5).



Figure 5

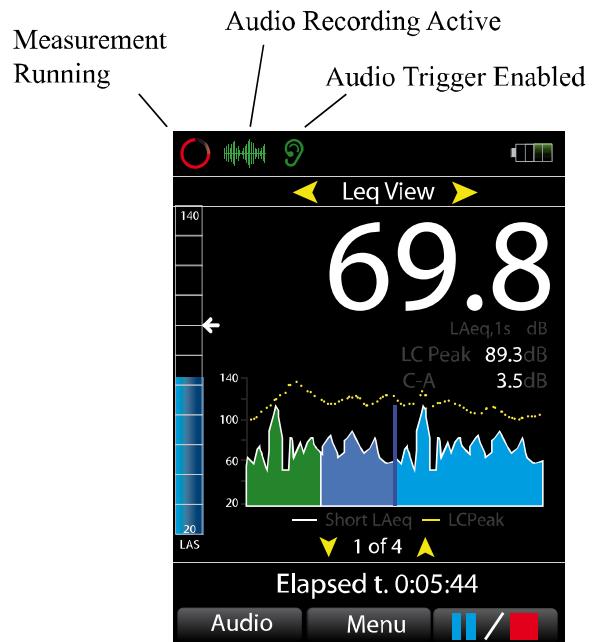


Figure 6

When the instrument is running and a template is triggered, the instrument will display an icon to show that audio is being recorded (see figure 6 above).

The Ear icon will also turn green to indicate that the template conditions have been met.

3.1 Using the simple threshold trigger in the optimus

The optimus is supplied with a simple template, called Default, with a single threshold rule using LAeq that can be used to demonstrate how the audio recording system operates. To activate the template, select Menu >Advanced Options > Audio Triggers



Figure 7



Figure 8

Highlight the Default option and press the Mark button. This will enable the trigger. Press the right hand arrow key to see the settings for the rule.

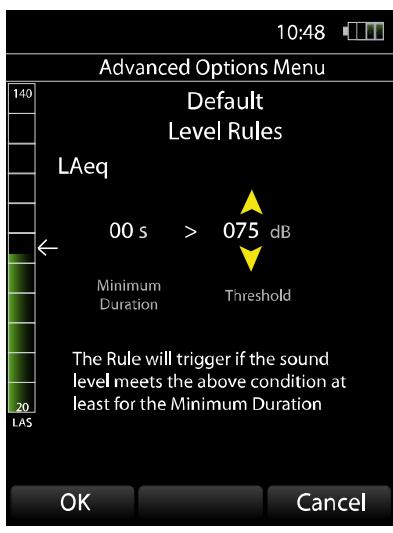


Figure 9

The Minimum Duration and the Threshold Level for the trigger can be set using the Up and Down arrows keys to increase or decrease the value and the Left and Right arrow keys to move between the values.

When any changes have been made, press the OK button, ensure that the Default template is ticked and press OK.

4 Advanced triggered templates

The following sections cover the configuration and use of audio recording templates and rules and include some example configurations.

4.1 Templates & Rules

The optimus sound level meters can support up to 5 templates, any or all of which can be active at any time, and up to 20 independent rules. A template contains rules and can be made up from a single, simple rule or a combination of different types of rules.

The 20 rules can be spread across the templates or used within a single template to create a very advanced triggering method.

Every Rule also has an Invert parameter that inverts its triggered state.

Example : *Trigger if the LAeq is above 75dB*

Inverted : Trigger if the LAeq is not above 75dB

Example: *Trigger if there is an increase in the LCeq of more than 15dB in 10 seconds*

Inverted : Trigger if there isn't an increase of the LCeq of more than 15dB in 10 seconds

Example: *Trigger if a tone is detected at 2kHz*

Inverted : Trigger if no tone is detected at 2kHz

Example *Trigger if a tone is detected*

Inverted : Trigger if no tone is detected

Templates and Rules can be set in the NoiseTools software. Templates can be enabled or disabled on the instrument from the Audio Triggers menu in Advanced Options.

Pressing the Right key will show an overview of the Rules of the highlighted Template. If the selected Template only has 1 Level Rule, pressing Right will instead go to an editor where the Threshold and Minimum Duration can be changed.

4.2 Additional information

-  Disabled Templates have a red LED icon on their side.
-  Enabled Templates have a dark green LED icon on their side.
-  This LED icon turns bright green if the Template is currently triggered.
- Icons representing the actions taken for the currently highlighted Template are displayed on the bottom of the screen.
 -  Green wavelength : Audio recording
 -  Envelope : SMS
 -  '@' character : E-mail
 -  Twitter blue bird : Tweet
 -  Marker Icon

A white arrow against the Analog Bar represents the position of the current Threshold.

4.3 Audio triggering parameters

The audio triggering within the optimus sound level meters can use almost any of the noise measurement parameters available in the instrument.

The more features that your instrument has, the more that are available to be used within the Templates and Rules.

The parameters that can be used are:

1. L_{xeq} (x = A, C, Z)
2. L_{xy} (x = A, C, Z ; y = F, S, I) – Sound Level
3. 1:1 and 1:3-octave (if supported)
4. LAE (Sound Exposure Level)

The data for these parameters is sampled at a rate of 1/16 second or 62.5msec.

4.3.1 Available actions to take

The instruments allow a number of different actions to be taken when a template is triggered and the instrument is measuring.

Some of these are only available when the instrument is fitted within the CK:680 outdoor noise measurement kit which provides 3G/GPRS and GPS support.

1. Start an audio recording (this is the default action available on all instruments)
2. Send an SMS to up to 3 predefined numbers (requires the CK:680)
3. Send an email to one or more predefined email addresses (requires the CK:680)
4. Send a Tweet to one predefined Twitter account

When a template is triggered, the time history data is automatically marked. This can be seen in NoiseTools software. An example is shown below.

4.3.2 Combining rules within a template

A template can contain up to 20 individual rules and these can be combined using AND and OR operators:

1. AND: The template will take action if all of its rules are triggered
2. OR: The template will take action if any of its rules are triggered

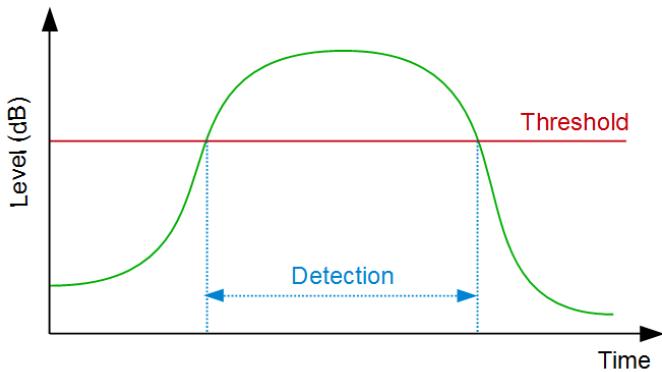
4.3.3 Additional options

1. Sustain duration : This extends the duration of the recording by a few seconds after the trigger conditions have ended. This can help to reduce the number of short recordings and works as a post-trigger.
2. Max Events per Timer : This limits the number of individual recordings that can be made within a single measurement period. If the instrument is set to repeating measurements, this limit applies to each individual measurement rather than the entire measurement duration. The default is for there to be no limit.

5 Threshold or Level rule

The threshold (or level) rule is the simplest of the three available. It uses a simple noise level in dB as the starting point, for example “Trigger when the LAeq is above 75dB for more than 5 seconds”.

This can be used, for example, to trigger a recording when a train passes or when a noise is detected within a frequency band.



Example: *Trigger if the LAeq is above 75dB for more than 5 seconds*

Example: *Trigger if the LAS goes below 30dB*

Data types: L_xeq (x = A, C, Z)
L_{xy} (x = A, C, Z ; y = F, S, I) – Sound Pressure Level
LAE - Sound Exposure Level
1:1 and 1:3-octave (where available)

Parameters:

1. **Threshold:** The level in dB to trigger when the level:
 - a. Is Above/ Is Below/ Goes Above/ Goes Below the threshold
2. **Minimum Duration:** The duration in seconds for which the noise level has to stay steadily above/below to trigger the rule (up to 10 seconds). Does not apply when LAE is selected
3. **Time Constant:** A time weighting applies to the detection. 0s (no time weighting), 62.5ms (approximates to Fast) and 1.2s (approximates to Slow). These are available as the detection system uses an internal sampling period of 1/16 second. Does not apply when LAE is selected.

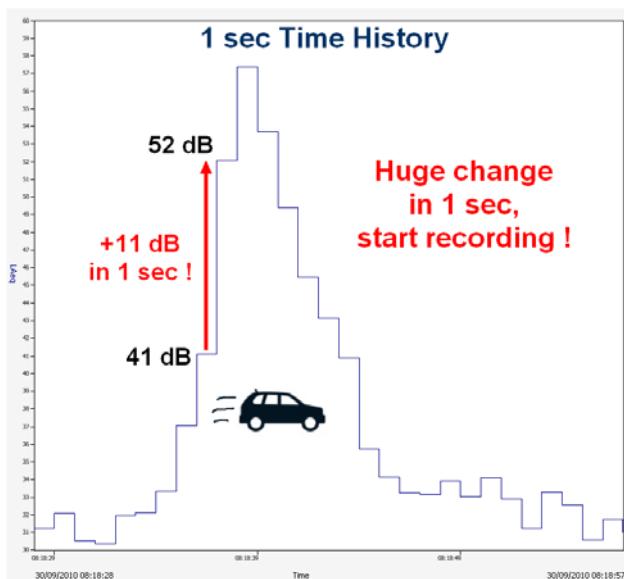
6 Rate of Change rule

The Rate of Change rule is very different to the Threshold rule. It is used to trigger recordings when the level changes at a certain speed and removes the link between level and triggering.

6.1 What is the rate of change?

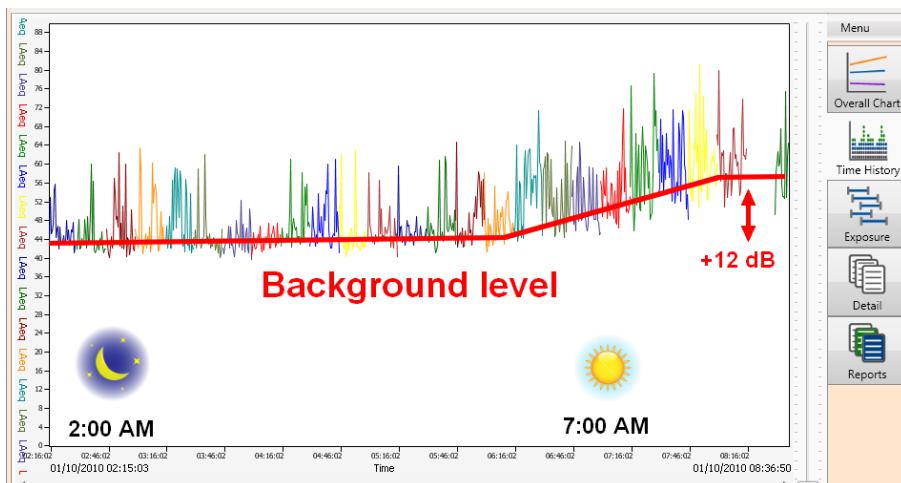
The rate of change is the "speed" at which the sound level changes, and it is usually expressed in dB per second (dB/s). It shows how *fast* the sound is changing.

A car passing by in a quiet morning changes the sound level significantly. In the example below, the rate of change threshold could be set to +10 dB/s to trigger audio recording when a car passes by.



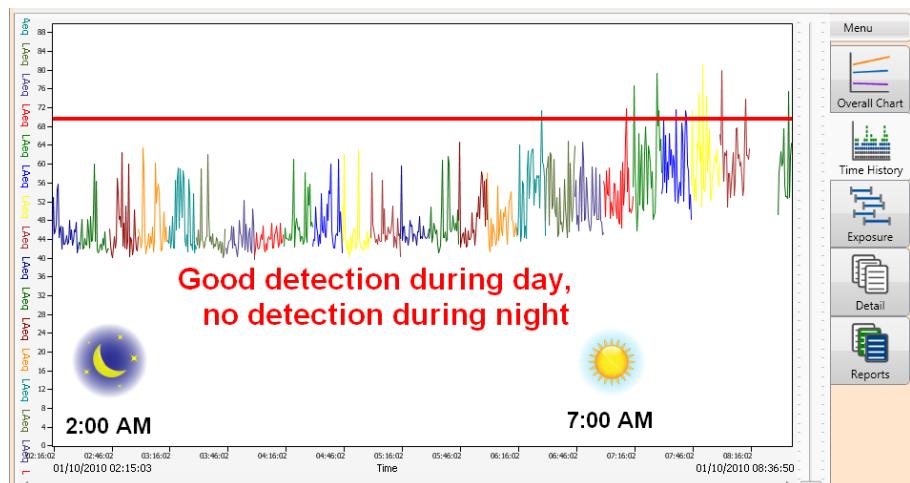
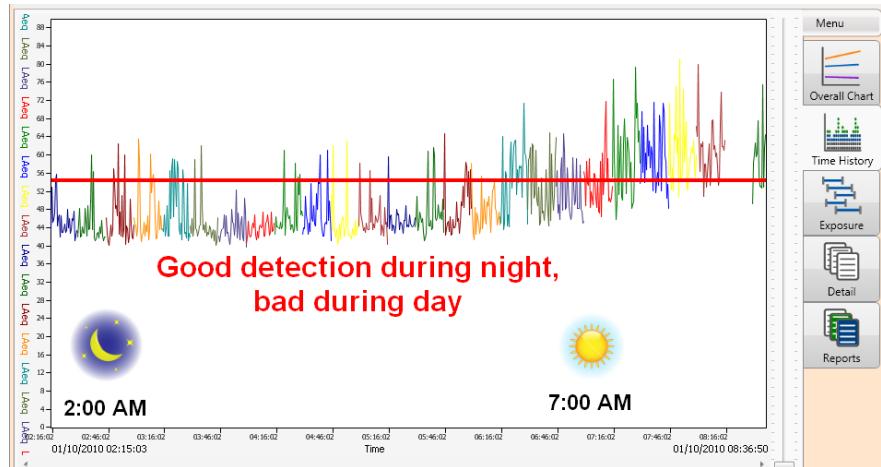
6.2 Why are rate of change rules useful?

A problem with level-based triggers is that they are background noise dependent, as seen in the following example:

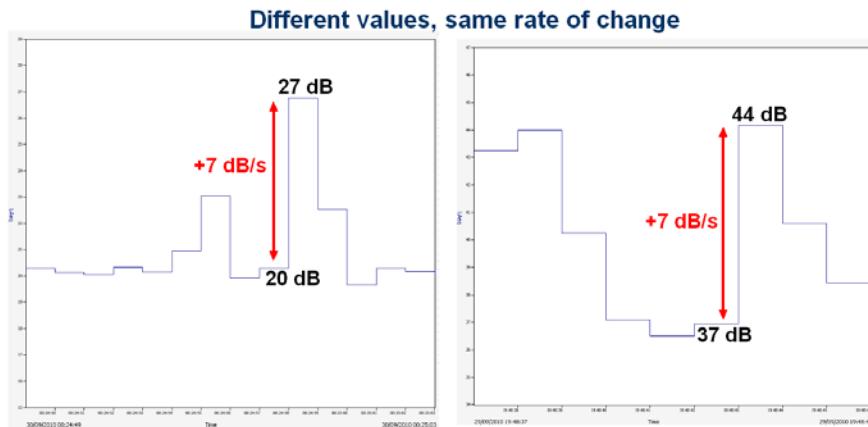


If one wants to record only cars in this measurement using a level-based trigger, it would fall into one of those two situations:

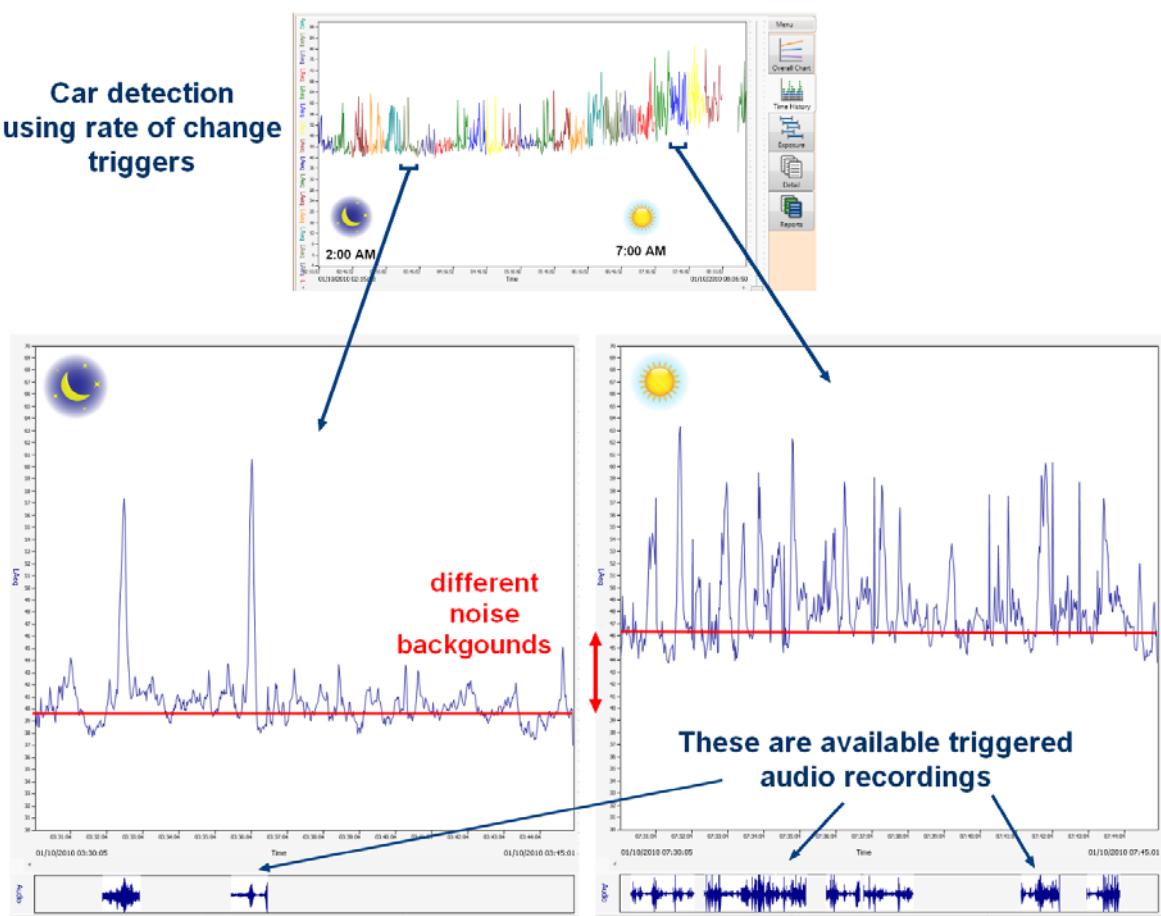
1. The threshold is set low to detect cars during the night, but because the background noise level increases in the morning, it would always trigger during the day.
2. The threshold is set to detect cars during the day, but because the background noise is lower during the night, it doesn't detect anything before 6:30 AM.



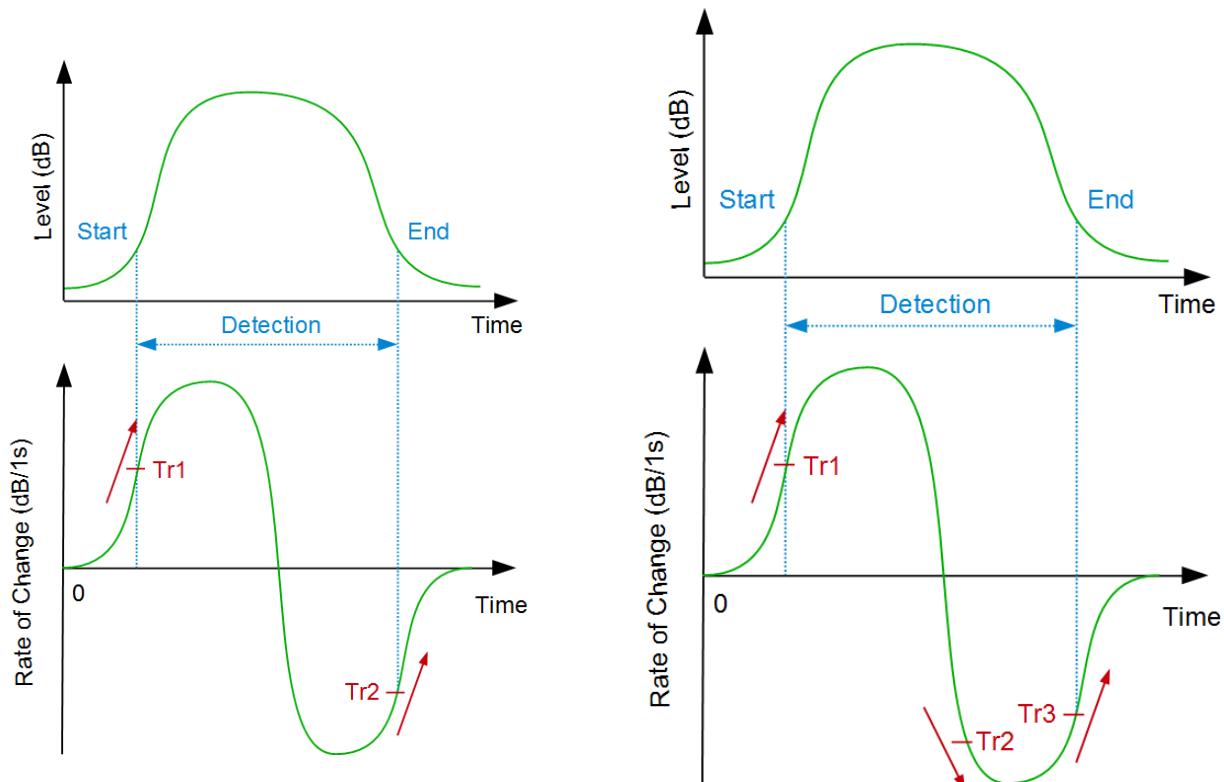
Rate of change based triggers don't have this problem because they look at changes in the noise instead of a fixed level, which means that they can detect things whatever the background noise is, night or day.



The following example taken from the earlier measurement shows that rate of change triggers are efficient for detecting events with different backgrounds so triggered audio recordings are available when the event is a car, both during night and day.



This allows much more sophisticated triggering templates to be created.



The Rate of Change is the difference of the current level and the level a few seconds before (the unit is then a number of dB/s).

Example: Trigger if there is an increase in the LAeq of more than 10 dB in 5 sec (10dB/5sec)

Example: Trigger if the LAeq has increased by at least 10dB since 5 seconds ago

Detection: Triggers when the level changes at a certain speed

Data types: Lxeq ($x = A, C, Z$)

Lxy ($x = A, C, Z ; y = F, S, I$) – Sound Level Meter

1:1 and 1:3-octave (where available)

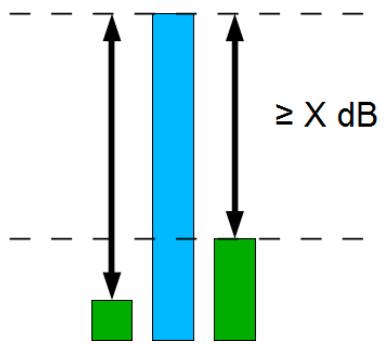
Parameters:

1. **Threshold 1** : Rate of Change to reach to trigger the Rule. Can be set to trigger if the Rate of Change :
 - a. Goes Above / Goes Below the Threshold
2. **Threshold 2** : Rate of Change to reach to stop the Rule. Can be set to trigger if the Rate of Change :
 - a. Goes Above / Goes Below the Threshold.
3. **Threshold 3 (optional)** : Additional Threshold that can be used for a more accurate detection. If used, typical settings are according to the graph below. Can be set to trigger if the Rate of Change :
 - a. Goes Above / Goes Below the Threshold
4. **Period** : Period of time over which the Rate of Change is evaluated. This parameter sets the unit of the Threshold.
 - a. Example : If Period is 5 seconds, the Rate of Change is the difference between the current level and the level 5 seconds ago. The unit of the Threshold is then X dB / 5 sec.
5. **Time Constant of the Time Weighting** in seconds.
 - a. Typical values are 0s (no time weighting), 62.5ms (~Fast weighting) and 1.2s (~Slow weighting). Note : The Time weighting is applied before evaluation of the Rate of Change. Does not apply when LAE is selected

7 Tonal Noise rule

The Tonal Noise rule allows recordings to be triggered when a tone is detected according to either the ISO 1996-2:2007 Simplified Method¹ or the Cirrus improved method².

This feature is available on the CR:171C & CR:172C instruments.



Example: *Trigger if a tone is detected in any band*

Example: *Trigger if a tone at 3,15kHz is detected*

Data types: 1:3 Octave Bands (6.3Hz to 20kHz) – 1 or any 1:3 Octave Band

Detection: Uses the currently selected Tone Detection Method (user selectable in NoiseTools)

Parameters:

- 1. Frequency Weighting**

1.1 If the ISO 1996-2:2007 is used, the frequency weighting is internally selected to ‘A’ weighting

1.2 If the Cirrus improved method is used, ‘A’ or ‘Z’ frequency weighting can be selected

2. **Minimum Duration.** The duration in seconds for which the tone has to be steadily detected to trigger the rule (up to 10 seconds which is the length of the audio back-buffer/pre-trigger)

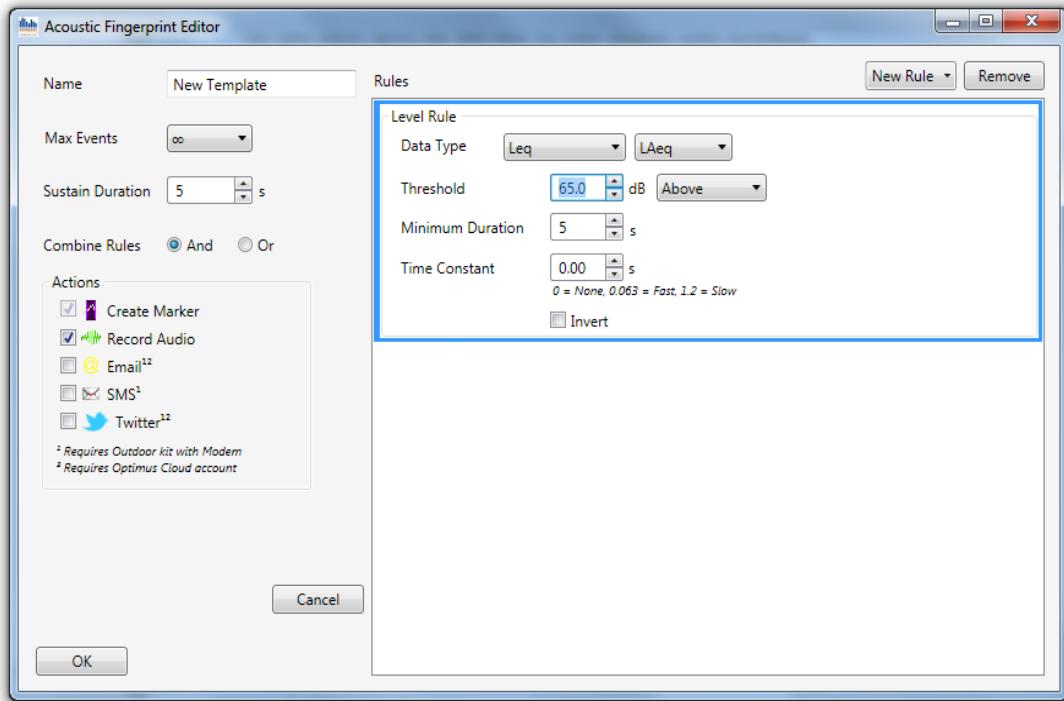
8 Example templates

This section contains some example triggering templates that can be used as a starting point for further development and testing.

8.1 Templates with single rules

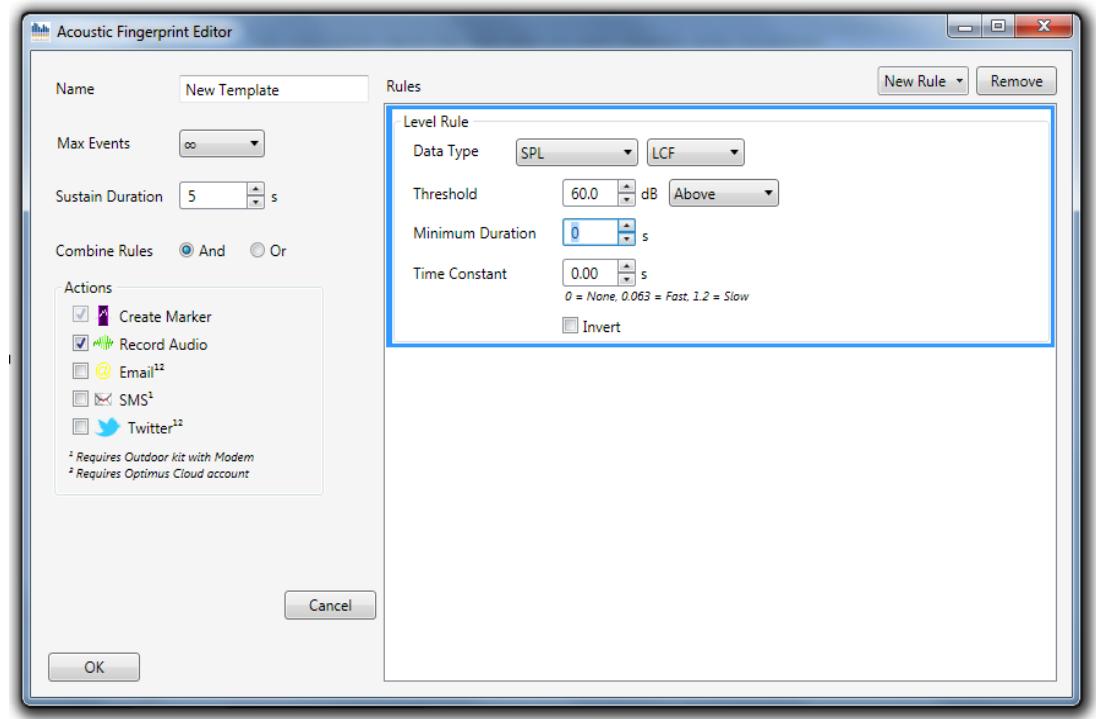
8.1.1 LAeq over 65dB for more than 5 seconds

Rule 1 - Level Rule : “Trigger if the LAeq is above 65 dB for more than 5 seconds”.



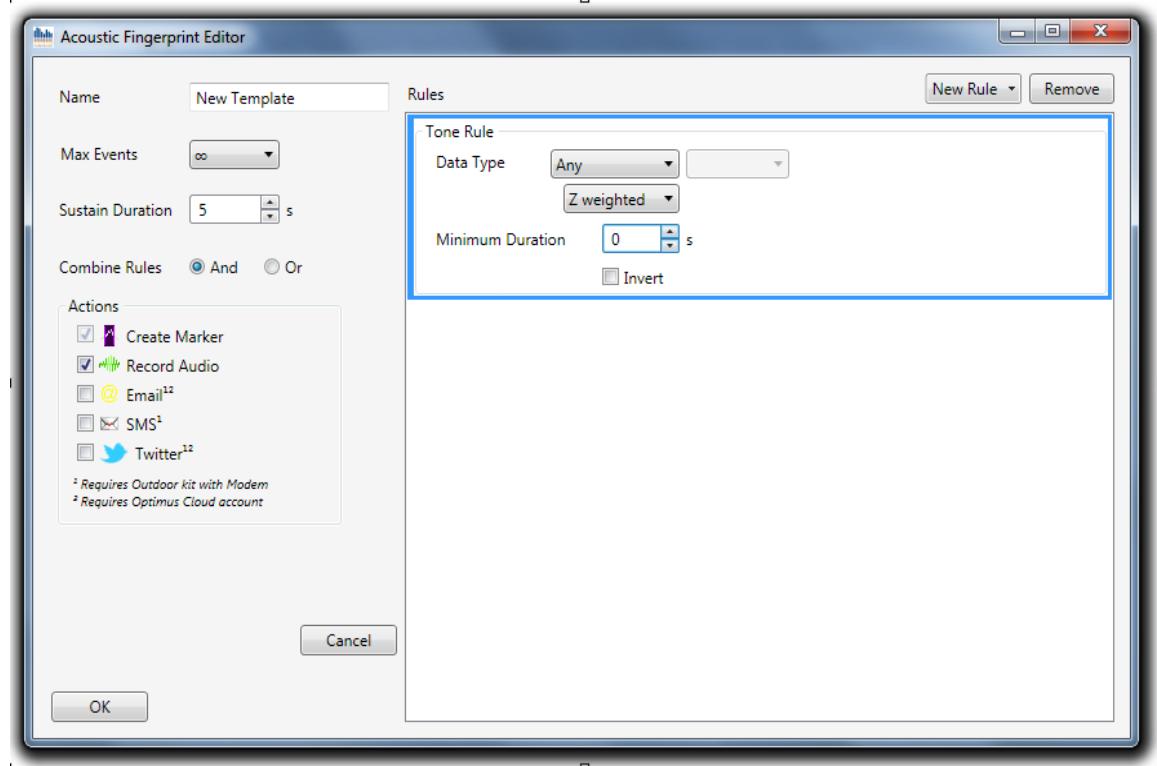
8.1.2 LCF over 60dB

Rule 1 - Level Rule : “Trigger if the LCF is above 60 dB.”



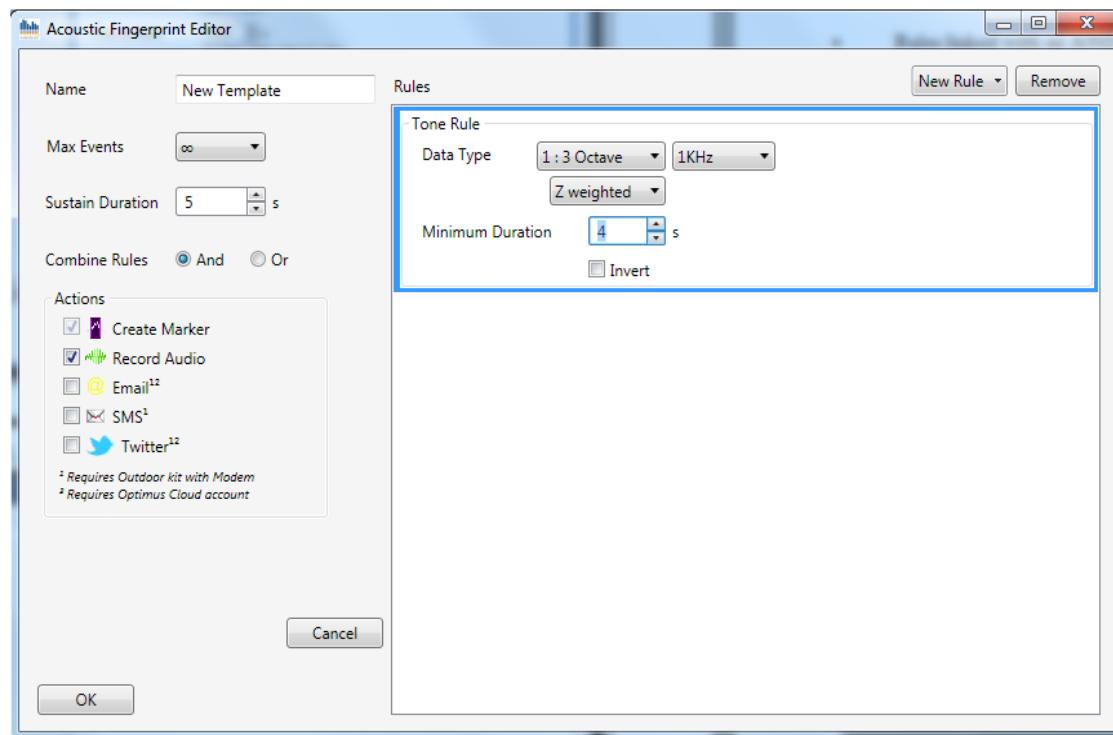
8.1.3 Tonal noise in any frequency band

Rule 1 - Level Rule : “Trigger if any tone is detected”.



8.1.4 Tonal noise in 1kHz octave band

Rule 1 - Level Rule : “Trigger if a tone is detected in the 1kHz 1:3 octave band for more than 5 seconds”.



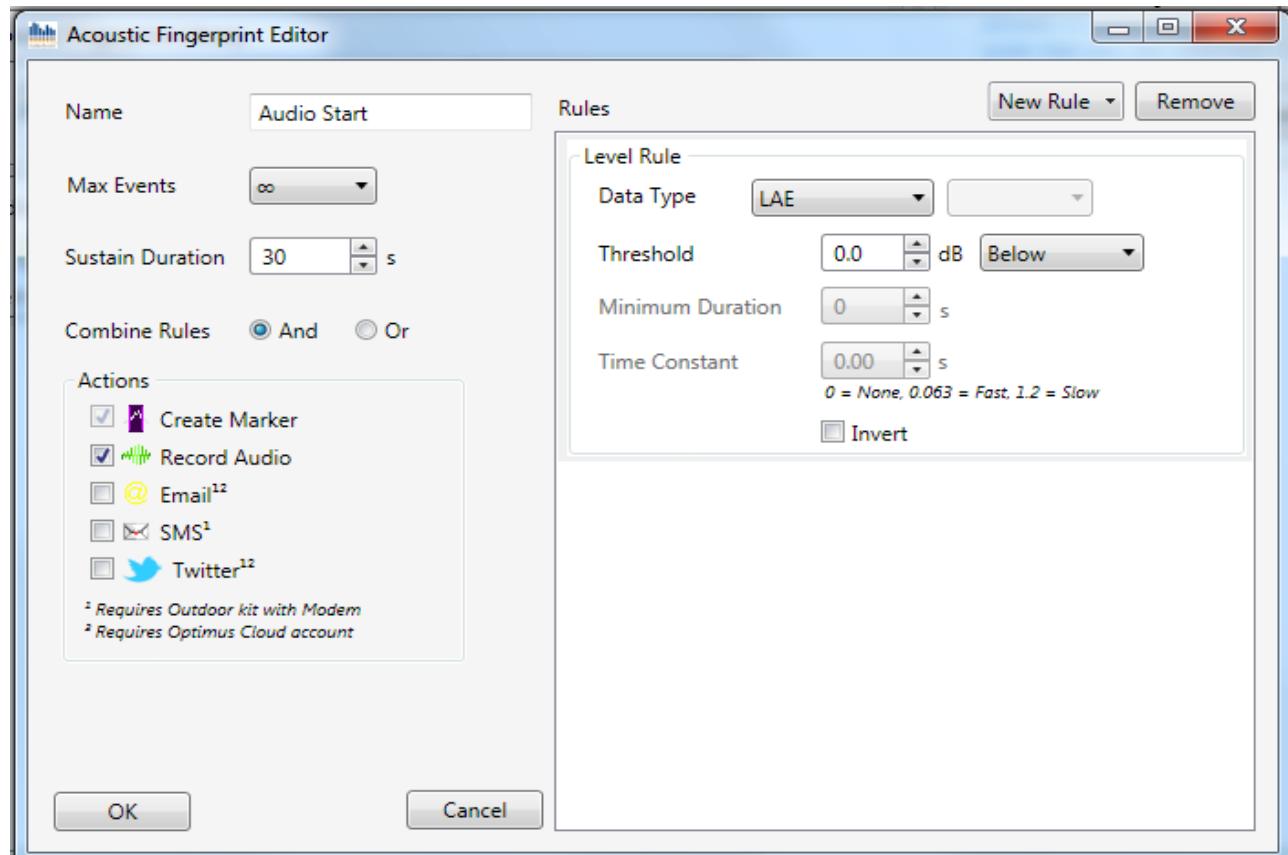
8.1.5 Record a 30 second sample at the beginning of every measurement

There may be applications where it is useful to make a short recording at the start of every measurement.

For example, when the instrument is set to make repeating 1 hour measurements, an audio recording at the start of each measurement can be useful to listen to and to hear the noise sources that are present.

This rule allows the instrument, at the start of each measurement, to record a 30 second sample. LAE is used as the trigger parameter to ensure that this condition is only met once at the very start of the measurement and the 30 second sustain time ensures that the recording lasts 30 seconds after the condition has been met.

Rule 1 – Level Rule: “Trigger when the LAE Threshold is Below 0dB with a 30second sustain”



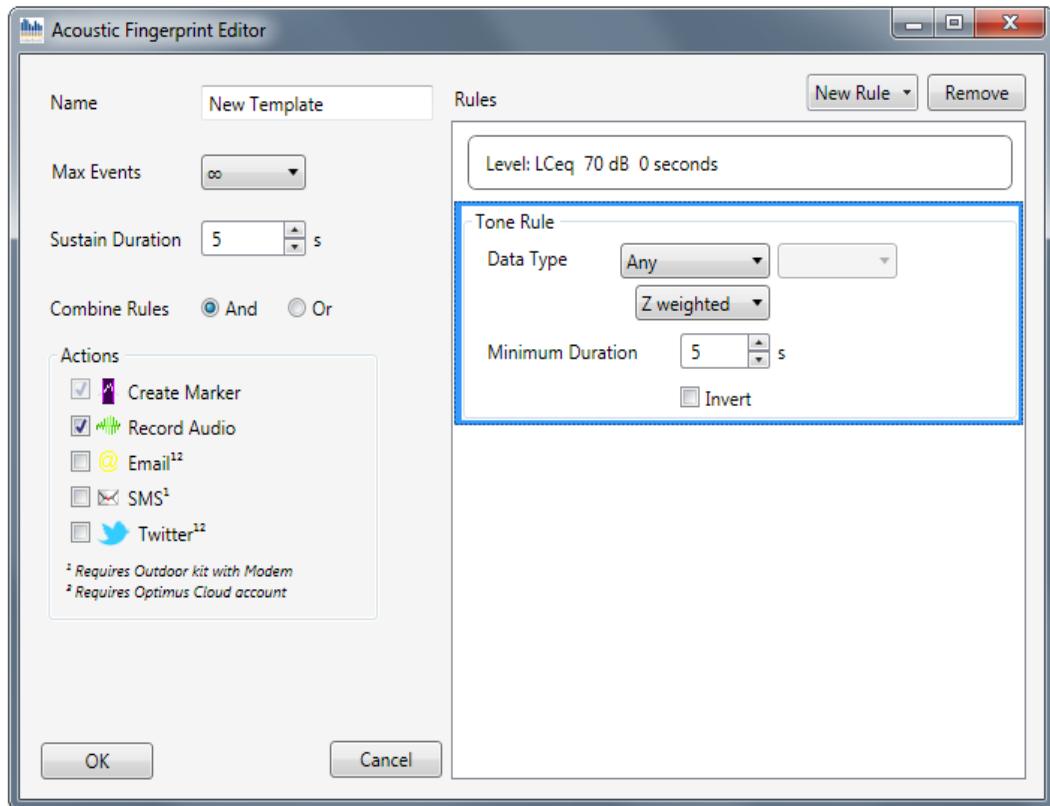
8.2 Templates with multiple Rules

8.2.1 Detection of tonal loud sounds

Rules linked with an AND.

Rule 1 - Level Rule : “Trigger if the LCeq is above 70 dB”.

Rule 2 – Tone Rule : “Trigger if a tone in any 1:3 Octave Band is detected for more than 5 seconds”.

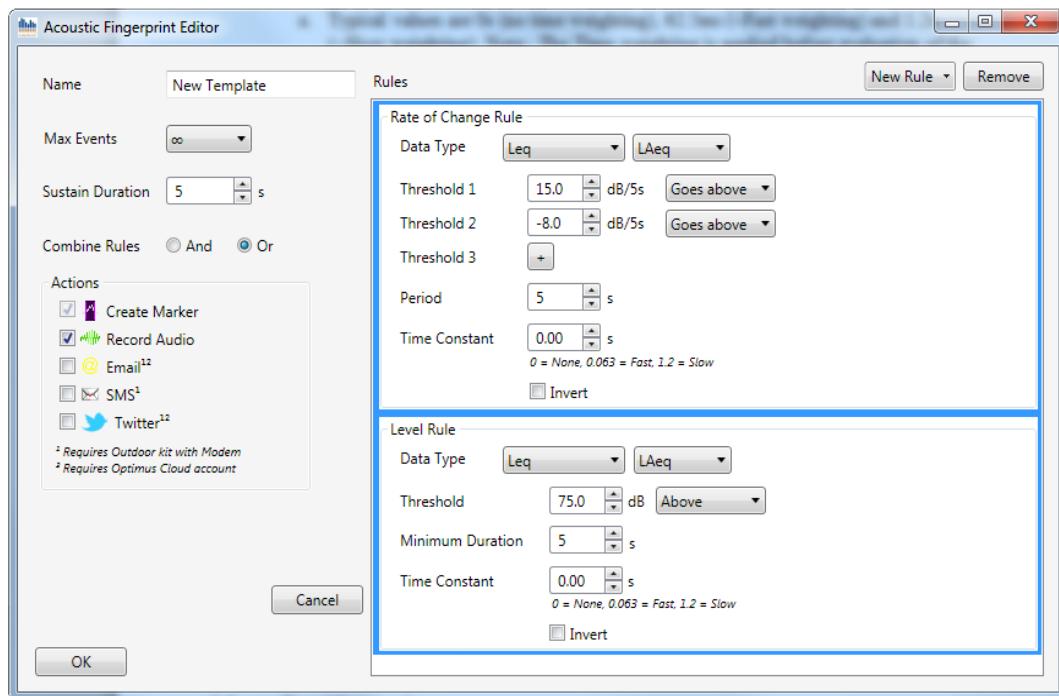


8.2.2 Detection of short or loud events

Rules linked with an OR.

Rule 1 – Rate of Change Rule : “Trigger if the LAeq increases by more than 15 dB in 5 seconds”.

Rule 2 – Level Rule : “Trigger if the LAeq is above 75dB”.



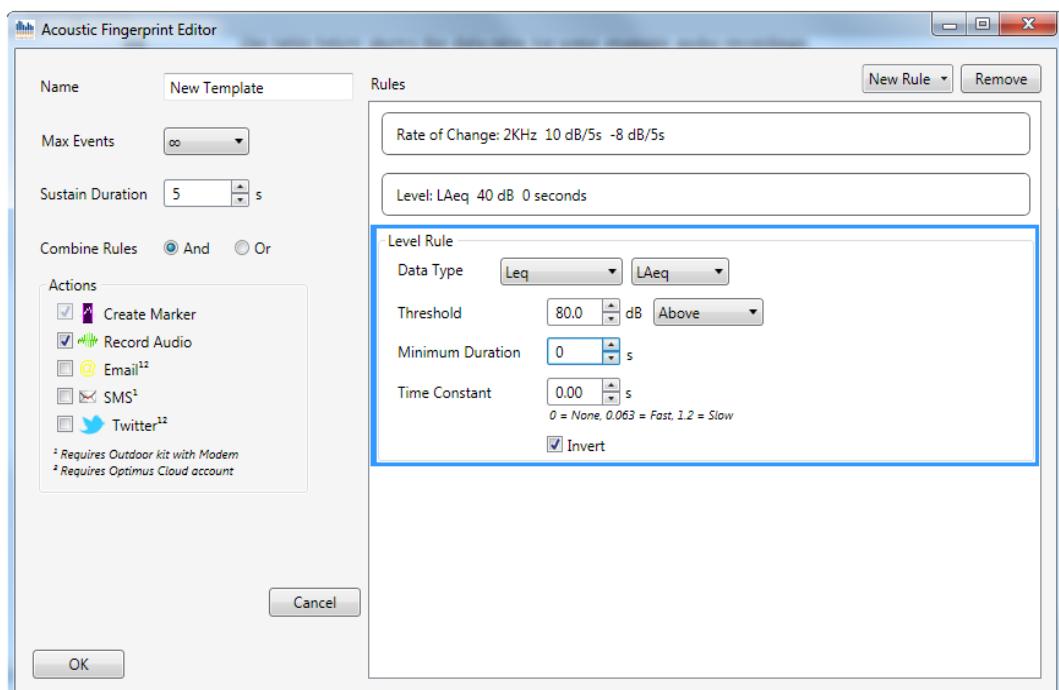
8.2.3 Detection of short events at 2kHz between 40dB and 80dB

Rules linked with an AND.

Rule 1 – Rate of Change Rule : “Trigger if the 2kHz 1:1-octave band level increases by more than 10dB in 5 seconds”.

Rule 2 – Level Rule : “Trigger if the LAeq is above 40dB”.

Rule 3 – Level Rule – Inverted : “Trigger if the LAeq isn't above 80dB”.



9 Audio Quality

Audio recordings are stored as a standard WAV file using either Standard or Studio quality. In any audio recording system, there is a trade-off between the amount of space used for storing the recordings and the amount of information that is recorded.

Using a high bit rate and sample rate can give much more detailed information that can be used for further analysis whereas a lower bit rate and sample rate can often be ideal where the aim is to listen to and identify the source of the noise.

The optimus green sound level meters give you a choice of two different recording rates so that you can choose which suits your application best.

The amount of memory used and the rate at which audio data is stored is determined by the audio quality setting. This can be configured in either the instrument or the NoiseTools software. The table below shows the data rates for some example audio recordings.

Duration	Standard Quality	Studio Quality
1 second	32KB/sec	375kB
1 minute	1.85MB/min	22MB/hr
1 hour	110MB/hr	1.32GB/hr

9.1 Standard quality

Standard quality uses a 16kHz/16bit recording rate which is sufficient for listening and source identification.

9.2 Studio quality

Studio quality uses a much higher resolution and bit rate (96kHz & 32bit) and is ideal for recordings that will be used for further analysis. This data can be viewed in the NoiseTools software using the 3D analysis and FFT analysis options.

This option uses 12x more memory than the standard quality option and will use the available memory much faster. Care should be taken when selecting this option if measurements are to be made over long periods.

There is no pre-trigger available when the Studio Quality is selected.

Please note that to playback the Studio Quality recordings, the sound card in the PC must support this type of file. Some older PC's may not be able to support the playback of high resolution audio files. An error message such as "Audio playback not supported by your sound card" may be displayed.

If this occurs, it is possible to use an external sound card to allow the high resolution audio files to be replayed.

Please note that this is a limitation of the hardware in the PC and is not a limitation of the NoiseTools software.

9.3 Memory requirements for storing audio recordings

The optimus green sound level meters are supplied, as standard, with a 4GB memory card. This internal memory is used to store the noise measurement data along with VoiceTag recordings and audio recordings.

The amount of memory available for the storage of audio recordings can be adjusted within the NoiseTools software and the instrument will display on the information view screen the amount of memory free.

The General View in the instrument will show the time remaining for storage of noise measurements and audio recordings.

The amount of memory used for each of these can be adjusted within the NoiseTools software to suit the specific application. The optional 32GB memory card allows for 8 times the amount of data storage. Please contact Cirrus Research plc for details.

10 References

1. ISO 1996-2:2007
Acoustics – Description, measurement and assessment of environmental noise
Part 2 : Determination of environmental noise levels
2. “Improvements in source identification from unattended sound level measurements using threshold-triggered audio recording
Richard A Wright; Guillaume Goulamhoussen
Affiliation: Cirrus Research plc; ISEN Lille, Internoise 2010”

11 Cirrus Research Offices

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