

## Rolling Bearing Diagnosis with the FAG Bearing Analyser



# State-Of-The-Art, Condition-Related Monitoring of Plants and Machines

Unforeseen bearing damage, often resulting in machine downtimes and production loss, does not only cause an enormous cost in paper mills, oil refineries, steel mills, chemical plants and power plants. It also causes an unnecessary repair expenditure even in less complex production plants. Condition-related maintenance helps every machine operator save enormous cost. To this end, any damage must be detected at an early stage, diagnosed, and its development monitored. In this way maintenance work can be scheduled well ahead and the necessary preparations can be made. The availability of machines increases, and the production cost is reduced.

## Rolling bearing diagnosis with the portable FAG Bearing Analyser

The FAG Bearing Analyser is an efficient and reasonably priced **vibration diagnosis tool for early detection of rolling bearing damage and gear damage**. By means of the field-proven envelope detection method it diagnoses all types of damage that cause noise - i.e. vibrations -, such as cracks, pitting, indentations or dirt. A commercially available laptop is turned into an efficient, reasonably priced, portable diagnosis device by installing the Analyser software, inserting the PC card and connecting the docking station. It enables the user to determine not only whether a bearing is intact or damaged but also which type of damage one is dealing with. It even permits detection of damage in bearings that are installed in a complex machine and whose structure borne sound signal is, consequently, superimposed by the vibrations of adjacent machine parts.

Other vibration diagnosis methods that use the characteristic values of the vibration signal (peak value, effective value, mean value) permit no reliable diagnosis of the condition of a rolling bearing and are not suitable for an early diagnosis of damage.

## Principle of envelope detection analysis

Faults or damage on machine parts, as a rule, cause additional vibration. Cycling of discrete damage on a rolling bearing, e.g. pitting in the raceways, causes a **periodic series of individual shocks**. These shocks induce structural resonances in the bearing or in adjacent machine parts. The shock frequency is characteristic of the type of rolling bearing damage and can be calculated if the bearing geometry and the speed are known.

Depending on the location of the damage (outer ring, inner ring, rolling elements) different shock frequencies are obtained that are referred to as kinematic bearing frequencies. These high-frequency vibrations are superimposed by running noise. The original shock values can be reconstructed for evaluation by filtering out all sinusoidal vibrations and rectifying the signal. The rolling bearing damage is characterized by increased amplitudes at the corresponding kinematic frequencies and by their multiples and side bands.



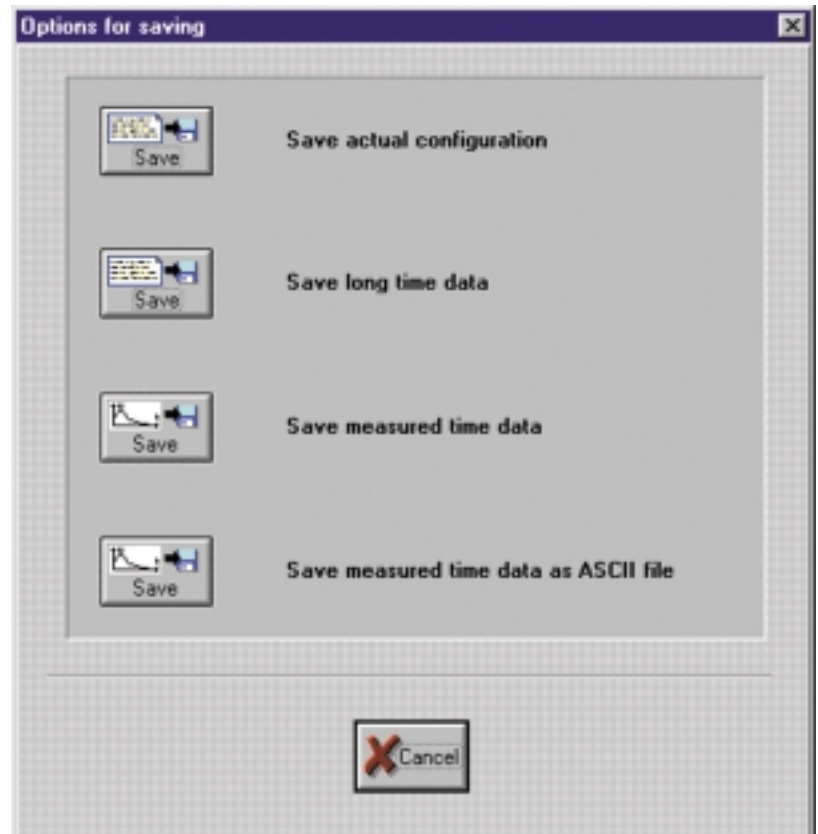
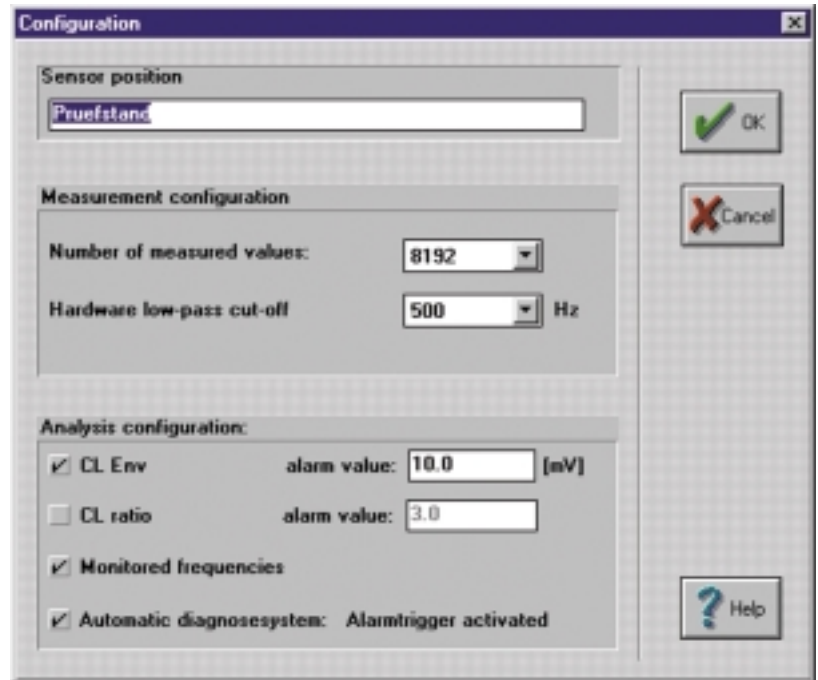
# Measurement and Program Description

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Before a measurement can be conducted, a configuration file must be generated. All parameters of the measurement are specified in this file and can be adjusted for the measurement of vibrations and for the diagnosis/analysis of the signal.

At the beginning of every measurement the configuration files are loaded. During the measuring process the FAG Bearing Analyser informs the user via a status window about which operations are performed at the moment. The amplification factor is automatically adjusted in the docking station to the maximum possible resolution without overamplification (autoranging). Then the FFT (fast fourier transformation) is calculated. The pickup rate is adjusted automatically in dependence on the low-pass filter selected by the user in the configuration file. Up to 8192 values can be recorded.

Configuration files can be saved separately. The same holds for the measured time signal, which can be saved both in its own format (IBH 2.0) and as an ASCII file. Up to 3000 long-term data are managed in a ring buffer. In this ring buffer the measured characteristic values and the results of automatic analyses and of the frequency monitoring process are saved.



# Measurement and Program Description

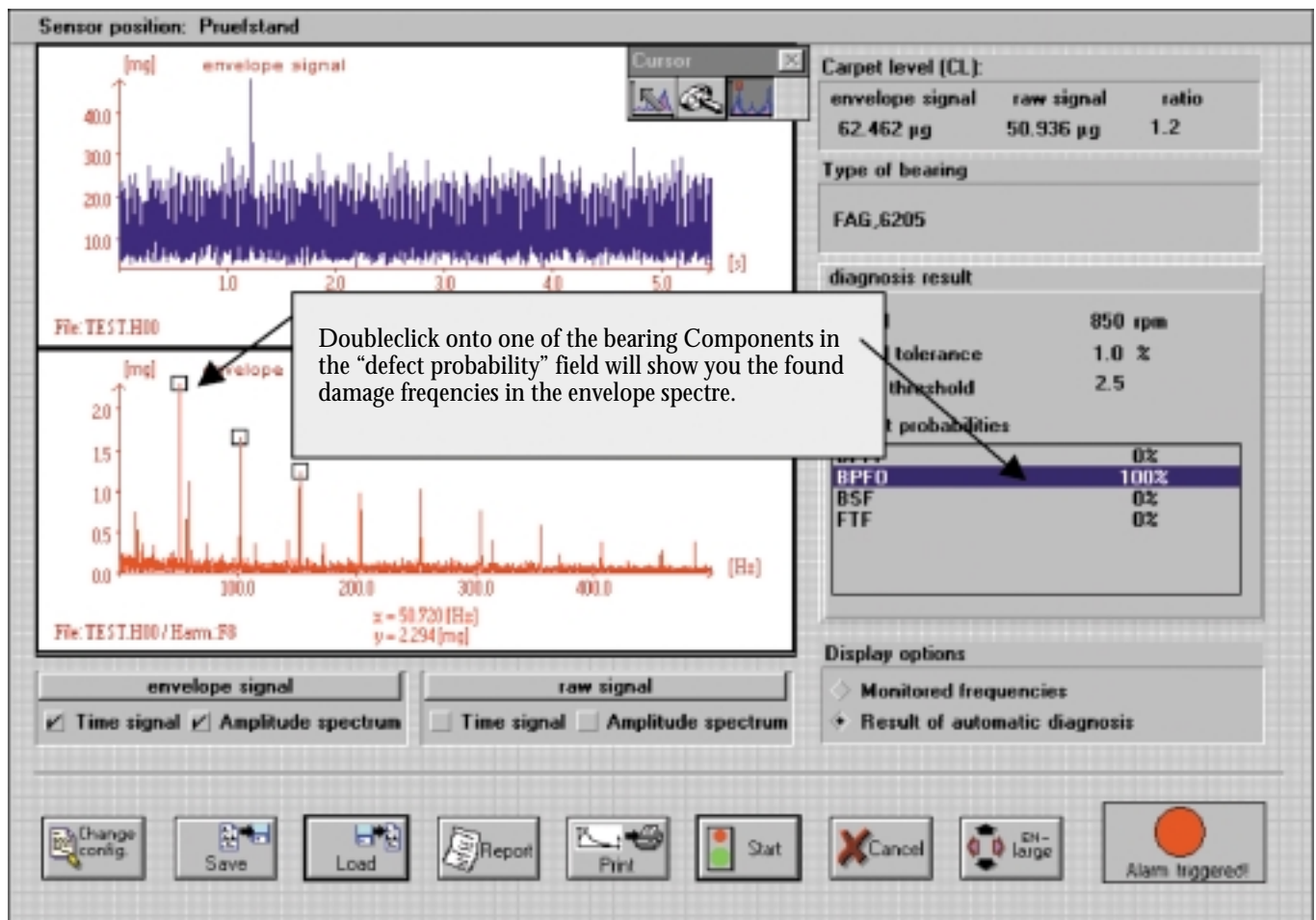
When a data record was loaded, or when a measurement was conducted, the Bearing Analyser displays the envelope time signal and the envelope spectrum in a window. By clicking on the "Raw signal" button below the graphic, the raw signal and the raw signal spectrum are displayed. Up to four signals can be visualized simultaneously.

On the right, the monitored frequencies and/or diagnosis results are displayed if these were selected in the configuration file.

Time and frequency signals can be examined very effectively by means of the functions in the relocatable cursor window. There is a zoom function, and the user can mark carpet-level characteristic

values. By double-clicking on the damage similarity, the detected cycling frequency and its harmonics can be marked by means of a cursor.

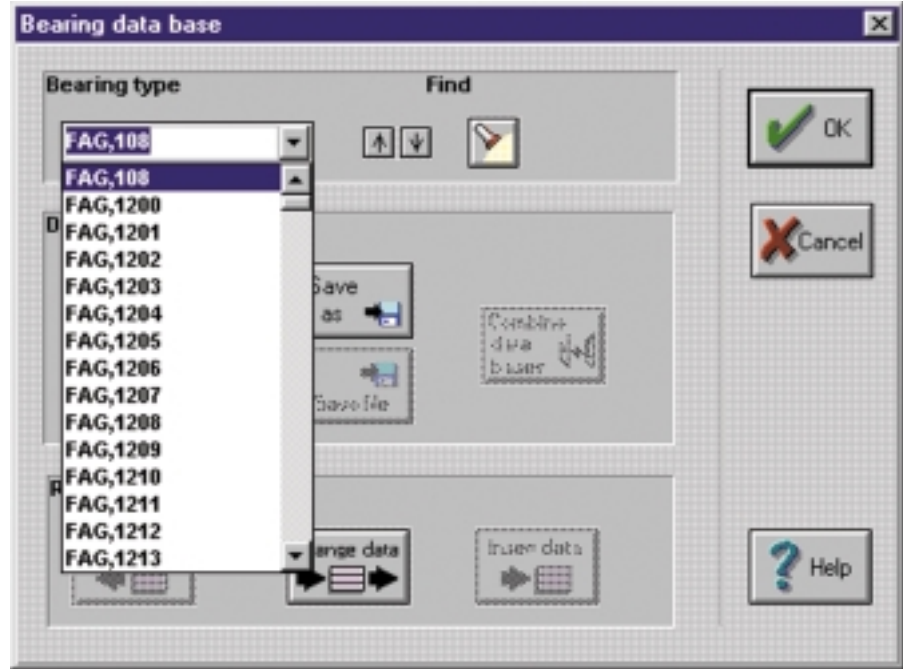
The report function permits the user to summarize and print all important diagnosis results in text form.



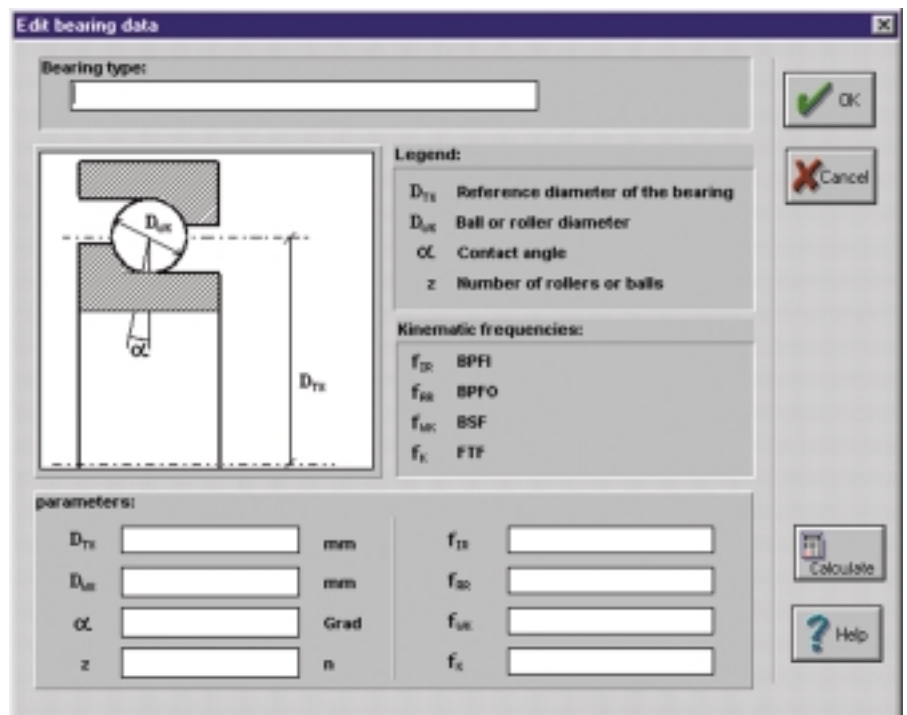
In order to diagnose the condition of a rolling bearing, the FAG Bearing Analyser needs information about the speed of the supported shaft and about the structure of the bearing.

The structure is specified by standardized cycling frequencies in which the component dimensions are encoded.

By entering the bearing type in the bearing database window, the user calls up these data from the database. The database that is part of the delivery scope contains the data of the commonly used FAG bearings.



If the required bearing type is not contained in the supplied database, this bearing type's data can be added to the database. The new bearing data can easily be input via a so-called bearing calculator. In this mask the bearing's standardized frequencies or geometry data must be entered directly beside the bearing code. Based on this information, the program can calculate the standardized (speed-independent) cycling frequencies; the program is started by clicking on the Calculate button.



# Measurement and Program Description

## Automatic Diagnosis

The system needs information about the bearing's operating speed in order to calculate the speed-related frequencies required for an automatic diagnosis from the standardized cycling frequencies.

It is also possible to specify a speed tolerance (in per cent) which is taken into account in the automatic diagnosis.

When evaluating a single measurement, the result of the automatic diagnosis is displayed in the form of damage similarities (in per cent).

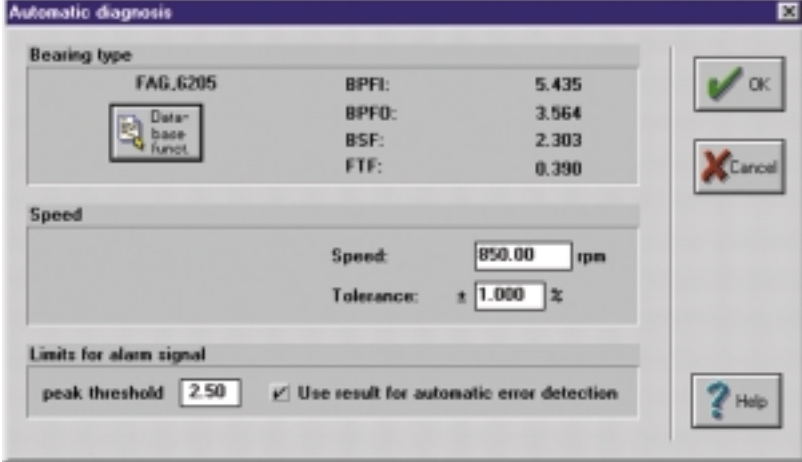
To this end, the software searches the frequency spectrum for bearing-specific frequencies, their multiples and side bands. In this way damage can be detected and analysed regardless of the absolute magnitude of the signal power, even without a reference measurement.

In addition to the specific frequencies of a rolling bearing, which the expert system automatically enters into a frequency table, up to 7 other frequencies can be monitored. In the automatic diagnosis the first three monitoring frequencies are the cycling frequencies of the rolling elements, outer ring and inner ring.

For every frequency to be monitored the basic frequency, a band width and an alarm value must be entered.

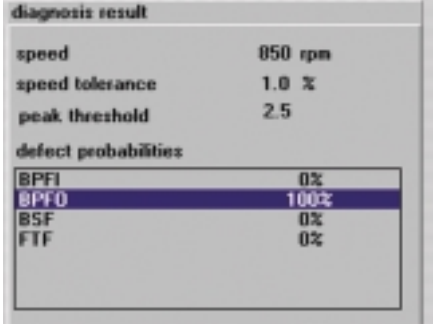
The system searches the frequency spectrum of the envelope signal for the highest peak in the specified band width around the basic frequency. If this peak exceeds the alarm value, an alarm is triggered.

The user can also specify trigger values for the alarm probability. If a damage similarity exceeds this value during a diagnosis, an alarm is activated, and the colour of the alarm button changes from green to red.



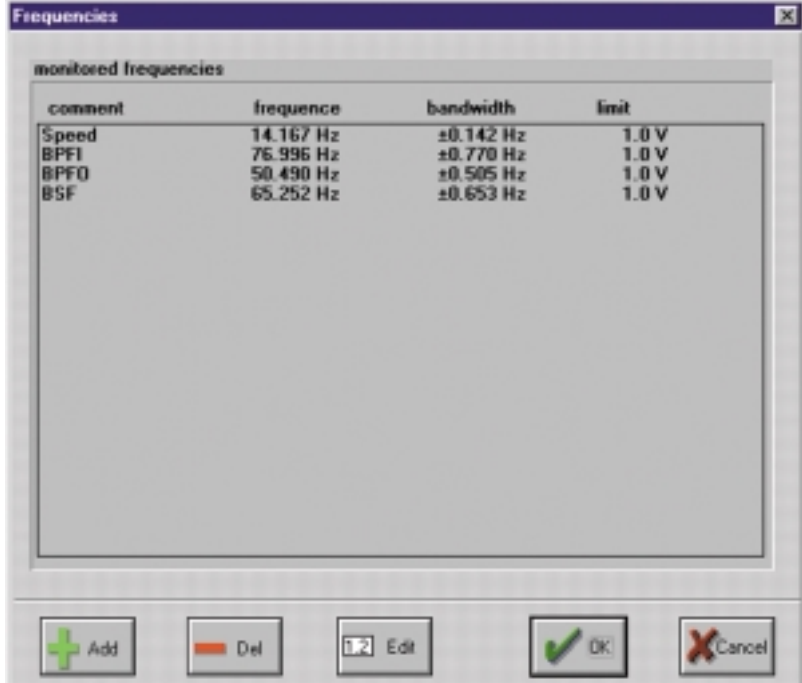
The 'Automatic diagnosis' dialog box contains the following fields and controls:

- Bearing type:** FAG.6205, with a 'Data-base-funct' icon.
- Parameters:** BPF1: 5.435, BPF0: 3.564, BSF: 2.303, FTF: 0.390.
- Speed:** Speed: 850.00 rpm, Tolerance: ± 1.000 %.
- Limits for alarm signal:** peak threshold: 2.50,  Use result for automatic error detection.
- Buttons:** OK (green), Cancel (red), Help (blue question mark).



The 'diagnosis result' dialog box displays the following information:

speed	850 rpm
speed tolerance	1.0 %
peak threshold	2.5
defect probabilities:	
BPF1	0%
<b>BPF0</b>	<b>100%</b>
BSF	0%
FTF	0%



The 'Frequencies' dialog box shows a table of monitored frequencies:

comment	frequency	bandwidth	limit
Speed	14.167 Hz	±0.142 Hz	1.0 V
BPF1	76.996 Hz	±0.770 Hz	1.0 V
BPF0	50.490 Hz	±0.505 Hz	1.0 V
BSF	65.252 Hz	±0.653 Hz	1.0 V

Buttons at the bottom: Add (green plus), Del (red minus), Edit (F2), OK (green checkmark), Cancel (red X).

## Installation of the Software

To permit an easy installation of the software, the setup CD contains a setup program that guides the user through the entire installation process. The FAG Bearing Analyser software runs under Windows 95, 98 and NT4.0. The screen resolution should be at least 800x600 pixels. A computer with a Pentium processor and at least 16 MB RAM should be available.

## Features of the “FAG Bearing Analyser” Software

- Simultaneous measurement of raw signal and envelope signal
- Automatic frequency analysis by a fuzzy-based expert system
- Monitoring of the envelope carpet level and of the carpet level ratio of envelope signal to raw signal
- Monitoring of freely definable frequencies in the envelope spectrum
- Integrated database system for 4200 standard FAG rolling bearings
- Integrated “bearing calculator” for easy input of not yet defined bearings
- Graphic presentation of the measured signals and their spectra. Tools for a thorough manual analysis, e.g. a harmonic cursor and various zoom functions
- Various tools for printing the graphics and reports or for copying them into the Windows clipboard from where they are imported into other Windows programs
- Trend function for long-term monitoring

## Standard scope of delivery:

Order code (complete system): **BA98.SYS**

The FAG Bearing Analyser comes ready to use, with the following accessories:

- |   |  |
|---|--|
| 1 docking station for connecting the sensor and processing the signals, power supply via notebook and PC card cable<br>Order code: <b>BA98.DOCK</b> | 1 setup CD, software as described above<br>Order code: <b>SOFTW.BA98</b> |
| 1 acceleration pickup with 1.5 m cable<br>Order code: <b>SENSORPZA12.2M</b>   | 1 data acquisition card NI DAQ-Card 700,<br>Order code: <b>BA98.CARD</b> |
| 1 magnetic base for attaching pickup<br>Order code: <b>MAGNETD30.M6</b>   | 1 user manual  |
|   | 1 extension cable (5 m)  |
|   | 1 extension cable (10 m)   |

Accessories in bold print can also be ordered individually as **replacement parts**.



# Technical Data

<b>Designation</b>	FAG Bearing Analyser Order code (complete system): <b>BA98.SYS</b>	
<b>Dimensions</b> (docking station)	290 mm wide, 230 mm long, 35 mm high	
<b>Weight</b> (docking station)	ca. 1.5 kg	
<b>Power supply</b>	Via notebook	
<b>Operating time</b>	1.5 to 2.5 h, depending on the notebook's type of battery	
<b>Temperature range</b>	0 to 50 °C	
<b>Operation</b>	Windows-based software Touchpad or mouse	
<b>Data recording capacity</b>	256 to 8192 samples (corresponding to a frequency resolution of 100 - 3200 lines)	
<b>Entries</b>	2 Lemos sockets, 4-pole, for acceleration pickup (4 mA ICP power source, 24 V) 1 trigger entry per channel (2nd entry in preparation)	
<b>Voltage ranges</b>	+/-5 mV to +/-5 V (peak-peak) +/-15 V max. input voltage Software issues warning if input sensitivity is exceeded.	
<b>Frequency ranges</b>	Simultaneous measurement of general vibration signal and envelope signal Band width: 5 Hz - 20 kHz; in this range, frequency bands can be selected as required	
<b>Triggering</b>	Automatic, pre-programmed externally	
<b>Process window</b>	Hanning	
<b>Filter functions</b>	High-pass filter can be switched: 750 Hz/2 kHz with envelope detection	
<b>Interfaces</b> (depending on notebook)	ECP/EPP parallel, serial, external VGA, PS/2 keyboard/mouse/keypad, PCMCIA interfaces (2 x type II or 1 x type I, PC card) Serial infrared interface	
<b>Standard scope of delivery</b> <b>BA98.SYS</b>	Data acquisition card Acceleration pickup Magnetic base for fastening the pickup Software, installed on CD-ROM Docking station User manual, extension cables (5 m and 10 m)	BA98.CARD SENSORPZA12.2M MAGNETD30.M6 SOFTW.BA98 BA98.DOCK
<b>Damage diagnosis</b>	Carpet level of the monitored noise for envelope signal and general vibration signal Threshold value monitoring of the amplitudes of up to 10 freely selectable frequencies Automatic frequency analysis with fuzzy-/neuro-based expert system	

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TI No. WL 80-63 E/99/4/01 - Printed in Germany by Weppert GmbH & Co. KG