

Task 1

Measurement of noise and vibrations by sound level meter

1.1 Task specification

1. Calibrate or check the calibration of sound level meter
2. Measure third octave band analysis of the source of noise in the given position
3. Calibrate the sound level meter by vibrating table
4. Measure octave band spectra of grinding machine and transmission to table with various damping liner (open foam, rubber, felt)

1.2 Theory

1.2.1 Sound level meter – acoustic analyzer

Basic measurement equipment of acoustician is sound level meter. One of the possible "classical" block schemes of sound level meter is presented in figure 1.1. At present thanks to development of digital measuring technologies sound level meter could be represented by more complicated measuring chain enabling measurement of various acoustical quantities. The most important extension of sound level meters is real time frequency analyzer that is represented by set of filters in our figure.

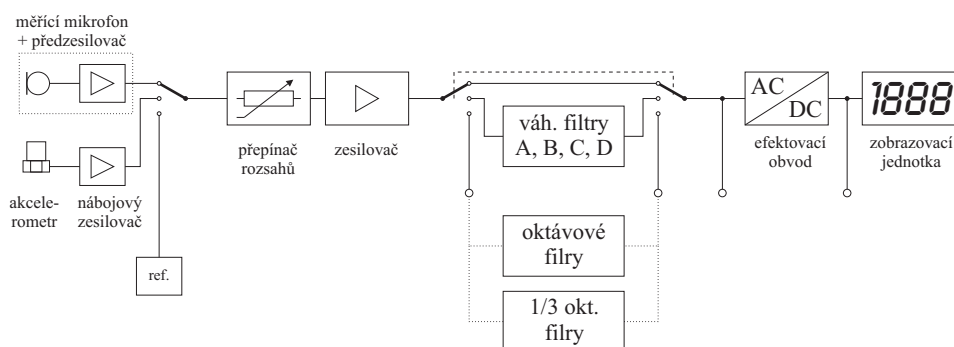


Figure 1.1: Block diagram of sound level meter

Acoustic sensor at the input is usually pressure microphone but for greater part of the sound level meters it is possible to connect also other transducers (e.g. accelerometer). In most cases condenser microphone with the best parameters is used. First of all linear characteristics in whole audible frequency range is important. Good stability in time is the second most important feature (it can be many years when properly used). Thin metallic diaphragm is placed close to and parallel with a back plate (usually perforated) forming a capacitor. The most important behaviors are linear characteristics in wide

frequency range and long time stability. Distance between diaphragm and back plate is about 10 μm . Changes of pressure in front of diaphragm lead to its deflection and consequently to changes of the microphone capacity.

For digital realization frequency weighting filters are realized by standardized functions. For *A*-weighted levels it is done by formula:

$$A(f) = 20 \log \frac{R_A(f)}{R_A(1000)}, \quad (1.1)$$

$$R_A(f) = \frac{12200^2 f^4}{(f^2 + 20,6^2)(f^2 + 12200^2)\sqrt{(f^2 + 107,7^2)(f^2 + 737,9^2)}}. \quad (1.2)$$

Corrections corresponding to the weighting filter *A* are presented in table 1.1.

Display unit is digital nowadays, but its dynamic characteristics are derived from analog scalars. Sound level meter has usually three or four time weighting characteristics called S (slow) 1 s, F (fast) 200 ms a I (impulse), which is unsymmetric: for rising it is 35 ms and for drop it is 2 s. Requirements on sound level meters are summarized in IEC 60651 and IEC 61672-1.

Freq. [Hz]	corr. [dB]	Freq. [Hz]	corr. [dB]	Freq. [Hz]	corr. [dB]
20	-50,5	200	-10,9	2 k	+1,2
25	-44,7	250	-8,6	2,5 k	+1,3
31,5	-39,4	315	-6,6	3,15 k	+1,2
40	-34,6	400	-4,8	4 k	+1,0
50	-30,2	500	-3,2	5 k	+0,5
63	-26,2	630	-1,9	6,3 k	-0,1
80	-22,5	800	-0,8	8 k	-1,1
100	-19,1	1 k	-0,0	10 k	-2,5
125	-16,1	1,25 k	+0,6	12,5 k	-4,3
160	-13,4	1,6 k	+1,0	16 k	-6,6
				20 k	-9,3

Table 1.1: Correction for weighting function *A*

1.2.2 Vibration measurements

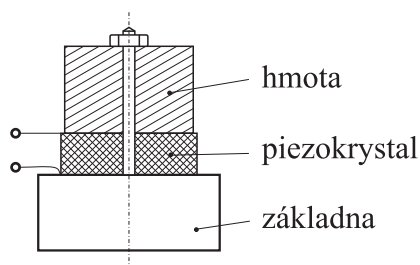


Figure 1.2: Piezoelectric transducer for acceleration measurement

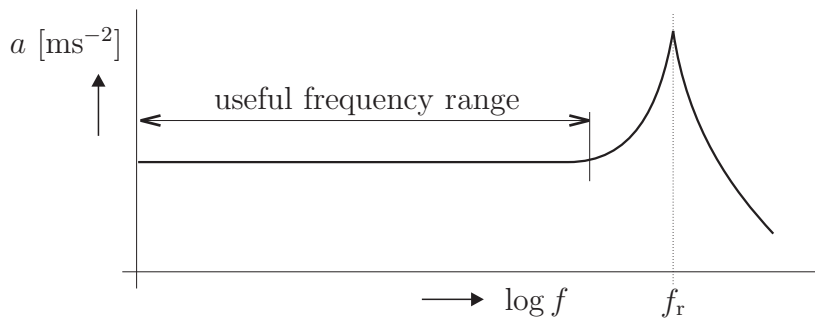


Figure 1.3: Frequency characteristics of accelerometer

1.2.3 Calibration

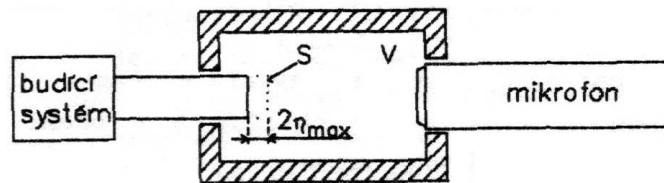


Figure 1.4: Principle of the pistonphon

$$p = p_0 \frac{S}{V} \varkappa \eta, \quad (1.3)$$

where p_0 is barometric pressure and \varkappa is Poisson's adiabatic constant.

Acceleration level is defined in the form

$$L_a = 20 \log \frac{a}{a_0}, \quad (1.4)$$

where $a_0 = 10^{-6} \text{ ms}^{-2}$.

1.3 Measurement procedure

1. Apply sound calibrator on sound level meter microphone and verify that sound pressure level indicated on calibrator appears on display. If not, calibrate sound level meter.
2. For selected source of noise (engine, drill etc.) measure third-octave band sound pressure levels in distance of 1 m. Then measure total A -weighted and linear sound pressure levels and total levels of background noise. **Measured levels display in graph.** Total SPL (linear and A -weighted) verify by calculation from measured third-octave band levels. What is the influence of background noise? Estimate uncertainty of measurement.
3. Fix the accelerometer on vibrating table (calibrator) and set the weight (right bottom button); centre of the scale corresponds to 16 g. Magnitude of acceleration equals to gravitational acceleration, it corresponds to RMS value of 136,8 dB. This

value should be set by preamplifier Nexus (roughly, by + and –) and then on sound level meter.

4. Fix the accelerometer using beeswax to rotating machine in vertical direction.
5. Measure vibration acceleration third-octave band and total levels. Do not use A-weighting! Convert acceleration levels into acceleration. **Take care not to overload input amplifier!**
6. Fix the accelerometer to the source of vibrations in horizontal direction and repeat previous item.
7. Fix the accelerometer on the top desk of the table and repeat item 5 for all type of isolation materials (rubber, felt, foam). **Process the results in graphical form and discuss features of materials.**

Note to item 2:

Calculation of total level is based on operations with energetic components, i.e. it is necessary to add sound intensities of individual frequency bands. It is impossible to add levels!

1.4 List of equipment

- Sound level meter Quest 1800 or Rion NL 31
- NTI-AL1 Acustilizer
- Charge amplifier Nexus
- Accelerometer, Brüel & Kjær 4500, weight 5 g
- Calibrator Quest, Typ QC-20
- Calibration table, Brüel & Kjær 4291