Brüel & Kjær Vibro

VIBRO-IC

The New Generation in Machine Monitoring

BVP-1005-EN

Diagnostic Machine Monitoring- VIBRO-IC the new Quality for Protection of Individual Machine Groups

For the first time the newly developed VIBRO-IC system allows individual faults and damage frequencies to be monitored in addition to pure machine protection by means of conventional monitoring. This heightens the level of monitoring reliability and at the same time provides all relevant information about the current machine condition so that timely corrective action can be taken.

Machine protection with conventional machine monitoring

Permanent monitoring of machine condition has for many years been an incontestable strategy for a large number of machines.

This is especially true for machines and plant where

- Disturbances lead to serious production losses
- There is a danger of spin-off damage because of machine complexity
- Repairs can be very costly
- No redundancy is available
- There is inherent risk to personnel and environment

Informative machine condition indicators, such as mechanical vibrations, speeds, axial position of the rotor, housing displacements, temperatures and process values, are continuously acquired, converted to characteristic values and compared to limit values. Any violation of these limit values leads to an alarm signal and/or shutdown of the machine through relays.

Selection of the right type and number of parameters to monitor in individual cases depends on the machine construction, application and site conditions.
For example many auxiliary machines are equipped at only one measuring point for monitoring bearing vibrations.

In the case of more complex machines that are important for the production process, e.g. compressors and turbines,
a complete series of measuring points and monitoring parameters must be included in the monitoring concept to guarantee reliable machine protection.

Diagnostic monitoring recognizes faults and damage in individual machine components at an early stage

Now the most modern measuring techniques provide new monitoring strategies through

- Comprehensive analysis of the information content of mechanical vibration signals
- Inclusion of the machine and plant operating mode and conditions in the monitoring concept
- Logic-, arithmetic- and statistical linking of various condition characteristic values
- Learning the normal behavior and automatically creating limit and reference values

Ventilators

Pumps

Gearboxes

E-Motors

Compressors

Separators

Centrifuges

Wind power-generator

Mills

etc.

Using these strategies it is possible to recognize on-going faults and damage at a much earlier stage, monitor them continuously and switch alarms and/or shutdowns when a critical state is reached.

With VIBRO-IC diagnostic machine monitoring is a reality!

The applied measurement techniques and diagnostic software are designed with the flexibility for an individual monitoring concept to suit any machine or plant type:

Machine protection and integration into a condition-based machine maintenance program

The measured data from VIBRO-IC can, with the use of the VIBROEXPERT software program, be archived and evaluated in a PC, and thus integrated into a concept of condition-based maintenance.

Network- and Modem operation

If a number of machines or machine groups are monitored, networking a number of VIBRO-ICs and remote operation via modem is possible.

Diagnostic Monitoring with VIBRO-IC

VIBRO-IC handles these measurement tasks

VIBRO-IC acquires all important machine condition parameters:

Mechanical vibrations

such as
- absolute bearing vibrations
- relative shaft vibrations

In the processing of mechanical vibrations the overall broad-band signal can be assessed in a number of individual frequency bands. From this measured signal a number of narrow-band values can be acquired as "harmonics" of a machine's rotational speed. Thus, overall machine safety monitoring and selective monitoring of individual vibration sources, such as unbalance, alignment error, gear damage, etc. are possible.

Rolling-element bearing condition

The rolling-element condition parameter (BCU-**B**earing **C**ondition **U**nit) enables early recognition of on-going damage in rolling-element bearings and therefore a timely bearing replacement.

Speed

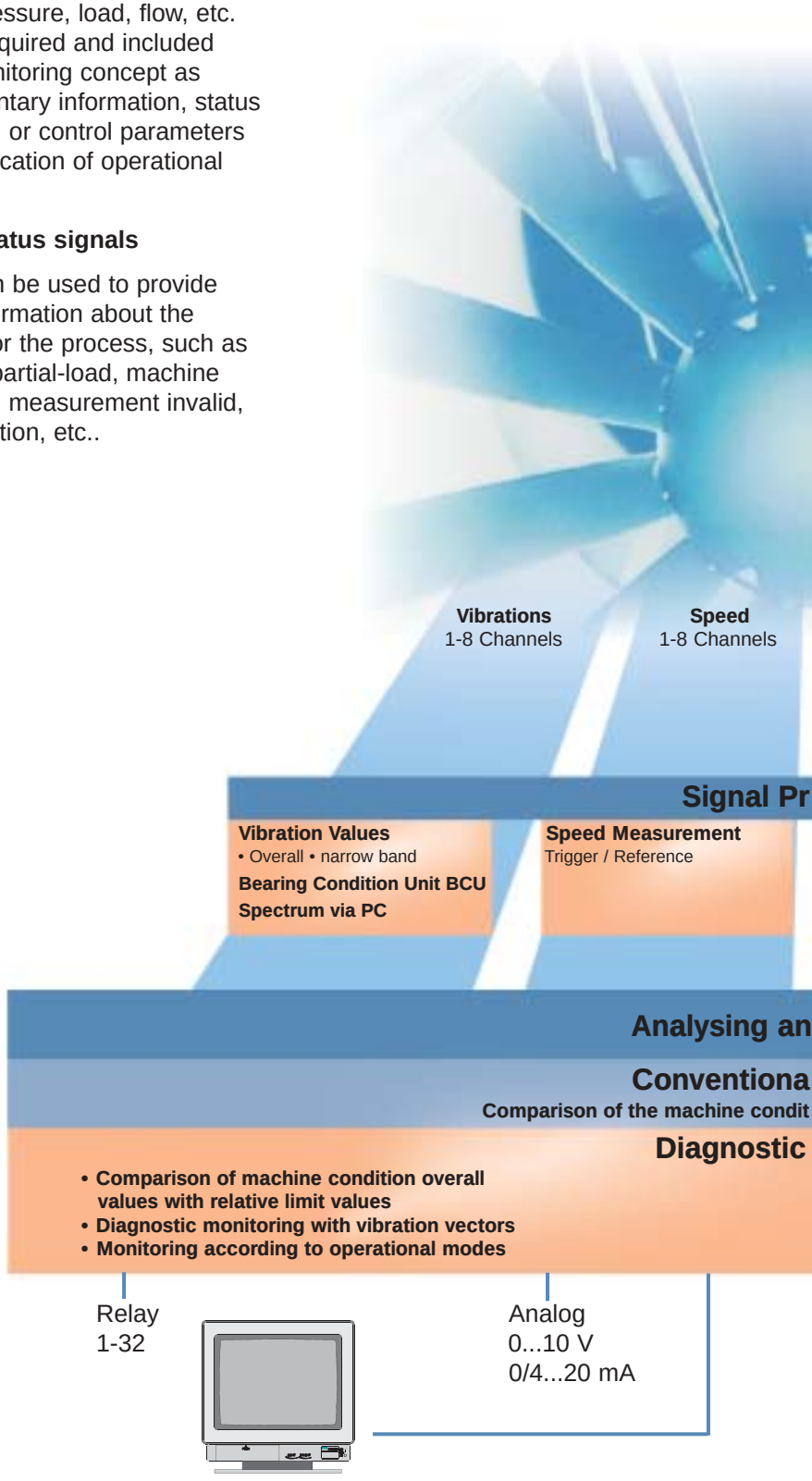
Speed measurement can provide important information apart from the simple indication of the machine speed. Operating conditions, such as zero rpm, partial-load, full-load can be recognized and classified (using speed as a control parameter).
Speed measurement is also used as a trigger for synchronization and execution of narrow-band vibration measurement.

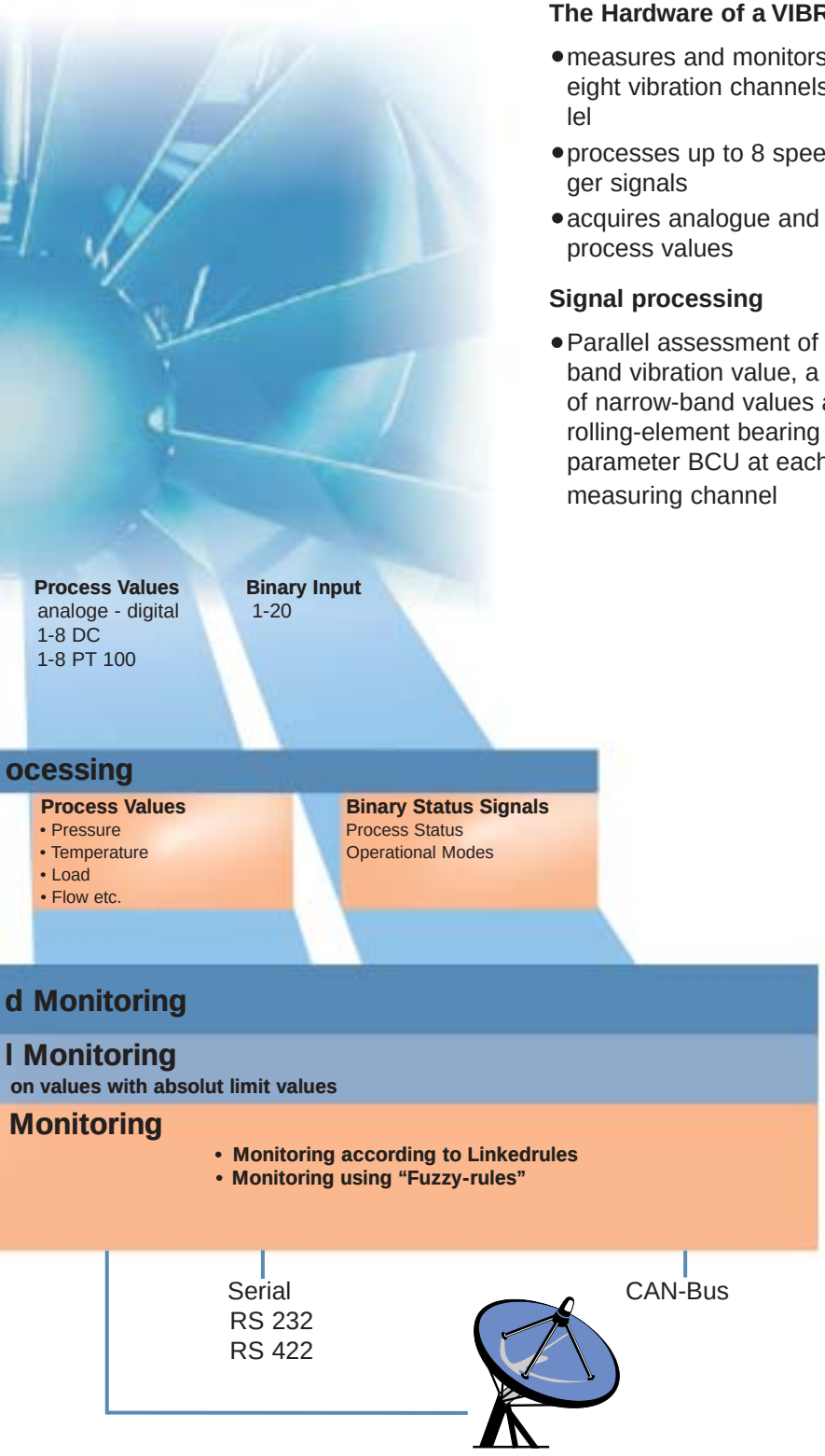
Process values

Process values such as temperature, pressure, load, flow, etc. can be acquired and included in the monitoring concept as supplementary information, status indicators, or control parameters for classification of operational modes.

Binary status signals

These can be used to provide digital information about the machine or the process, such as full-load, partial-load, machine stationary, measurement invalid, valve position, etc..





Particular advantages of VIBRO-IC

The Hardware of a VIBRO-IC

- measures and monitors up to eight vibration channels in parallel
- processes up to 8 speed or trigger signals
- acquires analogue and digital process values

Signal processing

- Parallel assessment of a broad-band vibration value, a number of narrow-band values and the rolling-element bearing condition parameter BCU at each vibration measuring channel

The monitoring concept

- Conventional monitoring by comparison of the broad-band vibration value with absolute limit values
- Limit-value comparison with reference values or "learned" values,
- Comparison of narrow-band values according to their amount and phase
- Limit comparison according to operational mode and dependent on control parameters
- Linking of numerous monitored values according to logic, arithmetic, statistical and Fuzzy rules

Interfaces and Communication

- Serial interfaces for networking multiple VIBRO-ICs, integration with the machine control, remote operation and for connection with a PC and modem
- Central archiving, evaluation and visualization of the measured data, event messages and the Logbooks with VIBRO-EXPERT CM-400

How a diagnostic monitoring system operates

Damage, faults and disturbances in machines often have numerous and complex causes. The causes are based on the constructive features of the individual machine itself, the connection within the machine group, the operating process and the mode of operation or environmental conditions.

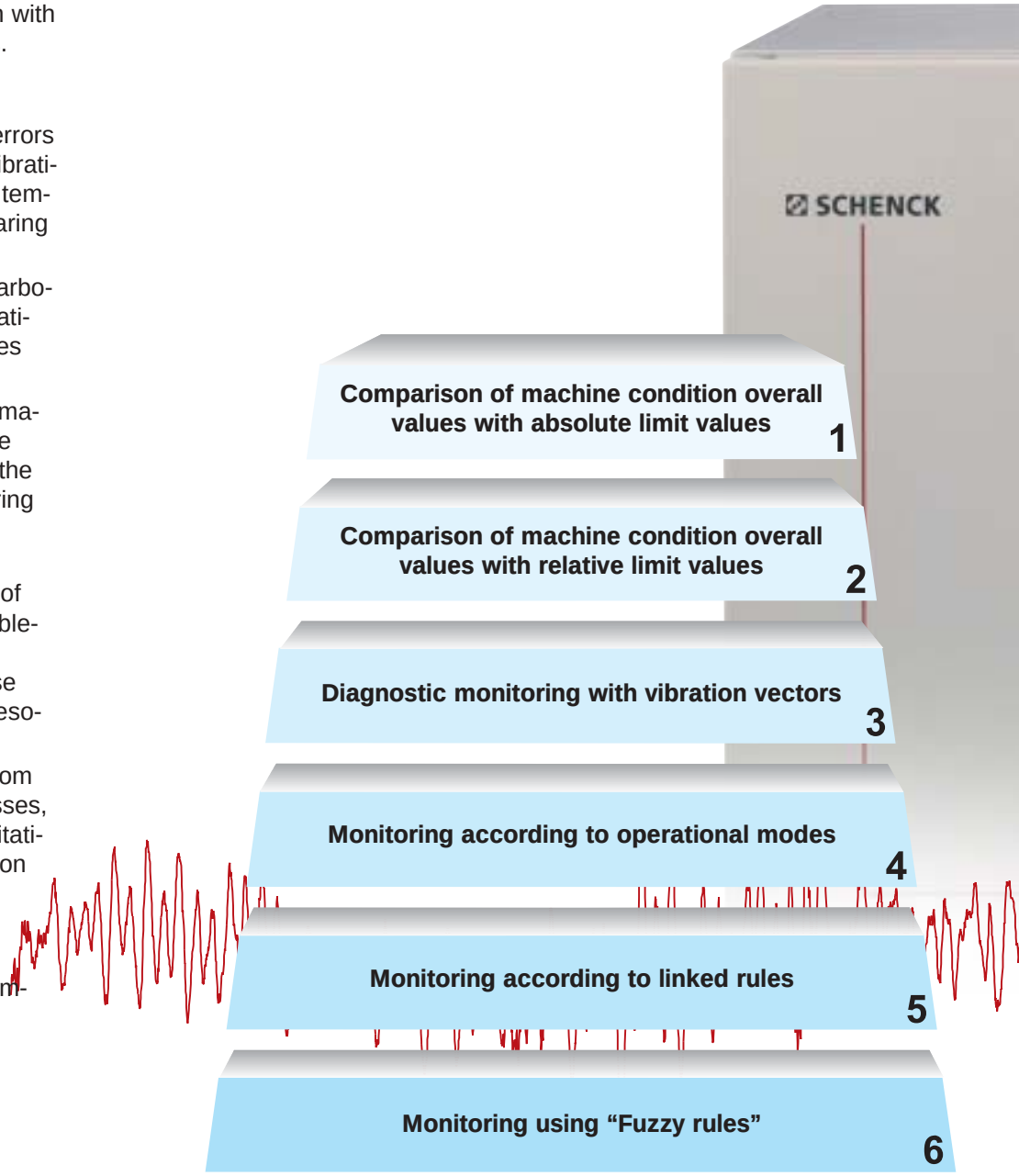
Many of the causes of faults can be identified during operation with the help of various indicators.

Some examples:

- Unbalance and alignment errors create rotor-synchronous vibrations and increased bearing temperatures due to higher bearing loading
- Damage to the gears in gearboxes leads to increased vibrations at gearmesh frequencies and associated sidebands
- Rolling-element bearing damage produces impulses in the bearing construction when the area of damage in the bearing comes into contact with rolling elements
- During run-up or run-down of the machine or under variable-speed operation increased machine vibrations can arise due to the appearance of resonances
- Stochastic impulses, e.g. from crushing and milling processes, hydraulic or pneumatic excitation lead to increased vibration load
- Neighbouring machines transfer vibrations to other machines via their common foundations

Conventional machine monitoring as a rule consists of monitoring the global condition of the machine, i.e. acquiring the overall vibration values within a broad frequency range, similarly to process values, and comparing them with absolute limit values. Differentiation according to individual sources of faults or a correlation with various condition parameters is not done.

Diagnostic monitoring with VIBRO-IC goes beyond a merely global evaluation of the machine. The monitoring concept of VIBRO-IC allows focussed monitoring of the individual problem locations of a machine. According to the complexity of construction and the application conditions, one or more steps of the following monitoring concepts can be applied.



Steps in the VIBRO-IC monitoring concept

Step 1.: Comparison of machine condition overall values with absolute limit values

Absolute limit values are determined using Standards and Guidelines, recommendations from the machine manufacturer or the users own experience. This monitoring concept allows a "good or bad" statement to be made about the machine condition and serves, as a rule, purely for machine protection or a criterion for starting an in-depth analysis procedure.
This conventional monitoring method is generally employed for machines that operate under steady-state conditions, i.e. without changes in operating mode.

Step 2.: Comparison of machine condition overall values with relative limit values

This allows monitoring of the machine against reference values or "learned" limit values determined during operation of the machine. Operational, constructional and environmental conditions are thus taken into consiuation

Step 3.: Diagnostic monitoring with vibration vectors

This is the monitoring of individual faults and sources of errors, such as unbalance, alignment errors, gear faults, etc. by measurement and comparison of the amplitude and phase of frequency-selective (narrow-band) vibration values with limit values.

Step 4: Monitoring according to operational modes

The limit values are determined and monitored according to the operational mode of the machine. To do this it is necessary to acquire the operational state of the machine with control para-meters, such as speed, load, flow, valve position, etc. and correlate them with the machine condition overall values.

Step 5: Monitoring according to linked rules

Often a single characteristic value is not sufficient to evaluate the condition of a machine or make a clear diagnosis of the cause of the fault. In these cases a number of parameters can be logically or mathematically linked to allow a reliable diagnosis to be made.

Step 6: Monitoring using "Fuzzy rules"

If the complex relationships in a machine cannot be described using rigid rules, this step allows linking of the machine parameters using Fuzzy rules to provide an extremely sensitive and narrowly focussed monitoring concept.

VIBRO-IC offers the advantage of combining these individual monitoring concepts for each application!

Typical Solutions for Specific Machines and Plants

For any number of important machines custom-made solutions exist that have been proven in practice:

Application class 1:

- **Sleeve-bearing machines**

Pumps, ventilators, large electric motors, small and medium-sized turbines, generators, compressors, etc.

Application class 2:

- **Machines with speeds higher than 10 Hz, with REB (rolling-element bearings)**

REB ventilators with REB drives, large sleeve-bearing pumps with axial thrust REBs, etc.

Application class 3:

- **REB machines with speeds under 10 Hz**

Slow-running milling and crushing machines, large fans, separators, etc.

Application class 4:

Plant-specific and detailed solutions for
- Rolling-mill plants,
- complete machine controls

Application 5:

Solutions for customer-specific applications that cannot, or only at great expense, be realized on the basis of applying any of the first 4 applications classes can be user-designed using the flexible programming functions of the VIBRO-IC. Experienced machine diagnosticians, in cooperation with programmers, can create their own specific machine monitoring solution.

Application

Condition-based Machine Maintenance with VIBRO-IC

Data archiving-Visualization-Diagnostic evaluation at the PC

VIBRO-IC permanently monitors according to the selected diagnostic monitoring concept and provides alarms through limit relays in the event of limit value violations.

Data archiving over the entire operational period of the machine, visualization, in-depth diagnosis and evaluation of the stored measurements can be done with the help of the VIBROEXPERT software program that runs under Windows 95/98/NT.

The archiving concept:

- Event-oriented archiving in the case of violation of a limit value: When a limit violation occurs all current measurements from all measuring points on the entire machine are saved internally in the VIBRO-IC and can be stored in the data base of the PC. Thus it is possible to assess the condition of the entire machine. Both vibration and process values are taken into consideration in this procedure.

- Time-oriented archiving at selectable time intervals: In a case where no limit violations occur over a long period of time in continuously operating machines, a complete set of measured vibration and process values can be requested from the VIBRO-IC at regular time intervals and stored in the data base. This allows a time-based trend to be displayed even in the case of machines or machine groups which are "healthy" from an operational point of view.

Alarming and visualisation of the current machine condition

The traffic light function signals critical machine conditions and faults in the monitoring system or the network. All limit value violations and fault messages are recorded in the Plant Logbook. The Bargraph display shows the current measured values.

Analysis and diagnosis functions

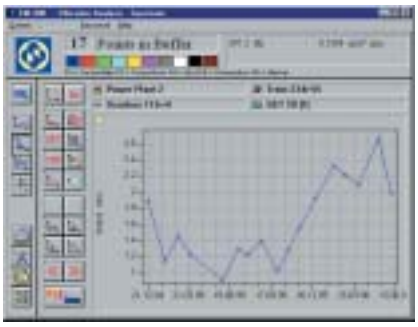
The analysis module of the VIBROEXPERT offers numerous visualisation and analysis functions for diagnosis of the faults and their causes, for example

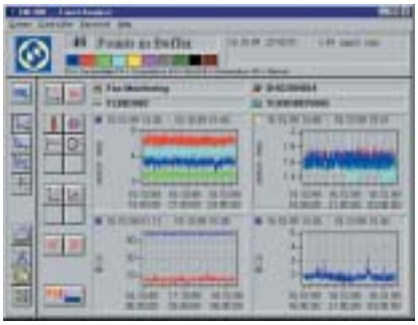
- Trend display with limit value comparison
- Prognosis of the time-based trends of measured values
- Amplitude and phase of the narrow-band values of mecha-nical vibrations

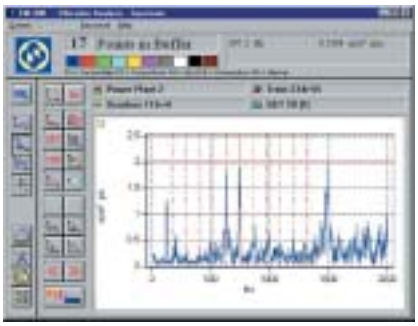
Communication with networked VIBRO-ICs

Up to 250 VIBRO-ICs can be networked with the VIBROEXPERT software program.

Configuration







VIBROCONFIG CM-405 Configuration and Operating Software

VIBRO-IC can be set up and operated using either the built-in operating panel or the VIBRO-CONFIG CM-405 PC software program that

- Permits communication between the PC and VIBRO-IC in single and network operation
- Sets up the configuration and parameter settings
- Operates and sets up the VIBRO-IC Normal, Learn and Service modes
- Allows visualisation of measured values, status messages and Logbooks
- Starts the Service functions

Orderinformation

CM-405	Configuration and Operating Software VIBROCONFIG 405

Orderinformation

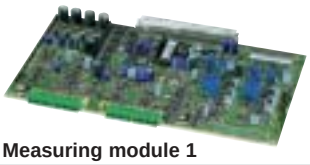
	Software for condition oriented machine maintenance
CM-470	VIBROEXPERT basic module Online with Database, setup and bargraph-display (runs under Windows 95/08/NT4.0)
Modul 23	Communication module for interfacing the VIBRO IC to the database
Modul 65	Analysis module for displaying the measured values, trend diagnosis and predictive function
Modul 66	Analysis module for displaying and diagnosis of spectra
Modul 67	Analysis module for displaying of amplitude'-and phase diagrams

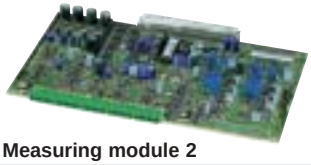
Ordering code: CM-470/23/65/66/67

Technical Data

Dimensions

Technical Data	**VIBRO-IC Basic module**	**CAN-I/O-Module (AC-610)**	**Operators panel (AC-620)**
Power			
AC	24/115/230 V (-20%...+ 10%) 40...60 Hz		
DC	18...36 V	from VIBRO-IC alternatively external 18...36 V	from VIBRO-IC alternatively external 18...36 V
Power consumption	max. 150 VA	max. 15 VA	max. 15 VA
Storage temp.	-10...+65°C (+60°C with AC-620)	-10...+65°C	-10...+60°C
Operating temp.	0...+60°C (+55°C with AC-620)	0...+60°C	0...+55°C
Protection	IP 65 (IP 54 with AC-620)	IP 20	IP 54 (IP 20 rear side)
Weight	approx. 19 kg	approx. 1 kg	approx. 1,5 kg
Interfaces	RS-232/422/CAN-Bus	CAN-Bus	CAN-Bus
Functions	Industrial housing with: Power supply (ESV), processor module (EBU), transformer, OK relay, max. 4 measuring modules modules of type MM-1 or MM-2 plus built-in operators panel AC-620 (only with VIC/01)	8 relay outputs for alarms 5 binary inputs, high/low 2 analog outputs, 10 Bit 0...10 V/0/4...20 mA 1 analog input for process values (DC) 0...10 V, 10 Bit	user dialog via LCD-Display with 4 rows, 20 characters, 24 buttons alternatively for installation in VIBRO-IC, Basic Module or external
Order Code:	**VIC/01 with AC-620** **VIC/02 without AC-620**	**AC 610**	**AC-620**





Technical data	**Measuring module 1**	**Measuring module 2**
Measuring Channels	2 x AC/DC 2 x Trigger	2 x AC/DC 2 x Temperature/DC 2 x DC or 1 x DC, 1 x Trigger
Power Supply	for connection of vibration, trigger and process sensors	
	- 24 V/30 mA	- 24 V/30 mA
alternatively	+ 24 V/3 mA	+24 V/3 mA
Vibration (AC)		
Signal level	24 Vpp, +/- 24 V	24 Vpp, +/- 24 V
input resistance	100 kOhm	100 kOhm
A/D-Converter	2-channell 16 Bit (96 dB)	2-channel 16 Bit (96 dB)
HP-Filter	1 Hz, 10 Hz, 2-pole	1 Hz, 2-pole
LP-Filter	40 Hz, 250 Hz, 4-pole	40 Hz, 250 Hz, 4-pole
Integrator	yes, selectable	no
BCU/BCS	yes, 1 channel, selectable	no
Trigger (pulses)		
Signal level	23 Vpp, +/- 24 V	23 Vpp, +/- 24 V
min. voltage swing	selectable, min. 0,5 V	selectable min. 0,5 V
	1 automatic trigger	1 automatic trigger
	1 manual trigger	
Temperature (PT 100)		
Sensor input		2 x PT 100, 1 mA constant current
LP-Filter		5 Hz, 2-pole
Process values (DC)		
Signal level		+/- 24 V resp. +/- 20 mA
input resistance		94 kOhm resp. 100 Ohm
A/D-Converter		10 Bit
LP-Filter		10 Hz, 2-pole

Direct measured values:

Vibration (AC)	
overalls	RMS, Peak-to-Peak
untriggered selective value (without reference)	DFT, amplitude (peak)
trigger selective value (with reference)	DFT, amplitude (peak) and phase
Frequency range	1 Hz...1 kHz (continuous)
	1 Hz...20 kHz (cyclic)
BCU/BCS	in frequency range 15 kHz...60kHz

Trigger (pulses)	
measured value	frequency, cycle time
frequency range	0...20 kHz

Temperature (PT 100)	
temperature range	-200... + 250°C
frequency range	0...5 Hz

Process values (DC)	
measured value	DC voltage/current
frequency range	0...10 Hz

Process values (binary)	
input	potential free contact
measured value	binary, high/low

System data	
operating system	Realtime/Multiasking
processor	16 Bit RISC-Microcontroller
main storage	5 MByte S-RAM
program storage	2 MByte Flash

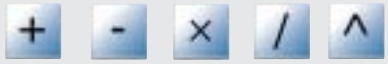
We reserve the right to discontinue or change specifications or designs at any time without notice or obligation.

Computed values:

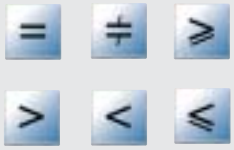
According to the application program (VIBROPLAN) VIBRO-IC can calculate computed values using direct measured values. Therefore, following operators und functions are available:

Operators:

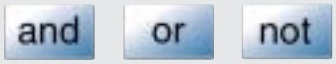
arithmetic operators



comparative operators



logical operators



Functions:

Monitoring modes:

The monitoring mode will be defined by the application program (VIBROPLAN).

Following monitoring modes are available:

- monitoring against fixed (absolute) limit values
- monitoring against relative limit values in relation to previous measured values
- monitoring against adaptive limit values in relation to learned reference values even for different operating modes of the machine
- monitoring based on Fuzzy rules
- self (OK) monitoring of VIBRO-IC

Relay data	**with resistive load**
AC	max. 250 V AC max. 5 A max. 1,25 kVA
DC	max. 48 V DC max. 5 A max. 100 W

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