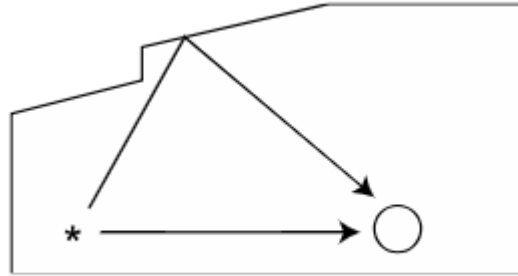


TT3010 - Audiotechnology and Room Acoustics

Lab 1 - Room acoustics measurements

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August 13, 2020



1 Introduction

The goal is that you should be able to carry out room acoustic measurements at Storsalen in Samfundet, and calculate the reverberation time, SPL and background noise levels.

2 Needed equipment

- Laptop with measurement software. Extension cord for the power supply (the wall outlet might be in an impractical location).
- External soundcard, with cable to the laptop, usually USB.
- Long microphone cable, from the microphone to the external soundcard
- Measurement microphone, with a microphone stand.
- Measurement loudspeaker, with a stand.

- Amplifier for the loudspeaker, unless it is built into the loudspeaker. Extension cord for the amplifier (the wall outlet might be in an impractical location).
- Long loudspeaker signal cable, from the sound card to the loudspeaker amplifier. You might need adapters at the amplifier end of the cable.
- Measurement tape, with a length of at least 20 m.
- Laser distance meter, for estimating room size.
- Sound level meter, for measuring the A-weighted background noise level.
- Microphone calibrator.

3 Details

The task is to use an impulse response measurement system (Easera, or WinMLS, or similar) with a measurement loudspeaker (with amplifier) and a measurement microphone to measure impulse responses. From the impulse responses, you can calculate:

- The reverberation time in octave bands 125 Hz – 4 kHz, or third-octave bands 100 Hz - 5 kHz (depending on what the measurement software offers). You need a number of measurement positions, and must calculate the average value. The T30 values should be presented.
- The relative sound pressure level as function of distance from the source. You need to measure for a number of positions along a straight line from the source. Please note that you should be able to get the relative sound pressure level in octave bands (or third-octave bands) from the impulse response. The absolute levels are not important, since the absolute levels depend on how loud the emitted sound from the loudspeaker is. But, the *relative* levels are always the same, regardless of how loud the emitted sound is.

You also need a sound level meter for measuring the background noise level. Then you can measure:

- The A-weighted background noise level. You need a number of measurement positions for this, and also need to make a calibration of the microphone (unless the sound level meter is known to have been calibrated already).

4 Procedure

You will need to make sure you get a high enough signal-to-noise ratio in the measurement. You could use this procedure to adjust the gain settings:

1. Choose the settings for the measurement software (sampling frequency, input and output channels, sweep length, stimulus signal amplitude (output amplitude)).
2. Turn on the stimulus signal, and adjust the sound card gain + loudspeaker amplifier to give a loud but not too loud level from the loudspeaker. After this, don't change the output gains!
3. Put the microphone at the shortest distance that you will use. Adjust the microphone amplifier (or sound card gain) to as high as possible gain without overload. After this, don't change the input gains!

5 Theory

5.1 Reverberation time

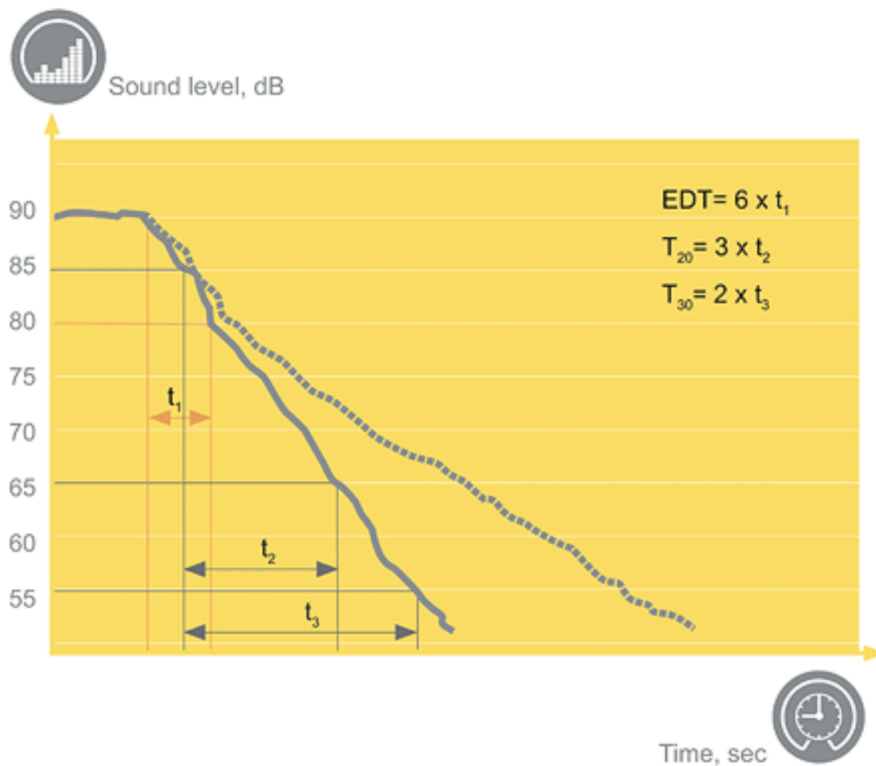


Figure 1: Illustration showing how to calculate EDT, T_{20} and T_{30} . From [?]. This is done automatically by the measurement software, for one octave (or third-octave) band after another.

The reverberation time is defined as the time it takes for the sound pressure level to decrease by 60 dB. To determine the length of this time, different parts of the reverberation curve are used. The descriptors T_{20} and T_{30} are sometimes said to refer to “late reverberation” as they measure at the later part of the curve. EDT is referring to “early reverberation” and is considered to better reflect how we perceive the reverberance in the room. If a single value is used, it is usually the T_{30} , which is chosen.

When measuring Early Decay Time (EDT), an interval of 10 dB is used. For T_{20} , an interval of 20 dB is used. When determining T_{20} , the evaluation does not start until after the sound level has already fallen by 5 dB. For T_{30} , an interval of 30 dB is used and here too, the evaluation starts after the sound level as fallen by 5 dB. If the reverberation curve is straight, the EDT, T_{20} , and T_{30} will all produce the same value. In practice, the reverberation curve is seldom straight (dashed line), which means that the descriptors will differ [?].

5.2 SPL

Together with the reverberation time, the sound pressure level is of primary importance in room acoustics. The simplest model of sound field in a room considers the direct sound and the reverberation (both early and late). The contributions from these two components can be predicted according to a simple formula

$$L_p = L_W + 10 \cdot \log \left(\frac{DF}{4\pi r^2} + \frac{4}{A} \right)$$

where the sound pressure level, L_p , depends on the sound power level of the sound source, L_W . If the sound power level is increased by x dB, then the sound pressure level will increased by x dB. The sound pressure level also depends on the term $10 \cdot \log \left(\frac{DF}{4\pi r^2} + \frac{4}{A} \right)$ which involves the direct sound, which depends on the distance r and the directivity factor, DF , and also involves the reverberation, which depends on the total sound absorption in the room, A . If one measures the sound pressure level, absolute level or relative level, in a room, and plots it as function of distance, then the measured level should follow a curve of the kind in the formula above.

6 Tasks

Measurements

0. Choose the source position that you are assigned, and try to measure its position relative to walls of the room.
1. Measure the impulse responses in a number of positions.
2. Measure the background noise in the same positions.
3. Measure the distance from the source to the receiver for all receivers.

4. Estimate the room volume using rough estimates based on measurements with the laser distance meter.

Post-processing (you can do this in the lab after the measurement session)

1. Plot the reverberation time, T_{20} , in third-octave bands from 100 Hz to 5 kHz.
2. Plot the relative SPL as function of distance for the third-octave bands of 1 kHz. Plot the data from 1-12m made by group 1 and compare it by the average of the other measured values from 7, 9 and 11 meters.
4. Plot the background noise SPL and give the value of the total SPL.

Write a simple report on this, one per group, using the standardized lab report format.