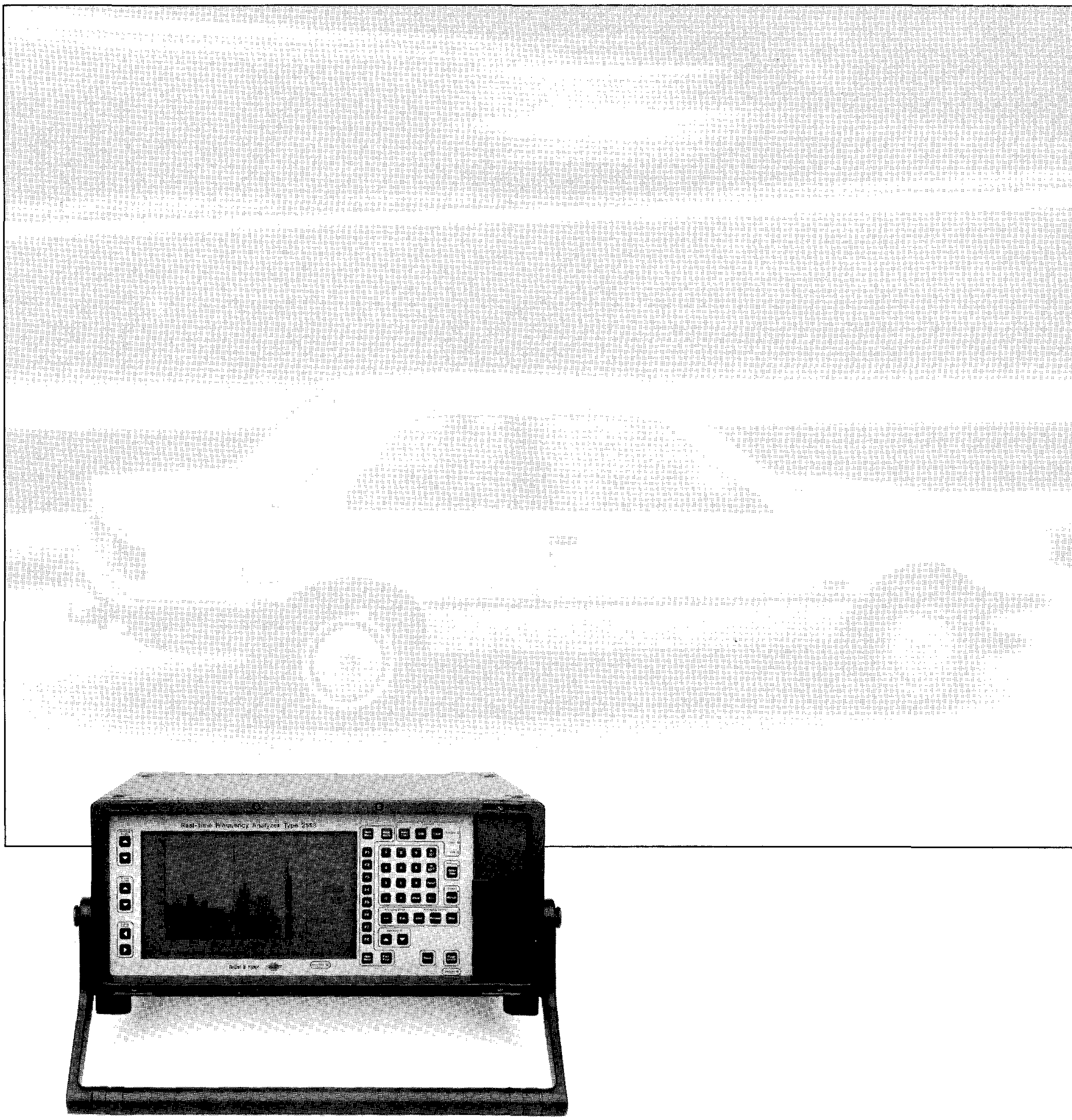
Application Notes

Measurement of Vehicle Exterior Noise using the portable Real-time Frequency Analyzer Type 2143



Brüel & Kjær

Measurement of Vehicle Exterior Noise using the portable Real-time Frequency Analyzer Type 2143

by Klaus Højbjerg

Introduction

Exterior noise is a major component of the environmental impact of cars, trucks, buses, motorcycles, and the like.

Control of exterior noise has led to the development of several test procedures which can be categorized into two groups: stationary tests and pass-by tests.

The necessary measurements for enforcement and certification for national and international legislation can be done with a sound level meter. However, designers of vehicles and components need more information about the noise characteristics. The higher level of information is used to single out individual noise components such as exhaust system, tyres, cooling fan, engine intake etc. Solving the actual noise problems leads to more sophisticated analysis techniques.

Suppliers of parts and components are often called on to contribute to solving the problem. Therefore, portability of instrumentation is convenient when the manufacturer and the supplier join together in testing at a remote test site.

Presently, the standards are being updated to improve the correlation between the manufacturer's measurements and the real impact on the environment. Likewise, local, national and EEC regulators are looking for more stringent standards, leading to greater design challenges.

Measurement Procedures

For both procedures, the reported level is the maximum A-weighted level, using the time constant FAST, occurring during the subscribed test.

Stationary tests: these are simple level measurements with the microphone close (0,5 m/45°) to the vehicle exhaust outlet. SAE 1169[2] and the state procedures all use a fixed but different engine RPM for testing. ISO 5130 uses a run-up to a specified engine RPM and then run-down to idle.

Pass-by tests use two main procedures: the wide-open throttle (acceleration), which is described in SAE J986 and ISO 362, and the less common partially open throttle (cruise-by), which is quite difficult to control.

The ISO and SAE test procedures are very similar. The vehicle approaches the start point of the test in second (lowest)* gear at a constant speed of 50 km/h (30 mph). Wide-open throttle is initiated at the start point and held for 20 m (125 feet). The sound is measured at 7,5 m (15 m) from the centreline of vehicle travel.

In both procedures, the maximum A-weighted level can be obtained with

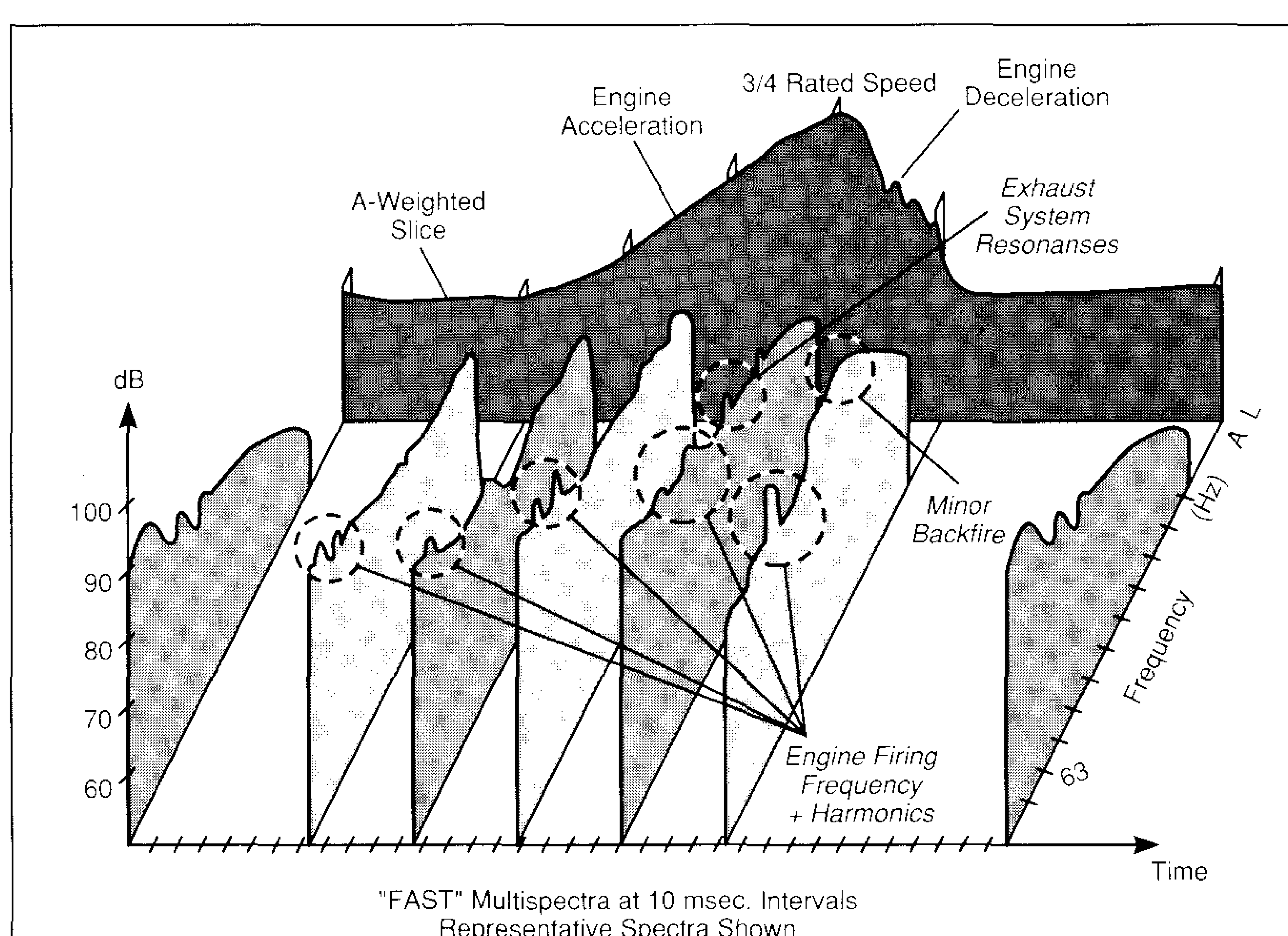


Fig. 1. Use of multispectrum. The recorded A-weighted level is shown in the background and single spectra at different points in time, identifying noise sources, are shown in the front

* Requirements are ISO (SAE).

a sound level meter. However, for development work, it is often necessary to acquire more information. This would typically be the complete time history of a pass-by and a frequency analysis of it. This can be done with a real-time analyzer having sufficient memory for recording and storage of the frequency analyzed event. The Brüel & Kjær Real-time Frequency Analyzer Type 2143 offers a range of possibilities for this purpose.

The basis for these possibilities is the multispectrum mode. A multispectrum is a sequence of spectra recorded and stored in the analyzer. An example of a measurement according to ISO 5130 is given in Fig. 1. The multispectrum concept is shown. In the background is the time varying A-weighted level. This type of display is called a slice. With this display the time history of the A-weighted level from idle, through acceleration to 3/4 of rated engine speed and then back to idle is visualized giving possibility of identifying not only the maximum level, but also a couple of peaks during deceleration. Looking at the spectra at the time of the peaks revealed further information about the frequency of the peaks telling something about what the problem is, in this situation a resonance in the exhaust system and problems with engine backfire. During this process, and after looking at more spectra, engine firing problems were revealed, which is shown in figure 2. The plot's are made using the plotting facilities on the Dual Channel Real-time Frequency Analyzer Type 2133, which also enables us to show a slice and a spectrum at the same time. This can be done because of complete data compatability between the portable and the laboratory analyzer's.

Recording a multispectrum can be done using both linear and exponential averaging. Averaging time and time between spectra are chosen independently, giving total freedom in the capture of the signal.

Three different measurements can be made:
- Maximum A-weighted level
- Exponential averaging (FAST), reading the detector at a high speed
- Linear averaging, where the averaging time depends on the lowest frequency of interest

Measurements

Two different measurements are shown. A standard wide-open throttle (WOT) measurement using exponen-

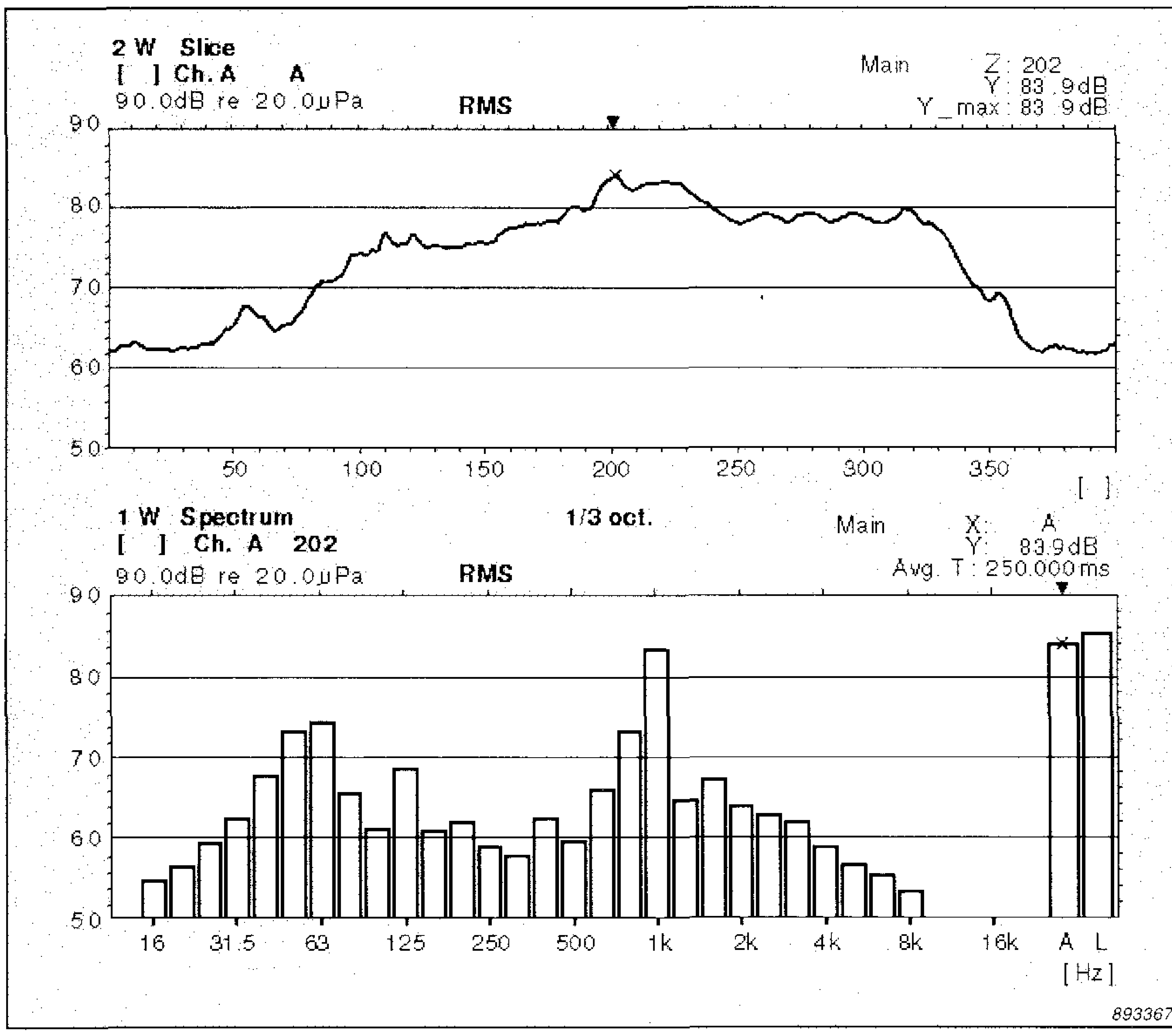


Fig. 2. Shows the measurement result also use in fig.1. The A-weighted Slice pointing out the max-value and lower the corresponding spectrum. 63 Hz and 125 Hz are engine-firing and 2.nd harmonic, 1 kHz is a resonance in the exhaust system

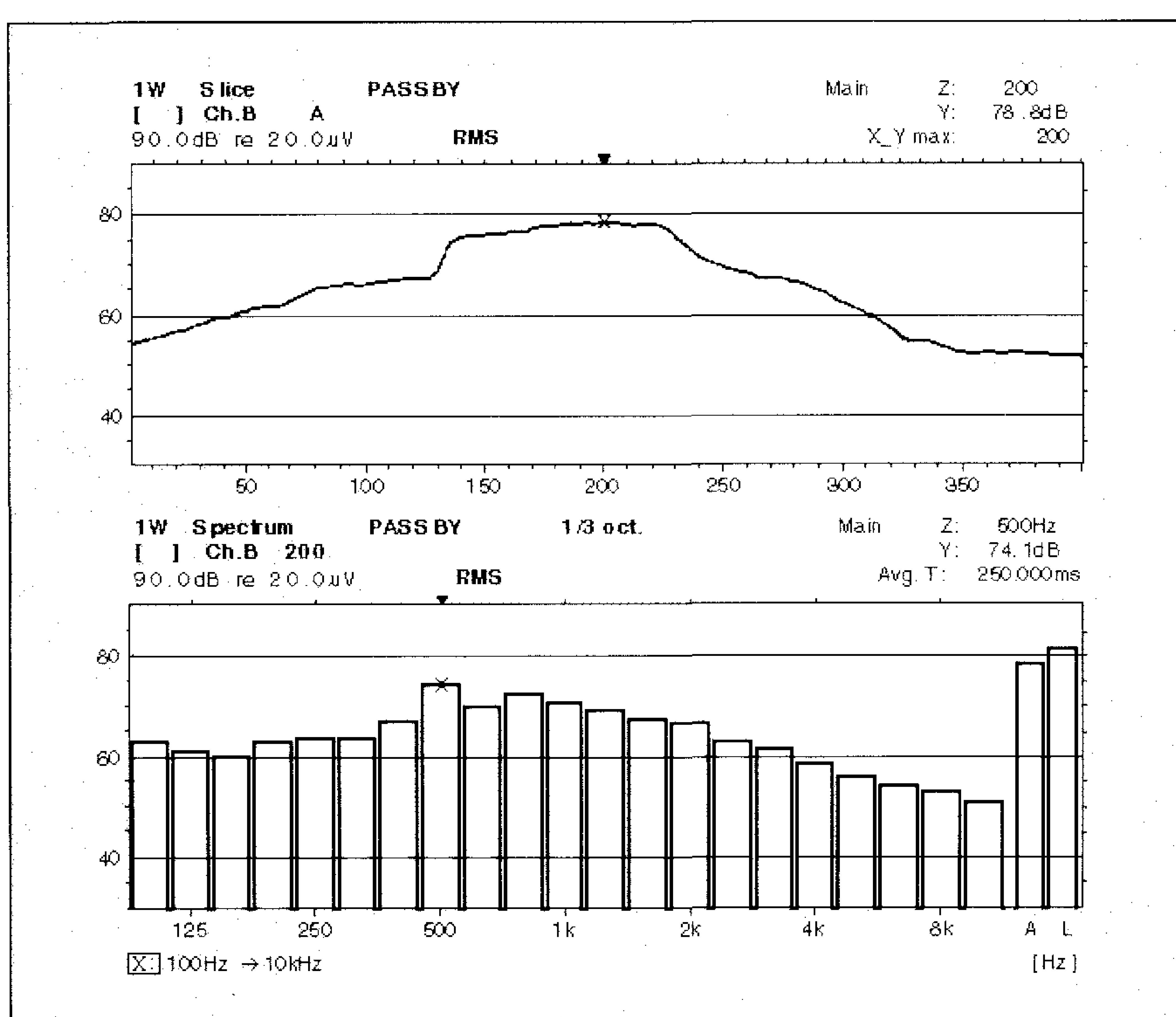


Fig. 3. Measurement result using exponential averaging time. The upper curve shows the time variation of the A-weighted level, with the maximum value at spectrum number 200. The lower curve is spectrum number 200. Note that the low-frequency information is maintained

tial averaging and a cruise-by measurement on a major road using linear averaging.

In the WOT test, the exponential averaging time is set to ¼ second equal to the sound level meter FAST response. The detector is sampled every 5 ms. The maximum sample rate is 1 ms and a maximum of 512 (with a possible extension to more than 2800) ⅓-octave spectra are stored. Fig. 3 shows the measurement result. In this type of measurement, the averaging is smoothing the result. However, low-frequency information is maintained and data is acquired in acceptance with standards. In the upper slice display, the A-weighted curve is shown and the maximum value is found. In the lower curve, spectrum no. 200, the maximum value is at 500 Hz.

In the cruise-by test, linear averaging is used. With a very short averaging time, the smoothing effect is avoided, but, due to a very small BT product at low frequencies, the data is only valid at higher frequencies (T_{avg} = 5 ms and BT ⩾ 1, f_c = 1 kHz is the lowest ⅓-octave band). The measurement result is shown in Fig. 4. Two things of importance should be noted here. The maximum A-weighted can not be reported as it is not recorded in accordance with the standards. The lack of low-frequency information is due to the mentioned problems with the BT product. However, there are situations where important high-frequency information can only be obtained this way.

With the extensive trigger facilities, many possibilities are open for synchronizing the measurement start with other measurements on the vehicle or with a certain event during the test. Quite often it is of interest to synchronize the recording with engine RPM or speed. This is possible using external sampling, which is also used for order analysis and tracking.

To improve the correlation between vehicle exterior noise measurements and the real impact on the environment suggestions have been made to combine measurement results and constants into a single index number. The operations necessary to perform these index calculations are built into the analyser as post processing functions.

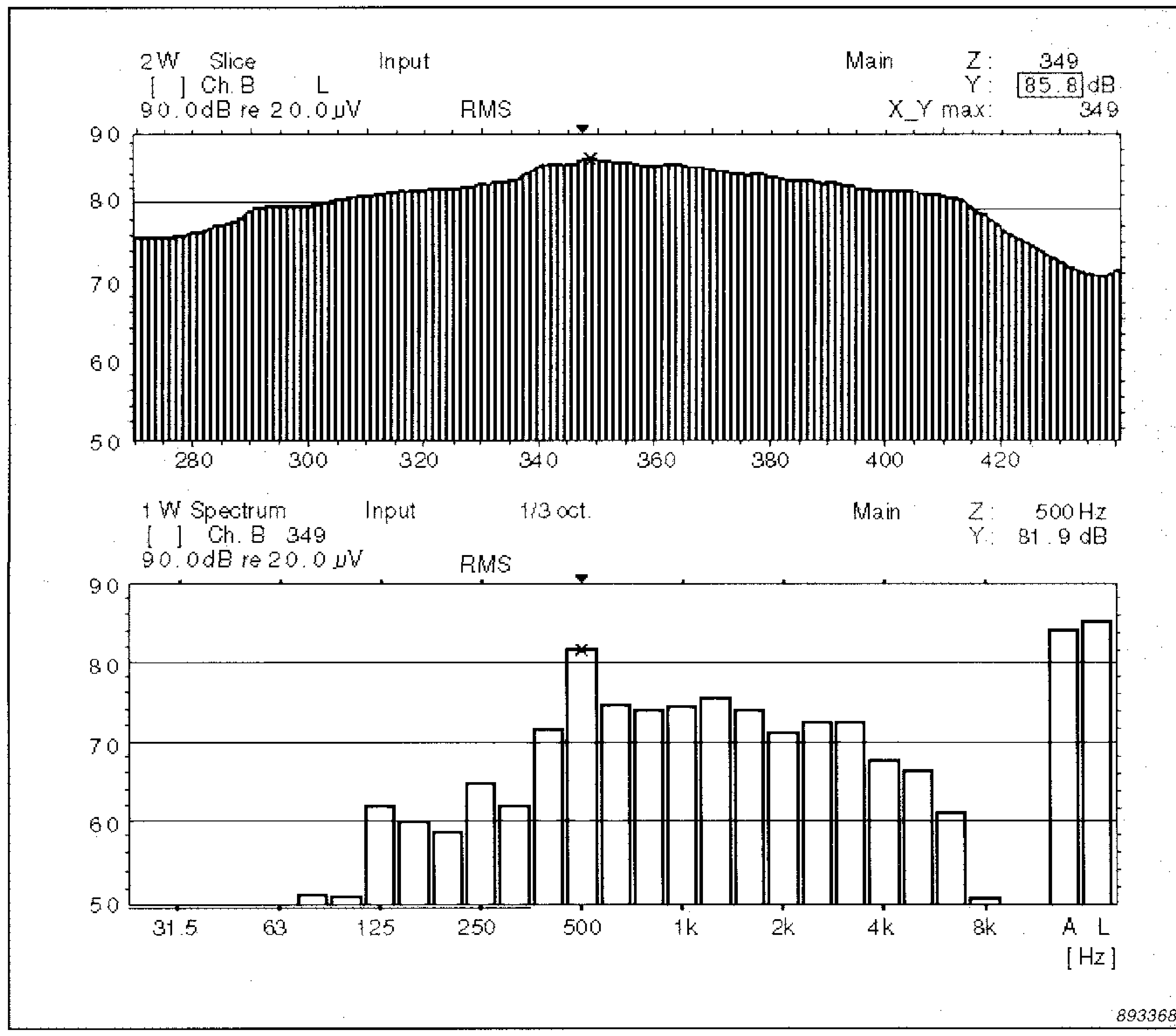


Fig. 4. Measurement result using linear averaging time. The upper curve shows the time variation of the wide-band level. The lower curve is the max. spectrum. Note that the lack of the low-frequency level

Conclusion

The new portable Real-time Frequency Analyzer Type 2143 can be used as a powerful tool for making pass-by noise measurements. Not only is the maximum A-weighted level measured, but also more sophisticated measurements are done. The built-in post-processing can be used to create a single number result from combinations of different types of pass-by situations. This leads to an in-the-field tool which matches the performance of the laboratory instrumentation of many pass-by sites, making it easier to identify the causes behind exessive exterior noise while on site.

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References

[1] T. M. HOWELL, R. F. SCHUMACHER: "*Vehicle Sound Measurements – 20 years of Testing*", SAE 850969

[2] SAE J1169: "*Measurement of Light Vehicle Exhaust Sound Level under Stationary Conditions*"

[3] ISO 5130: "*Acoustics – Measurement of Noise Emitted by Stationary Road Vehicles*"

[4] SAE 1986: "*Sound Level for Passenger Cars and Light Trucks*"

[5] ISO 362: "*Acoustics – Measurement of Noise Emitted by Accelerating Road Vehicles – Engineering Method*"

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