PRODUCT DATA

DIRAC Room Acoustics Software — Type 7841

Photo courtesy of Muziekcentrum Frits Philips, Eindhoven, The Netherlands

MEASURING ROOM ACOUSTICS

Brüel & Kjær is the sole worldwide distributor of DIRAC, an acoustics measurement software tool, developed by Acoustics Engineering.

DIRAC PC software is used for measuring a wide range of room acoustical parameters. Based on the measurement and analysis of impulse responses, DIRAC supports a variety of measurement configurations. For accurate measurements according to the ISO 3382 standard, you can use the internally generated MLS or sweep signals through a loudspeaker sound source. Survey measurements are easily carried out using a small impulsive sound source, such as a blank pistol or even a balloon. Speech measurements can be carried out in compliance with the IEC 60268-16 standard, for male and female voices, through an artificial mouth-directional loudspeaker sound source or through direct injection into a sound sytem, taking into account the impact of background noise. DIRAC is not only a valuable tool for field and laboratory acoustics engineers, but also for researchers and educational institutions.

7841

Brüel & Kjær

USES

- ❍ Measurement of the acoustical properties of an enclosure
- ❍ Measurement of the speech intelligibility of a sound system
- ❍ Characterisation of the acoustics before and after room modification
- ❍ Comparison of acoustical quality of different rooms
- ❍ Modelling room acoustics using measurements taken in a scale model
- ❍ Research and education on acoustics
- ❍ Room acoustics troubleshooting

FEATURES

- ❍ Measures reverberation, spaciousness, speech intelligibility and many other parameters
- ❍ Dual input
- ❍ Conforms to ISO 3382 (room acoustics) and IEC 60268-16 (speech intelligibility) standards
- ❍ User friendly and fast
- ❍ Impulse Response editing
- ❍ Supports many different types of sources and receivers
- ❍ Reverse filtering technique enables accurate short reverberation time measurement
- ❍ Multiple time and/or frequency views of the impulse response
- ❍ Statistics calculation (mean, standard deviation, min-max)
- ❍ Supports scale model measurements
- ❍ Soundcard test and validation

About DIRAC

Basic Principle

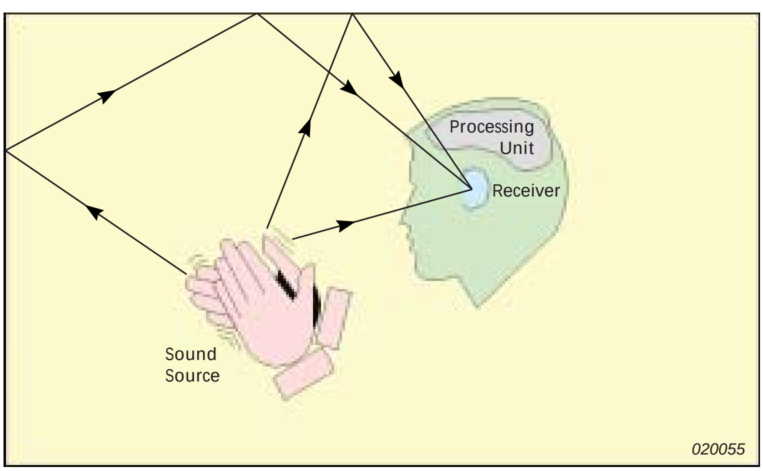


Fig. 1
Basic principle of impulse response measurement

To investigate the acoustical properties of a room, you can clap your hands and listen to the response of the room. Although it may not be easy to describe accurately what you hear, this method evidently gives you an impression of whether music would sound pleasant or speech would be intelligible in this room. DIRAC uses this principle as the basis for measuring the acoustical properties of a system through impulse responses.

Impulse Responses

The mathematical impulse or *Dirac delta function*, named after the theoretical physicist Paul A.M. Dirac, is infinitely short and has unit energy. A system's response to such an impulse contains all the information on the system, and as such, is convenient for analyis and storage. DIRAC measures and saves acoustical impulse responses, and calculates acoustical parameters from impulse responses.

Other Excitation Signals

Through deconvolution, DIRAC can also calculate the impulse response using other excitation signals, thereby enabling the use of loudspeaker sound sources. These sources feature a better directivity, frequency spectrum and reproducibility than impulsive sound sources, but would have difficulties in reproducing high power impulsive signals. Examples of suitable non–impulsive excitation signals are the MLS (Maximum Length Sequence) signal, the sweep (swept sine), white noise and pink noise.

Required Hardware

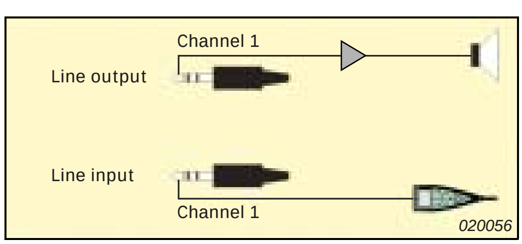
The minimum hardware required to use DIRAC is a PC with a soundcard, an impulsive sound source, such as a blank pistol, and a microphone connected to the actual soundcard line input. Each of these three components can be varied, depending on the type of measurement to be performed.

Typical soundcard functions, used by DIRAC, are a line input, a line output and gain controls. In case of a notebook or laptop PC, soundcard functions are integrated or otherwise can be attached as a PCMCIA or USB device. DIRAC determines the soundcard properties by means of a soundcard calibration in a loopback configuration: the soundcard output is connected to the input. During calibration, redundant functions are disabled, gain controls are calibrated and the frequency response is equalised. In this way, the software becomes independent of the soundcard and the input and output gain can be easily controlled from within DIRAC.

As mentioned before, instead of an impulsive sound source, you can use a loudspeaker sound source. To measure room acoustical parameters in compliance with the ISO 3382 standard, an omni-directional sound source should be used. To simulate a real talker in speech intelligibility measurements according to the IEC 60268-16 standard, you can use a mouth simulator or a small loudspeaker. To measure the speech intelligibility through a sound reinforcement system, you can use the loudspeakers of that system. In any case, the excitation signal can be obtained from DIRAC through the soundcard output, or under certain conditions from an external generator.

At high sound–pressure levels, the signal from the microphone may be sufficient to perform impulse response measurements, when fed directly into the soundcard line input. However, additional amplification is usually required. In this instance, a sound level meter with a line output could be used. For a list of recommended types, please refer to the Ordering Information on the back cover.

If only one channel is used, it should be channel 1 or in audio terms, the left channel. For jack plugs, used with most soundcards, this corresponds to the tip of the plug.



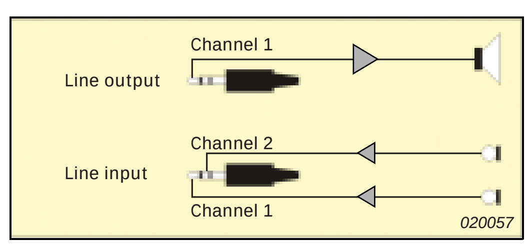


Fig. 2
Using one or two soundcard input channels and a sound level meter or a microphone with amplifier.

Measuring Methods

DIRAC supports several impulse response measuring methods, which are related to the sound source. Which method is used, depends on the situation.

The Internal MLS or Sweep method is accurate, but requires a connection between the PC and a loudspeaker sound source or some other system.

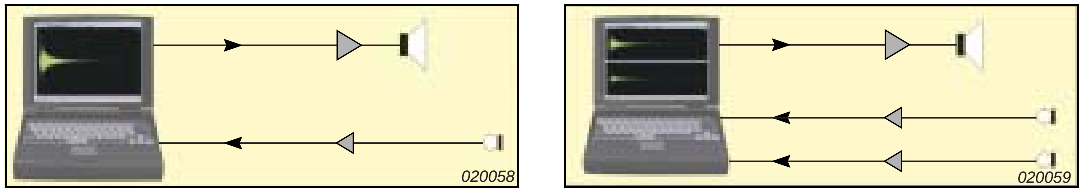


Fig. 3
Internal MLS or Sweep: DIRAC produces MLS or swept sine excitation signal at the line output

The External MLS or Sweep method does not require a connection between the PC and a sound source or other system, which is convenient for long distances, but the method is less accurate.

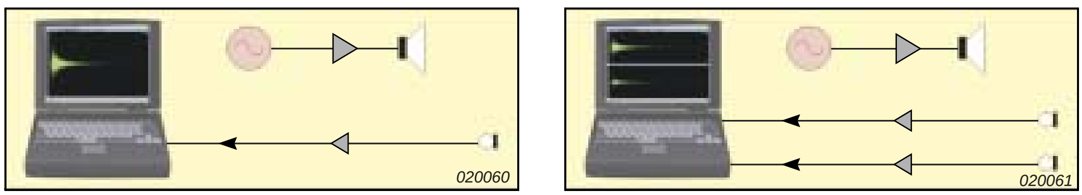


Fig. 4
External MLS or Sweep: external generator produces copy of DIRAC excitation signal

The External Noise method allows the use of any broadband continuous signal source, such as noise or music, but the method is less accurate, and only one measurement channel is available.

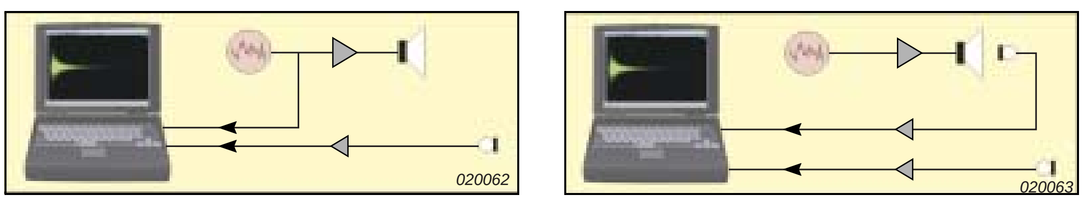


Fig. 5
External Noise: excitation by broadband signal, such as noise or music

The External Impulse method allows the use of small lightweight sound sources, such as balloons or blank pistols, but is less accurate.

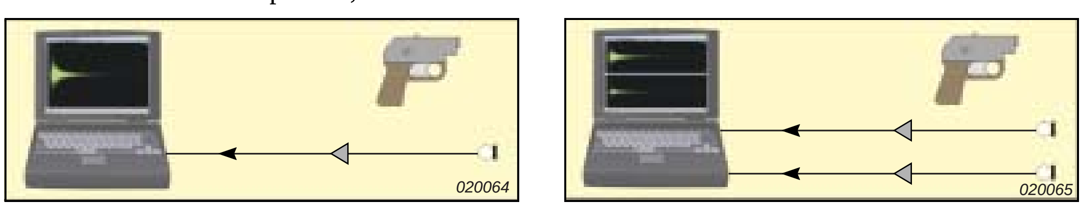


Fig. 6
External Impulse: exciation by impulsive signal, such as from blank pistol or paper bag

Acoustical Parameters

DIRAC can calculate a set of acoustical parameters, from 1 or 2 impulse responses, depending on the receiver type used during the measurement. You can select from 6 different types (see Table 1).

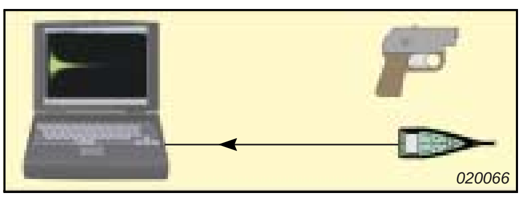
Table 1
Relation between receiver type selected and parameters to be calculated

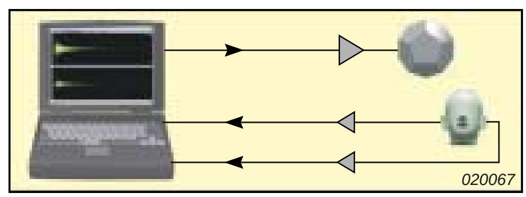
Parameter	Single Omni–directional Microphone	Switchable Omni–bi–directional Microphone	Dual Omni–directional Microphone	Omni–directional + Bi–directional Microphone	Head Simulator	Intensity Microphone Probe
	Ch1	Ch1	Ch1 Ch2	Ch1 Ch2	Ch1 Ch2	Ch1 Ch2
INR	●	●	●	●	●	●
G	●		●			●
EDT, T_{10}, T_{20}, T_{30}	●		●			●
T_S, C_{80}, D_{50}	●		●			●
LF		●		●		
LFC						●
IACC					●	
ST_{early}, ST_{late}, ST_{total}	●		●			●
STI (male & female)	●		●			●
RASTI	●		●			●

Practical Examples

The figures below show examples of practical measurement setups.

Fig. 7
Left: measuring reverberation times and energy ratios for survey
Right: measuring IACC





Calibrations

DIRAC supports 3 different kinds of calibration. **Soundcard calibration** (as mentioned earlier) enables optimal operation and user control of the soundcard from within DIRAC. It will also equalise the frequency response of the soundcard. **System calibration** enables the measurement of the sound strength G, and improves the accuracy of LF and LFC measurements. **Speech level calibration** enables you to measure the speech intelligibility in a noisy environment.

Results

Impulse Response Views

DIRAC can display an impulse response in several ways. The reflectogram highlights the energy peaks, the decay curve shows the energy progression, the Schroeder curve displays the backwards integrated energy progression. In all ‘time domain’ views, the signal can be displayed, either unfiltered or third/full octave band filtered.

In a time domain view you can select any part of the impulse response, and then edit, listen to or view details of the selected interval.

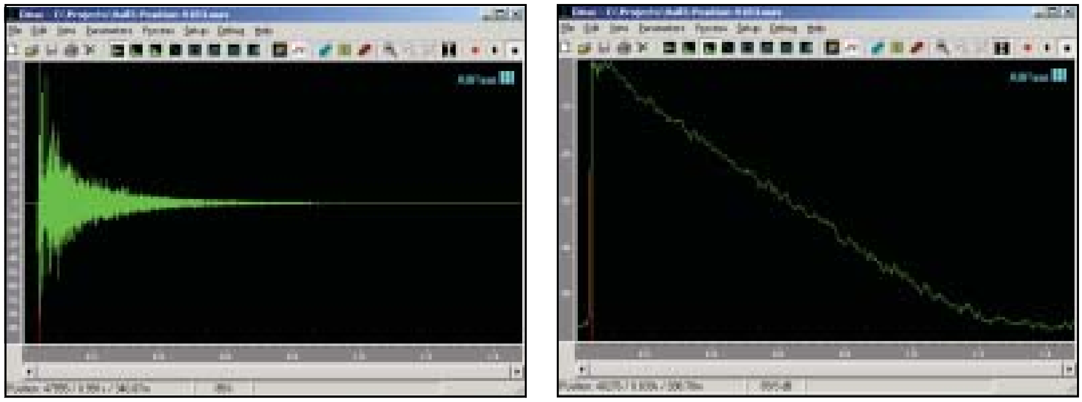


Fig. 8
Time domain views: original impulse response and decay curve from a single channel measurement

Several frequency spectrum views allow convenient analysis in the frequency domain.

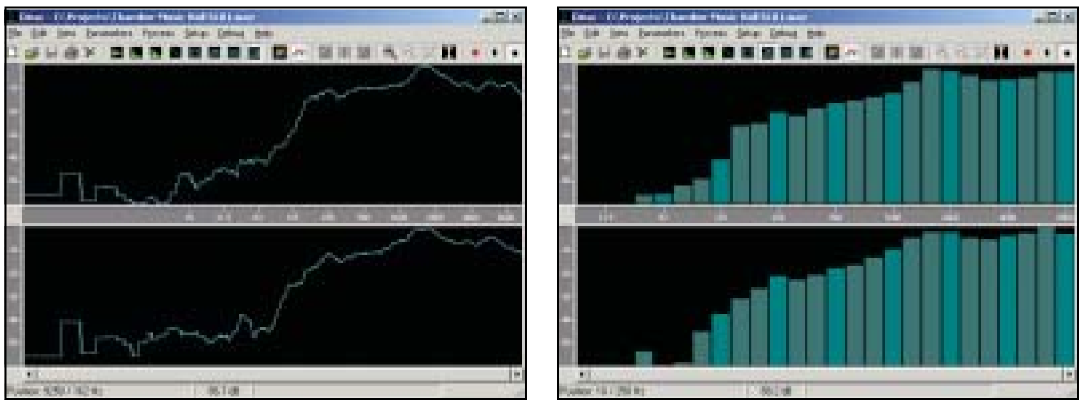


Fig. 9
Frequency domain views: smoothed FFT and third octave spectrum from a dual channel measurement

Energy Time Frequency Plots

To give a clear view of the spectral progress of an impulse response, DIRAC features several types of energy-time-frequency plots, such as the CSD (Cumulative Spectral Decay) and the spectrogram.

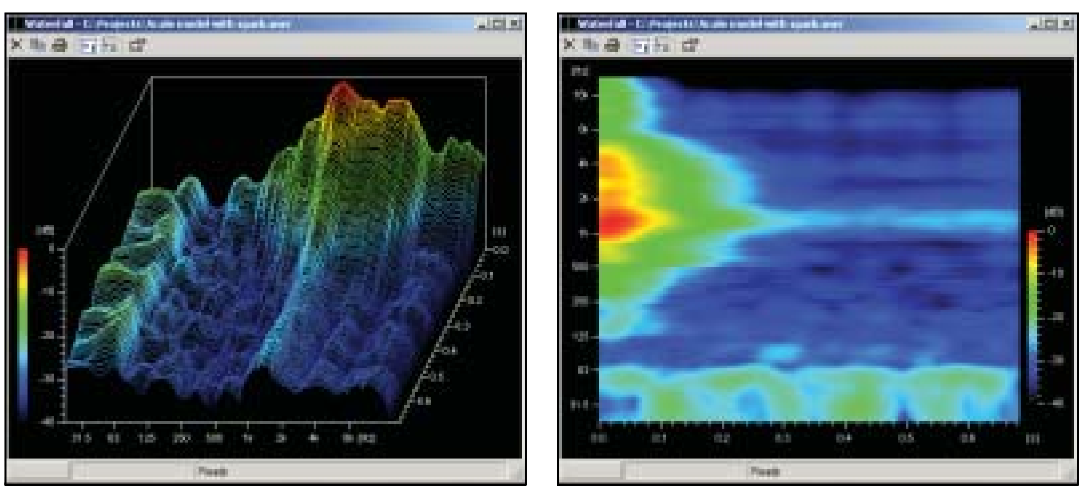


Fig. 10
Energy Time Frequency plots: waterfall plot and spectrogram

Parameter Graphs

Acoustical parameters, derived from the impulse responses, can be displayed in table format or graphically. Over a set of files, you can calculate averages, minima, maxima, and standard deviations of the measured acoustical parameters. The results can be viewed on screen, or copied and pasted into a report.

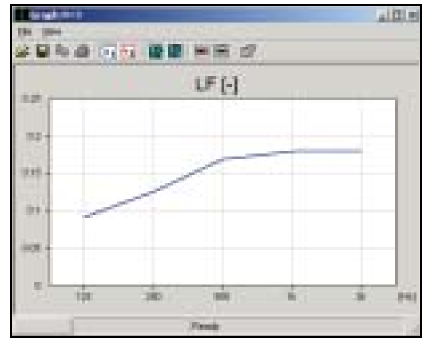
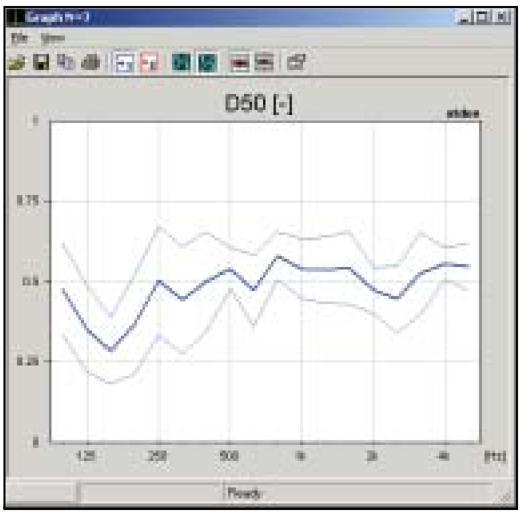


Fig. 11
Left: The ISO 3382 table displays parameters measured in compliance with the standard
Right: LF graph



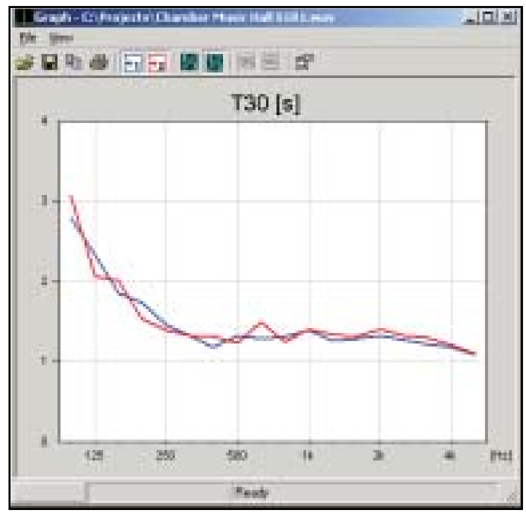


Fig. 12
D_{50} average and standard deviation over 7 measurement positions
Right: T_{30} from channel 1 and channel 2

Other Applications

Fig. 13
Measurement in a scale model of a reverberation chamber, using a miniature omni-directional sound source

Scale Model Measurement

To predict the acoustics of, for instance, a concert hall that is being designed but not yet realised, you can measure impulse responses in a scaled down model of the hall. After DIRAC has converted the scale model impulse responses to real world impulse responses, you can analyse them in the usual way.

Specifications – DIRAC Room Acoustics Software Type 7841

STANDARDS
Conforms with the following:
IEC 1260 – Octave and 1/3-octave Bands Class 0
ISO 3382 Acoustics – Measurement of the reverberation time of rooms with reference to other acoustical parameters
IEC 60268–16 Sound system equipment – Part 16: Objective rating of speech intelligibility by speech transmission index

OPERATION
The software is a true 32–bit Windows® program, operated using buttons and/or menus and shortcut keys

HELP AND USER LANGUAGE
Concise context–sensitive help is available throughout the program in English

MEASURING METHODS
Internal MLS, Internal Sweep, External MLS, External Sweep, External Noise, External Impulse
MLS and Sweep Lengths: 0.34 – 21.8 s
Pre-average: 1 – 999 times
Filters: None, Pink + Blue, Female, Male, RASTI

RECEIVER TYPES
Single omni-directional, dual omni-directional, switched omni-bi-directional, omni-directional and bi-directional, artificial head, sound intensity probe

FREQUENCY RANGE
10 octave bands from 31.5 Hz to 16 kHz
30 third octave bands from 20 Hz to 20 kHz

CALCULATED PARAMETERS
- Early Decay Time, EDT
- Reverberation Time, T_{10}
- Reverberation Time, T_{20}
- Reverberation Time, T_{30}
- Strength (Level rel. 10 m free-field), G
- Centre Time, T_S
- Clarity, C_{80}
- Definition (Deutlichkeit), D_{50}
- Early Lateral Energy Fraction, LF
- Early Lateral Energy Fraction, LFC
- Inter Aural Cross–correlation Coefficient, IACC
- Speech Transmission Index, STI
- RApid STI, RASTI
- STI for TELecommunication systems, STITEL
- Percentage Loss of Consonants, % ALC
- Early Support, ST_{early}
- Late Support, ST_{late}
- Total Support, ST_{total}
- Impulse response to Noise Ratio, INR
- Signal to Noise Ratio, SNR

All parameters can be viewed in table and/or graph format.

REVERBERATION TIME RANGE
1/1-octave bands: 0.002 – 100 s (1 kHz)
1/3-octave bands: 0.006 – 100 s (1 kHz)
Minimum reverberation times inversely proportional to frequency

SCALE MODEL
Scaling factors: Adjustable between 0.01 and 100
Frequency range: 40 kHz (1/3-octave band), at 96 kHz sample frequency

IMPULSE RESPONSE VIEWS AND PLOTS
Pressure curve, reflectogram, decay curve, Schroeder curve, full octave band spectrum, third octave band spectrum, linear frequency spectrum, logarithmic frequency spectrum, CSD plot, waterfall plot, spectrogram

PRINTOUT AND EXPORT
Graphs and tables can be exported via the clipboard, or printed. All results can be printed or exported in ASCII (text) format for further processing in other programs

COMPUTER SYSTEM REQUIREMENTS
Operating systems: Windows® 95, 98, ME, 2000, XP, Windows NT®
RAM: Minimum 32 MB, recommended 128 MB
Free Disk Space: Minimum 120 MB
Auxiliary hardware: CD-ROM drive, SVGA graphics display/adaptor, mouse or other pointing device
Sound Card: 2 channels, full duplex, 22.05, 44.1, 48 or 96 kHz sample rate

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Ordering Information

Type 7841 including:
- Software on CD ROM
- HASP Key
- Loopback Cable AO 0593

Optional Accessories

ZE 0770 A	PCMCIA Sound Card
Type 2238	Integrating Sound Level Meter
Type 2239	Integrating Sound Level Meter
Type 2260	Precision Sound Level Analyzer
AO 0585	3 m Cable from 2238/2239 AC Output to Soundcard input (3.5 mm jack plug)
AO 0586	3 m Cable from 2260 Aux. output to Soundcard input (3.5 mm jack plug)
AO 0592	10 m Cable to extend AO 0585 or AO 0586 (3.5 mm jack plug female/male)
AO 0592–V	Extension Cable, 3.5 mm jack plug, customer–specified length
7841–MS1	Software Maintenance and Upgrade Agreement

Note: For sound sources, please see Product Data BP 1689

BP 1974–11 02/05 Rosendahls Bogtrykkeri

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