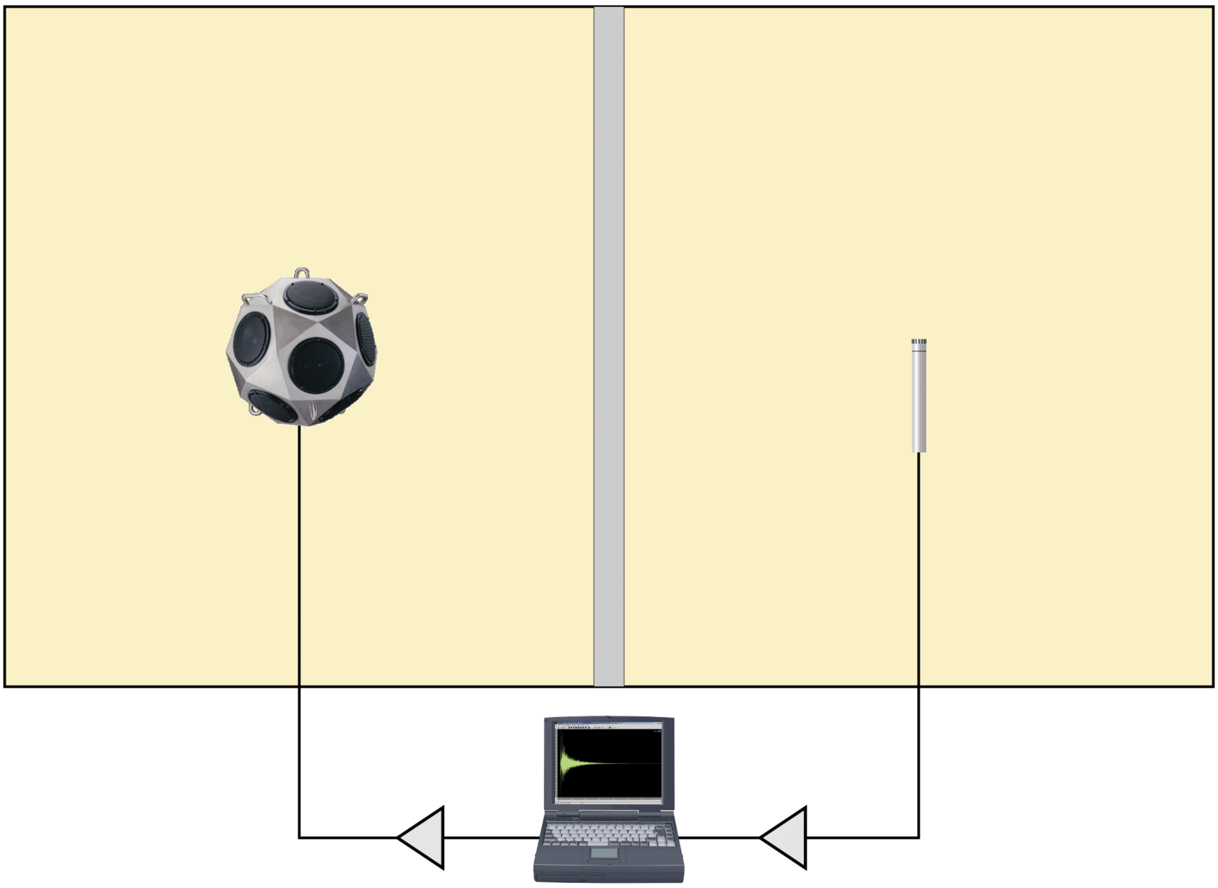
Acoustics Engineering

**TN006**

# Technical Note

## INSULATION MEASUREMENTS USING DIRAC

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# 1 Basic Principle

To measure of the airborne sound insulation between two rooms, you can use the parameter G in Dirac as a relative sound level that does not require a system calibration. The basic measurement setup consists of a PC, an omni-directional loudspeaker sound source with power amplifier and an omni-directional microphone with amplifier, as depicted in figure 1.

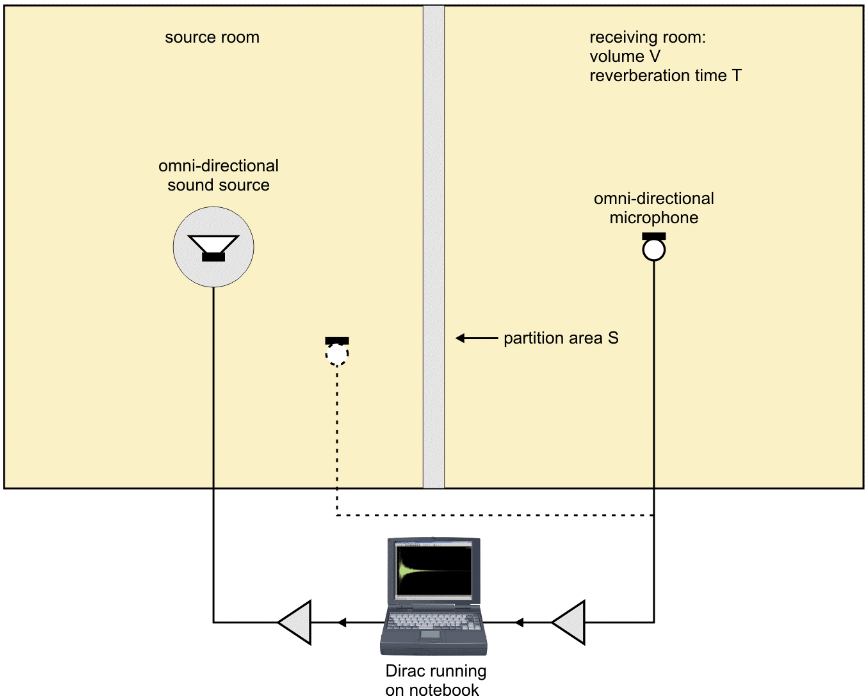



*Figure 1. Basic airborne sound insulation measurement setup.*

G is measured at m positions in the source room ($G_S$) and at n positions in the receiving room ($G_R$). The insulation or sound reduction index R is then calculated as follows from these G values, the partition area S, the reverberation time T of the receiving room and the volume V of the receiving room:

$$R = 10 \cdot \log\left[\frac{1}{m} \cdot \sum_{i=1}^{m} 10^{\frac{G_{S,i}}{10}}\right] - 10 \cdot \log\left[\frac{1}{n} \cdot \sum_{j=1}^{n} 10^{\frac{G_{R,j}}{10}}\right] + 10 \cdot \log\left[\frac{S \cdot T}{0.16 \cdot V}\right]$$

The first term represents the average relative sound level in the source room, the second term is the average relative sound level in the receiving room and the third term represents a correction term enabling R to be obtained from sound pressure levels rather than sound power levels. This calculation is performed for a subset of third octave frequency bands from 50 through 5000 Hz. To carry out the calculations you can copy the G table and T table from the Parameters window (**Graph/Statistics** button) to the clipboard and paste them into a spreadsheet program, such as Microsoft Excel.

The subset and the numbers of microphone positions m and n depend on the standard to comply with. For instance, ISO 140-3 (laboratory measurements) prescribes at least frequency bands from 100 through 5000 Hz and 5 microphone positions in each room, while DIN 52 210 (laboratory or building measurements) prescribes frequency bands from 100 Hz through 3150 Hz and a number of microphone positions that depends on the room size and the frequency of interest. A minimum of 6 positions in each room is safe. For further details on microphone and source placement, please refer to the related standards.

# 2 Measuring relative sound levels

## *2.1 Introduction*

The most accurate way to measure relative sound levels in Dirac is by using the internally generated MLS or sweep signal. A disadvantage of this method is that both the source and the microphone have to be connected to the same PC, which may be quite impractical, if not impossible, when measuring in the receiving room.

There are several ways to overcome this problem. You can use the external sweep method, driving the sound source from an audio CD rather than directly from the measuring PC. It is also possible to use a wireless transmitter for either the sound source or the microphone. Finally you could drive the sound source from a random noise generator, and record the signal in Dirac using the external impulse method (the name of which in this case obviously has no relation to the stimulus used).

Hereafter, each of the methods will be described in more detail. In any case, it is important to keep the total sound absorption in the source and the receiving room (to a certain extent) constant during the measurements. In practice, this can easily be accomplished by 2 persons, one in each room, or by a single person, staying outside during measurments in the source room. Hereafter, unless otherwise noted, it is assumed that a single person will perform the measurements, in which case the Auto Measure function in Dirac 3.0 will be very helpful.

## *2.2 Using Internal MLS or Sweep*

With the Internal MLS or Internal Sweep measuring method, Dirac generates the excitation signal. The corresponding measurement setup is shown in figure 2. For minimum equipment movement, the power amplifier resides in the source room.

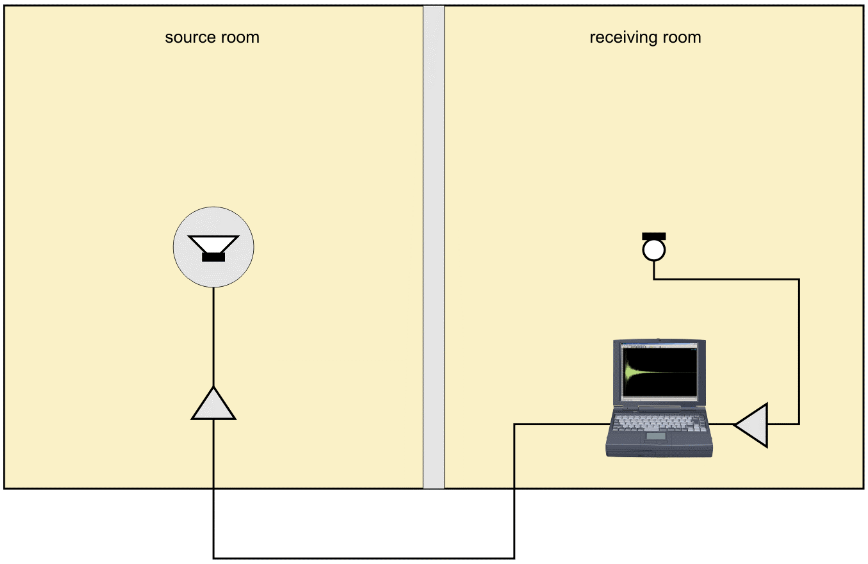



*Figure 2. Measuring relative sound levels using internally generated stimulus.*

When measuring the sound levels in the source room, the measuring engineer repeatedly enters this room to move the microphone, leaves the room and then starts the measurement. The measurement can be started either manually, if the PC is placed outside the source room, or timer-based, using the Auto Measure function in Dirac 3.0, if the PC is inside the source room.

When measuring the sound levels in the receiving room, a source signal cable has to be wired from receiving room to source room.

Of all measuring methods, the Internal MLS or Sweep methods offer the highest INR (Impulse response to Noise Ratio) values, which is particularly useful with very high insulation values. The impact of background noise is reduced as the Pre-average value in the Measurement window is increased. Up to a certain limit, the INR is increased by 3 dB each time the Pre-average value is doubled. The limit mainly depends on the soundcard quality and the stability of the air conditions in the rooms, such as temperature, relative humidity and air convection.

Sweeps result in lower crest factors in the measurement chain than MLS, thereby allowing a certain power amplifier to produce more output power, which usually results in higher INR values.

To increase the INR at low frequencies, at the cost of the INR at high frequencies, you can use the Pink+Blue filter with MLS or linear sweep. With Dirac 3.0, you can also use the e-sweep (a.k.a. 'log' sweep).

## 2.3 Using External MLS or Sweep

With the External MLS or External Sweep measuring method, the excitation signal is generated from a separate signal generator. Figure 3 shows a typical measurement setup with a stimulus signal played from an audio CD. There is no connection between the PC and the source.

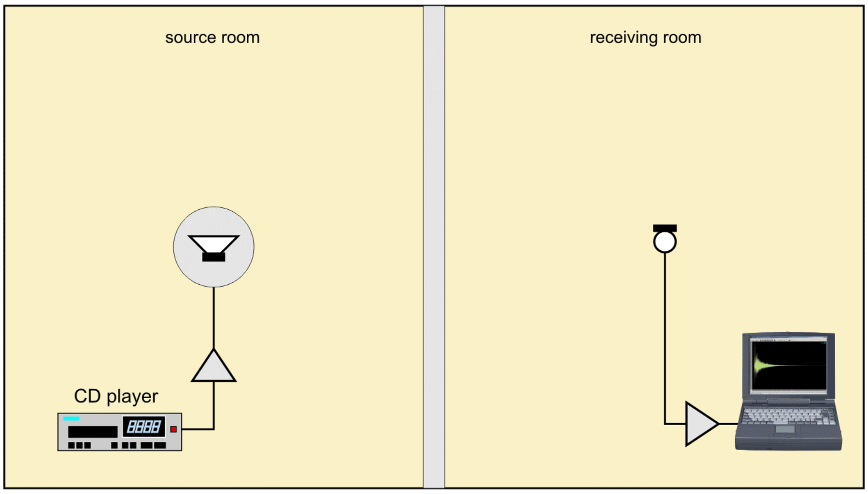



*Figure 3. Measuring relative sound levels using sweeps from an audio CD.*

Like with the Internal MLS or Sweep measuring methods, when measuring the sound levels in the source room, the measuring engineer repeatedly enters this room to move the microphone, leaves the room and then the measurement is started, manually or automatically.

The sound level measurements in the receiving room can now be performed without a cable running between the rooms.

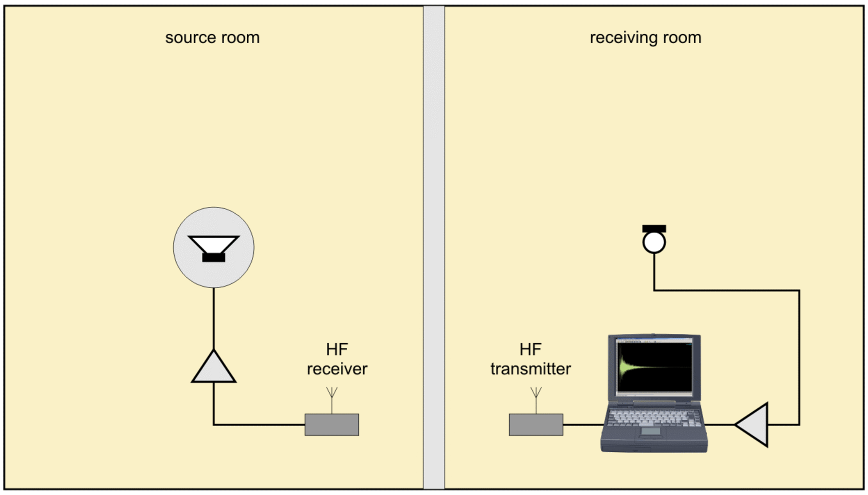
The excitation signal on the CD must be a copy from an internal excitation signal produced by Dirac, while the settings of the measuring PC have to be accordingly. External sweep measurements are highly recommended over external MLS measurements, because of their lower sensitivity to timing errors.

With external signals, increasing the Pre-average value will improve the INR only if the sample clock frequencies of the CD player and PC do not differ too much. This can easily be checked by inspecting the INR at several Pre-average values.

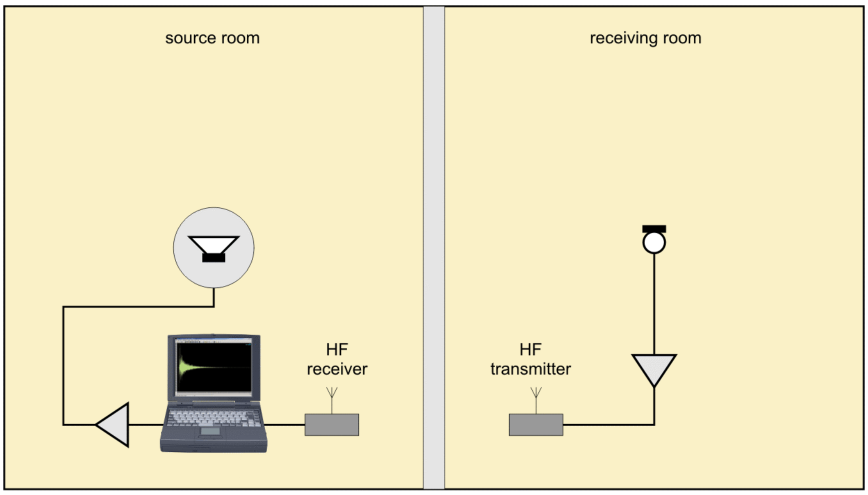
To increase the INR at low frequencies, at the cost of the INR at high frequencies, you can use the Pink+Blue filter with MLS or linear sweep. With Dirac 3.0, you can also use the e-sweep. When you are using a pre-recorded Pink+Blue filtered MLS or linear sweep, make sure that in the Measurement window on the measuring PC, the Pink+Blue filter is switched on as well.

## 2.4 Using wireless signal transmission

To combine the advantage of the Internal and External signal measuring methods, you can use a wireless signal transmission line. In this case, Dirac generates the stimulus signal, resulting in good INR values, but one of the soundcard cables is replaced by a wireless HF transmission channel. Figure 4a shows a setup in which the wireless transmission channel replaces the line output cable, whereas in figure 4b it replaces the line input cable.




*a) In PC output channel.*




*b) In PC input channel.*

*Figure 4. Measuring relative sound levels using a wireless HF transmission channel.*

When using a wireless channel, it has to be inserted during both the source and receiving room measurements to ensure equal measuring equipment conditions for both measurements.

When measuring the sound levels in the source room, the measuring engineer repeatedly enters the source room to move the microphone, leaves the room and then starts the measurement manually or automatically.

The way the sound levels in the receiving room are measured depends on the setup. With a wireless source, such as in figure 4a, Dirac can be controlled manually. With a wireless microphone, such as in figure 4b, the Auto Measure function or a second person is required to start each measurement.

## *2.5 Using random noise*

Under the condition that the same measurement equipment is used for the source and the receiving room measurements, it is also possible to use random noise, just as with conventional airborne sound insulation measurements. Instead of using a sound level meter, which measures absolute sound pressure levels, you can use Dirac, which measures the relative sound pressure level G. Figure 5 shows the corresponding setup.

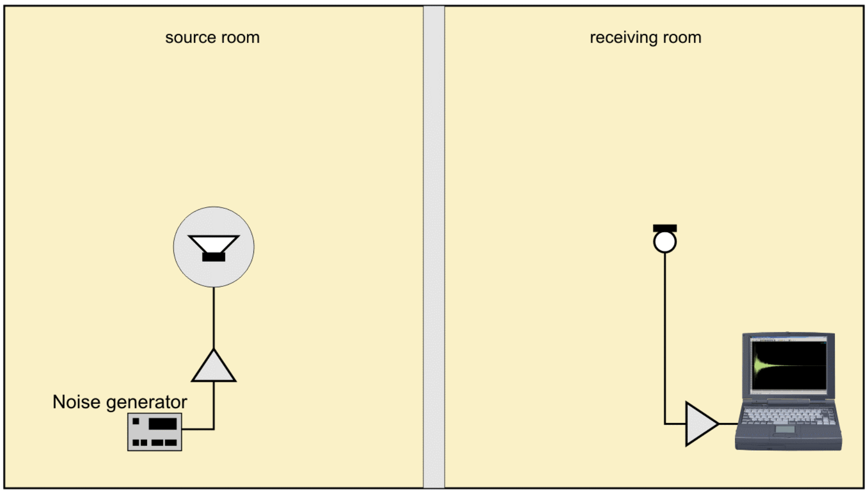



*Figure 5. Measuring relative sound levels using random noise.*

With the External Impulse measuring method selected, Dirac simply records the received sound. The resulting parameter G then reflects the relative sound level. The advantage of this method is the absence of a cable between the PC and the sound source. The disadvantage is the much lower reproducibility that can be achieved given the same number of measurements.

# 3 Measuring the reverberation time

## *3.1 Introduction*

To measure the reverberation time in the receiving room, you can use any measuring method available in Dirac. Sometimes it is convenient to use the same equipment as used for the relative sound level measurements; sometimes other equipment better suits the job, such as a smaller source, which is easier to carry.

## *3.2 Conditions and methods*

To obtain the reverberation time of the receiving room, a source has to be placed there. For this purpose, you could use the source used for the measurements in the source room. Usually, this is a heavy high power loudspeaker sound source. Moving this source can be inconvenient, whereas the size of the receiving room would not require much power. Therefore, it is advisable to consider the choice of the measuring method.

To measure the reverberation time, use the same omni-directional sound source as used for the sound level measurements, if any of the following conditions is met:

- There is no other, smaller sound source available
- The receiving room is large
- The moving distance between the rooms is relatively short (e.g. no vertical movement through stairs or elevator necessary)
- The source room for the current insulation measurement is the receiving room for another insulation measurement. This is a special case. If the current relative sound level is obtained by impulse response measurements, the very same impulse responses can be used to calculate the reverberation time of that room.

If neither of these conditions is met, you can use a smaller sound source, such as a blank pistol, to carry out the reverberation time measurements in the receiving room.

**Note**
In any case, during the reverberation time measurements, the occupation of the receiving room must be the same as during the receiving room sound level measurements.

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