The VCM-3 products are flexible, state-of-the-art machine condition monitoring units with powerful built-in analysis capabilities. The devices can perform today's most demanding condition monitoring and diagnostic tasks and yet still provide a platform for customization and development for future monitoring requirements. The list of specification below is the shortest possible summary. Many of the features can be enabled, disabled or modified using the "monitoring template" configuration concept to customize operation towards the specific application.

Product Keywords			
Latest technology	Cyber Secure	Cloud Connected	Service Free
360° Monitoring	Off-line data collection	Large internal memory	Open Interfaces
Customization	Full Remote Operation	Flight Recorder	Edge computing device

Hardware Features

This section specifies the general feature set of the VCM-3 products.

12, AC/DC Analog Input Channels	
Sampling Frequency	204.8kHz synchronous on all channels
Analysis Frequency Range	DC-80kHz
Input Type	Differential, bipolar (-25.5V to +25.5V)
Dynamic Range	> 100dB at 1kHz, > 94dB at 0.1kHz
Channel Interference	>-100dB
AC Amplitude Accuracy	±0.5dB
DC Amplitude Accuracy	1% relative of full scale with ±40mV Offset.
Total Harmonic Distortion	< 0.01%/250Hz/4Vpp
Input Impedance	>100kΩ
Common Mode Rejection	>50dB at 50Hz
Phase Match Between Channels	<0.3° at 80kHz
Sensor Power Supply	10mA/+24 Volt/ -24 Volt(external)

4, Speed/High Accuracy DC Input Channels		
As Speed Channel (pulse input)	Types	: Industrial switches: NPN and, PNP (Namur compatible) : Analog: Displacement sensors
	Input Range	: 0-150.000 RPM
	Speed Accuracy	: 500RPM < 0.04RPM, 1500RPM < 0.1RPM
	Pulse Divider	: For use with tacho signals with multiple pulses per revolution
As DC Channel	Sampling Frequency	: 8kHz
	Accuracy	: <±5mV Absolute
	Dynamic Range	: > 100dB

8, 4-20mA Input Channels	
Sensor Types	Normal and NAMUR sensor types are accepted
Bandwidth	0-20Hz
Sampling Frequency	4kHz
Offset Current Drift	< 6.5µV/°C
Current Source	Internal or External

4, Digital Input Channels	
Levels	Input high: 13-33V, Input low: -3 – 5V according to IEC 946
Input Logic	1oo1, 1oo2, 2oo2, 1oo3, 2oo3, 3oo3, 1oo4, 2oo4, 3oo4, 4oo4

2, Digital Output Channels	
Photo relay type	Implements a "mechanical relay like" switch. Max. current 1A, Max. voltage 33V.

Internal Storage	
Internal Storage	4GB
SD Card storage	Original Size SD. microSD via an adaptor. No limit to storage capacity, depends on card size File system formats: Windows compatible FAT32. Linux compatible: Ext3 and Ext4
USB Flash Disk (USB 2.0)	No limit on storage capacity. Depends upon Flash disk. File system formats: Windows compatible FAT32. Linux compatible: Ext3 and Ext4
Storage Interval	Can be configured for each individual descriptor or array measurement
Buffer Size	No. of days in buffer is specified for individual descriptors and array measurements

LED Indicators on the Front Panel	
SFP, RJ45	Green light indicates network activity
System	Green: Everything is OK. Red: Operating system malfunction.
Template	Green: Monitoring OK. Red: Monitoring not running, Yellow: Some descriptors not running
On-line	Green: If there is contact to backend server, Red if no contact. Checked at regular intervals.
Boot Status	Green when boot sequence is completed
RS485	Green flashes during data transfer

System Integration – General Networking	
Network Connections	3 RJ45, 1 optical SFP connector
Low level protocol	Ethernet TCP/IP. IPv4, prepared for IPv6.
Switch functionality	The 4 network ports have built-in switch functionality
RS485 Interface	The serial bus RS485 supports MODBUS RTU interface on VCM-3.

Cyber Security – Networking	
Firewalls	Restricts access by defining rules for control of incoming network traffic.
Secure protocols	Communication takes place through secure and encrypted protocols, such as Websockets, HTTPS, SCP.
Port configuration	All services using a TCP/IP port (e.g. https, default port 443) can be configured to use another port.
NERC Compliance	VCM-3 can be part of solutions complying with NERC CIP Standards. (North American Electric Reliability Corporation – Critical Infrastructure Protection).

Cyber Security – Operating System Level	
Operating System – Security Releases	Operating system is Linux. The operating system is maintained with new security releases as part of firmware update service.
Strong passwords	The use of strong passwords is enforced. Compliance with NIST SP800-118 – Guide to enterprise Password Management. Can be changed by user.
Activity logging	VCM-3 performs activity logging of users and services.

Environmental	
Ambient Temperature	In operation. -30 °C - 60 °C in accordance to EN/IEC 60068-2-2. Applies to device and to device mounted in cabinet. -40 °C with reduced accuracy - 70 °C with de-rated Mean Time Between Failures (MTBF).
Ambient Temperature	Storage. -40 °C - 85 °C in accordance to EN/IEC 60068-2-2.
Temperature Change	Operational during a temperature change rate of 1°C per minute in accordance to EN/IEC 60068-2-14.
Static Damp Heat, Cyclic Damp Heat	In operation. According to EN/IEC 60068-2-78, EN/IEC 60068-2-30 and EN/IEC 60068-2-38.
Salt Mist	In operation. According to EN/IEC 60068-2-52 when mounted in cabinet.
Random & Sine Vibration	According to EN/IEC 60068-2-6.
Rough Handling	Storage. According to EN/ IEC 60068-2-31.
EMC	According to EN/IEC 61326-1, EN/IEC 61000-6-2 and 61000-6-3
High Altitudes	According to EN/IEC 60068-2-13. Air pressure equivalent to 3500m altitude.
Inclination	According to IEC 60092-504.
Corrosion	According to ISO 9223 Class C3-medium when mounted in cabinet.
IP Rating	The device IP rating is IP20 according to EN/IEC 60529 without cabinet. In cabinet rating is IP66
CE Marking	In compliance with the EMC and RoHS 2011/65/EC directives.
HALT Test	Has been subject to HALT test. Excessive vibration and temperatures and combinations hereof
UL Certification	cULus certified
Hazardous Area Approval (Only available for VCM-3 Ex)	24V dc / max. 1,6 A / max. 30 W T4 T_{amb} -30 ° C to +60° C **UL Hazardloc Area Approval** Class I, Division 2, Groups A-D Class I, Zone 2, Group IIC 2 **IECEx Approval IECEx UL 20.0034X** Ex IIC ec T4 Gc **ATEX Approval UL 20 ATEX 2467 X** ⟨Ex⟩I 3G Ex IIC ec T4 Gc

Mechanical	
Dimensions	280 x 153.5 x 35 mm
Weight	1.5 kg
Mounting	DIN Rail Mounting or mounting plate

Power Supply	
Voltage/Power Consumption	Nominal 24V (SELV – Safety Extra Low Voltage) 18-26 V DC/10W + power consumption of each sensor. Worst case sensor current consumption: 48W (including network load) The VCM-3 is intended to be supplied from an isolated Limited Energy Source per UL61010-1, 3rd ed cl. 9.4 or Limited Power Source per UL60950-1 or Class 2 per NEC."
Fuses	Power supply inputs are fused to protect against over-voltage and fire

System	
Operating system	Linux
Python	Environment for calculating iDescriptors, array measurements and customizations
Watchdogs	Software: Software process monitoring. Hardware: Monitors the software watchdog and operating system
Logging	System Log, Measurement system log, Python user module log

Operational	
Fully remote operation	Upload of firmware updates and monitoring templates via network or modem connection
Device homepage	For remote or local service. Commissioning, view of trend and array data, view Log files, selection of Monitoring Templates
Calibration	Factory calibrated. No further calibration needed.
Service	No onsite service required. VCM-3 has no moving parts, or other parts which requires regular service
Design lifetime	20 years

Software Features

This section specifies the sum of features that can be enabled or customized using monitoring templates. Depending on the specific application and requirements. BKV provides a range of standard monitoring templates targeted specific applications. Customized templates can be provided on request.

Real Time Descriptor Types	
Real time descriptors are constantly updated by repeated calculations every second. The real-time descriptors analyze a continuous stream of samples from the input stage. All data are analyzed.	
Time Domain Analysis	Low-pass, High-pass, Band-pass (tracking and fixed), ECU-Envelope Condition Unit (tracking and fixed), BCU-Bearing Condition Unit, DC, Phase, Speed, Process
	Detectors : RMS, Peak, Peak-Peak, Crest factor
	Physical Parameters : Acceleration, Velocity, Displacement (with proximity probes)
Frequency Domain Analysis (DFT)	Narrowband – CPB (constant percentage bandwidth) - fixed or tracking
	Narrowband Envelope Condition Unit – CPB Envelope filter - fixed or tracking
	Detectors : RMS, Peak, Peak-Peak
	Physical Parameters : Acceleration, Velocity, Displacement (with proximity probes)
Speed (for tracking analysis)	Either direct from sensor, or derived speed using pulse divider and/or gearbox exchange ratio.
Process	Any 4-20mA transducer signal. DC via AC/DC or Speed/DC (high accuracy measurements)
Imported Descriptor	
This descriptor type is based on import from other devices. That is, a PLC, a SCADA system, an oil debris sensor etc.	
Modbus descriptors	Via Modbus TCP/IP Client or Modbus RTU Master
OPC descriptors	OPC UA Client
Customized interfaces	Clients can request special interfaces implemented
Import Rate	Import rate can be set depending upon device type
iDescriptor Types	
In contrast to the real-time descriptors, iDescriptors are calculated and updated with certain intervals. This interval may vary depending upon the priority given to the descriptor and the complexity of the calculation. Some complex descriptors will be calculated with intervals such as minutes, hours etc. Simpler descriptors may be calculated every 10 sec. iDescriptors are calculated using the Python script language and libraries which are embedded in the firmware.	
Time waveform feature extraction	Kurtosis value of a bandpass filtered time waveform
	Bandpass, Low pass, High pass, Stopband
Spectrum based feature extraction	Extraction of harmonic families (Rahmonics from cepstra)
	Extraction of sideband families
	Extraction of residual values
	QMA Quefrency (Magnitude of specified quefrency bands)
	FMA Magnitude of specified frequency bands
BCU	Bearing Condition Units
Statistics on descriptor values	Linear Average, Exponential Average, Median
Automatic regression analysis	Linear, exponential or polynomial fit (up to 3). Makes extrapolation and calculates the time until a descriptor exceeds a given limit with a specified confidence and correlation factor.
Arithmetic	Arithmetic formulas (exp, log, sqrt, abs, +, -, *, /)
Linked calculations	Formulas can take input from other calculations results.
Customized	Other descriptor types can be supplied as customized solutions

Array Measurements

Array measurements supplies data for diagnostic purposes. Transformation of time waveform data into frequency spectra etc. represents a data reduction from the raw time samples. Due to the data reduction, array measurements can be downloaded more frequent than high resolution time waveform data from the sample buffer without compromising network bandwidth or require high volumes of data storage space.

Time Domain.	Time Waveform – absolute
	Time Waveform – with angular resampling for subsequent order analysis or signal enhancement
	Signal enhancement – Time synchronous averaging
	Envelope Time waveform
	Filtered time waveforms using bandpass, low pass, high pass and notch filters.
	No. of samples: 65536
Frequency Domain	Autospectrum
	Magnitude and Phase spectra
	Order spectrum related to any shaft, based upon angular resampling of the time waveform
	Envelope Spectrum (Hilbert or SED)
	Envelope Order Spectrum (Hilbert or SED)
	Power Cepstrum
	Order based Power Cepstrum
	CPB Spectrum
	Full Spectrum
	Number of Lines: 25600
Linked analysis	One analysis can take input from another. E.g. Autospectrum of a signal enhanced time waveform
Customized	Other analysis methods can be supplied as customized solutions

Flight Recorder - Storage of long time waveforms

The Long Time Waveforms are direct storage of the raw time samples recorded from the connected sensors. The Long Time Waveforms are high resolution data very well suited for diagnosis and root cause investigations where it is necessary to make detailed analysis of either the time waveform itself or use of frequency analysis for further investigations.

No of ring buffers	32 synchronously sampled
Channel types for ring buffer recording	AC/DC channels, Speed/DC channels, 4-20mA channels.
Total ring buffer storage	2G byte
Sampling Frequency	Freely configurable. Max. sampling frequency 204.8kHz
Ring buffer time length	Depends upon sampling frequency. Examples: 3.6min (204,8kHz), 62 hours (200Hz)
Trigger of time waveform recording	Hardware trigger : 1oo1, 1oo2, 2oo2, 1oo3, 2oo3, 3oo3, 1oo4, 2oo4, 3oo4, 4oo4
	Software trigger : Triggers on a combination of value ranges for several descriptors
	Fixed Interval : Triggers upon a fixed time interval
Stability Criteria	Parameters indicating stability, such as speed range can be specified together with trigger criteria

Operational State Bin Classification

To describe the environment for a set of condition monitoring measurements, the operational state bin concept has been developed. Some machines has a wide range of operational conditions causing a large variety of loads on the mechanical structures. Data can be stored according these states in multiple dimensions.

No. of bins	Any number of bins per descriptor can be defined
Bin definition, dimensions	Multidimensional bins can be defined. 1,2 and >

Alarm Descriptors

Alarm Descriptors can be used to indicate alarm states locally in the device based on other descriptors.

Default state value	User defined value of the alarm descriptor value when no alarm is present
Max. no. of basic alarm limits	5
State dependency	Basic alarm limits can be automatically raised or lowered depending on value ranges specified for a combination of other descriptors. E.g. for disabling alarm limits under certain process conditions
Reference	A reference setting is used to define the 5 alarm limits as high or low alarms.
Alarm hysteresis	Time thresholds can be defined for on- and off-going alarms.

Software Controlled LED Indicators

The channel specific LEDs can be defined and controlled based on conditions in the device. The examples below is a configuration that gives local operators direct insights into the device conditions. More advanced usage is also possible depending on operational data.

Digital Output	Green if output state is high
Digital Input	Green if digital Input enabled and in-use
AC/DC Input	No light: Not enabled. Green: Sensor OK. Blue: Sensor Malfunction.
Speed/DC	No light: Not enabled. Green: Sensor OK. Blue: Sensor Malfunction.
4-20mA	No light: Not enabled. Green: Sensor OK. Blue: Sensor malfunction(Namur)

System Integration

VCM-3 has several options for system integration. System integration is the process of joining the device with other subsystems and components, thus either adding value to the VCM-3 monitoring strategy by importing data from other subsystems, or by exporting data which can add value to other parts of the system.

Web socket Interface	Full-duplex communication via HTTP protocol. Used for communication with central backend server. For remote transfer of monitoring templates, firmware, configuration commands, descriptors and time waveforms.
OPC UA Client	For data import from controllers, SCADA systems or other system components.
OPC UA Server	For data export to controllers, SCADA systems or other system components.
Modbus TCP/IP Client	For data import from wind turbine controllers, SCADA systems or other system components.
Modbus TCP/IP Server	For data export to wind turbine controllers, SCADA systems or other system components.
Modbus RTU Master	Via the serial RS485 connector. Used for collecting data from other sensors.
Modbus RTU Slave	Via the serial RS485 connector. Allows other systems to read data from VCM-3.

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