



RUBY: WIRELESS SENSOR SOLUTION

HIGH-PRECISION, LOW-NOISE VIBRATION SENSOR



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Ruby - Wireless Sensor Solution for Machine Vibration Monitoring

Wireless Sensor for Vibration Signal Measurement

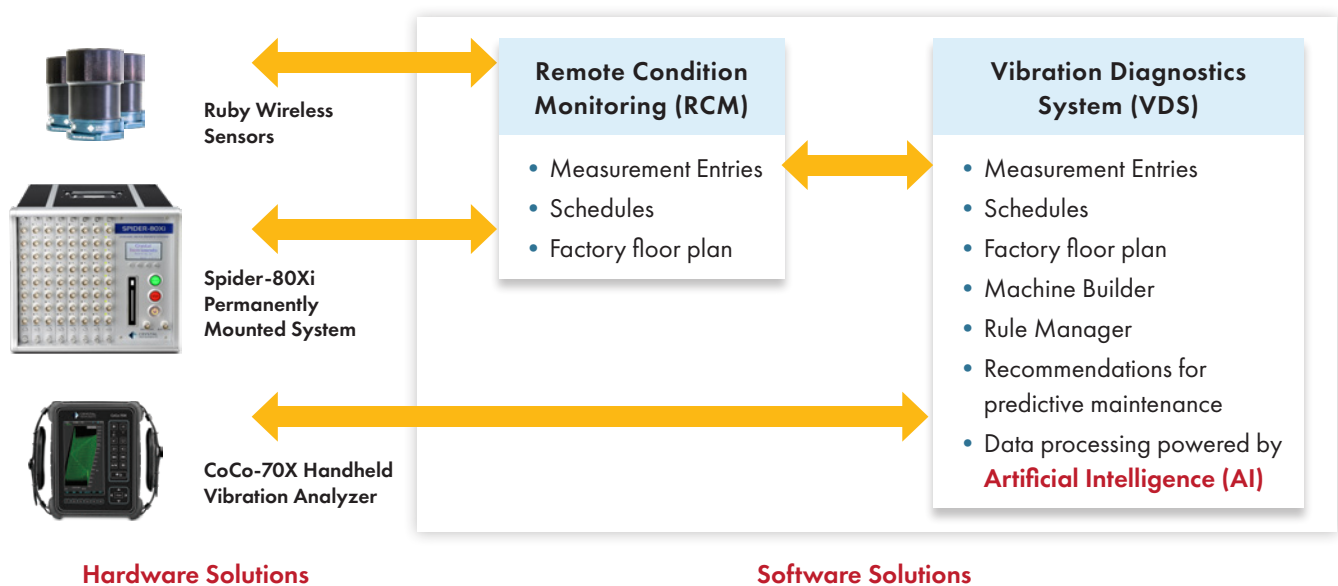
Ruby is an advanced wireless vibration sensor designed for precision condition monitoring of industrial machinery. Engineered by Crystal Instruments, it integrates a high-fidelity 3-axis accelerometer, 24-bit ADC, onboard ARM processor, Bluetooth, USB and secure ISA-100 wireless communication within a rugged IP67 housing. The Ruby platform delivers laboratory-grade accuracy in a compact, battery-powered design suitable for long-term deployment in harsh environments.



Key Advantages

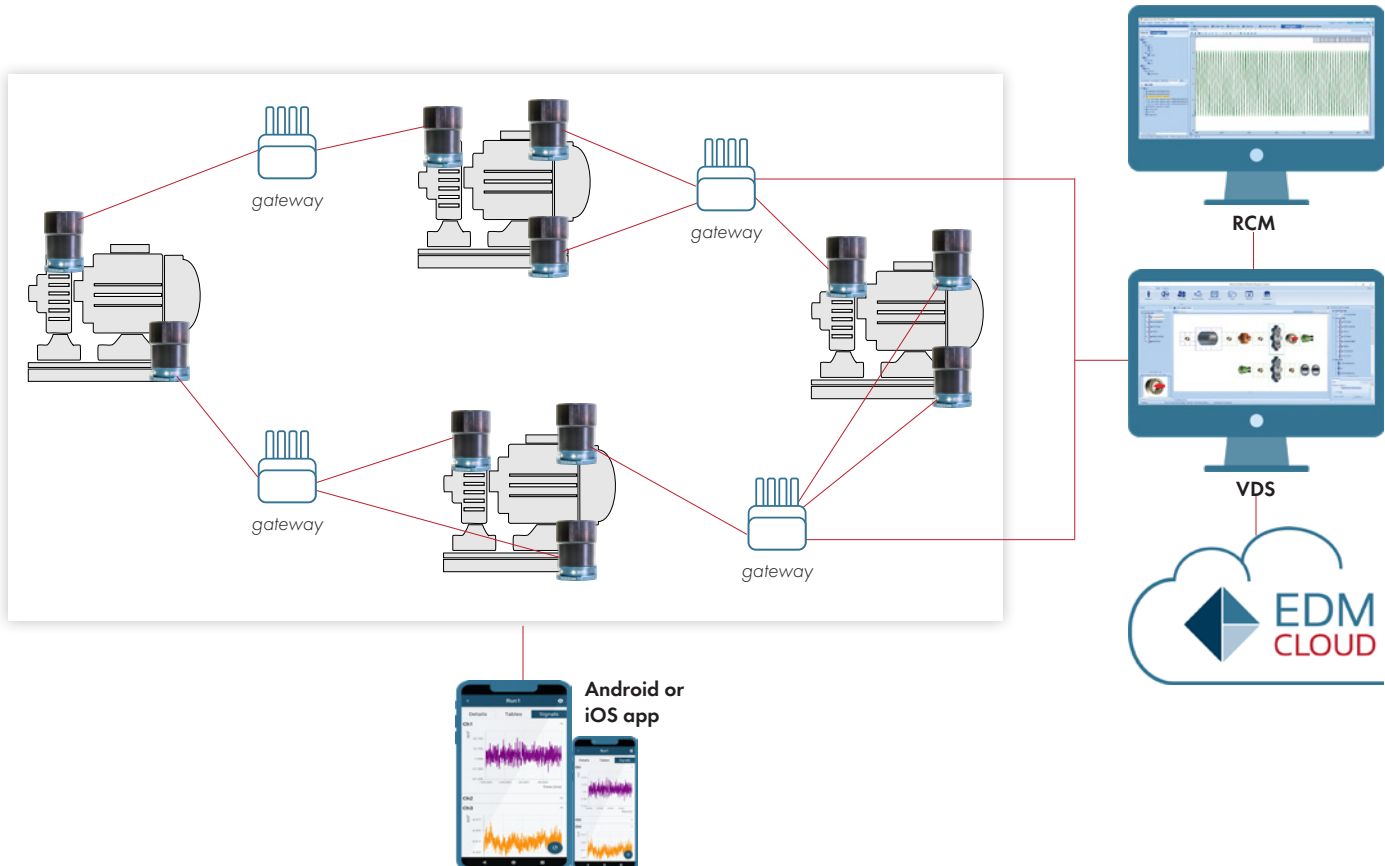
- High-fidelity 24-bit measurement with $<100 \mu\text{g}/\sqrt{\text{Hz}}$ noise floor
- Up to 6.5 kHz usable bandwidth (Z-axis) and ± 1 dB accuracy
- 24-month battery life with intelligent deep-sleep scheduling
- ISA-100.11a industrial wireless networking and Bluetooth connectivity
- IP67 waterproof and dustproof design
- Remote data recording and signal processing
- ISA-100 wireless, Bluetooth and USB connectivity
- Fully compatible with Crystal Instruments' RCM and VDS software suites

Machine Vibration Monitoring Solutions



Crystal Instruments provides a complete solution for machine vibration monitoring. The solution is based on three hardware platforms: CoCo-70X, a handheld vibration analyzer; Spider front-ends, permanently mounted data acquisition systems; and Ruby, a series of wireless sensors. The RCM software is in charge of configuring the Ruby and Spider systems and acquiring the data. VDS, a vibration diagnostic system, processes the data using **artificial intelligence** and a rule-based expert system.

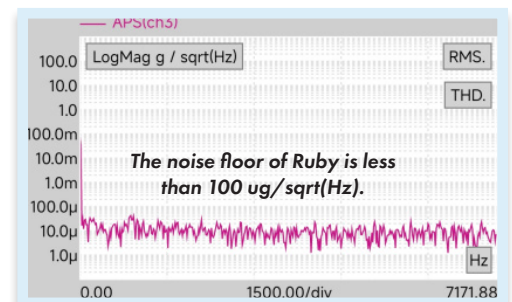
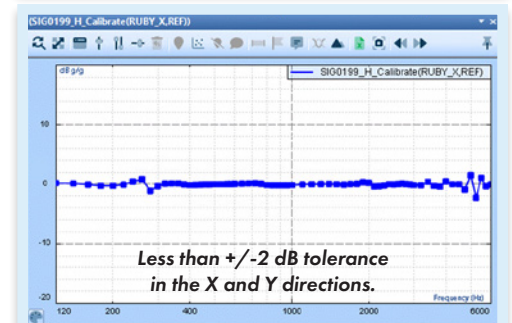
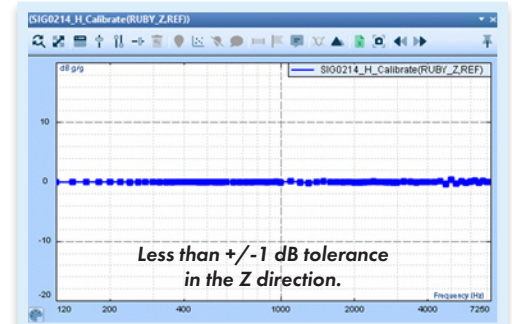
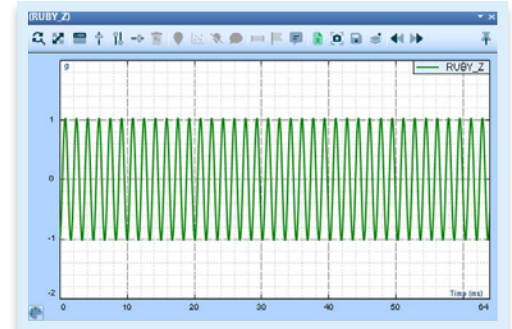
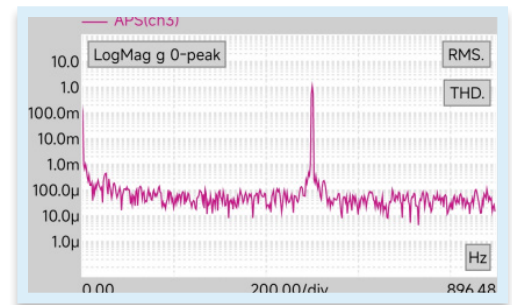
Ruby is depicted as a hardware sensor system in the following diagram:



High Precision Measurement in 3-Axis



Ruby provides measurements in 3-axis as accurate as common charge vibration or piezoelectric sensor measurements. The frequency range goes up to 6.5 kHz while the tolerance is within ± 1.0 dB.



Ruby in the ISA-100 Environment



Reliable and Scalable Industrial Networking

Ruby operates on the ISA-100.11a industrial wireless standard, a proven communication protocol designed for secure, real-time data transfer in demanding automation environments. Its self-organizing, multi-hop mesh architecture ensures robust connectivity and seamless scalability across large facilities.

High-Integrity Data Transmission

Each Ruby sensor acts as both a measurement node and a network relay, forming a resilient mesh that maintains communication even in RF-challenging or obstructed areas. Processed vibration data is transmitted securely to the RCM software database via the ISA-100 network.

Hundreds of Sensors, One Network

A single ISA-100 system can support hundreds of Ruby sensors installed across multiple machines. Strategically placed gateways provide optimal coverage, enabling centralized condition monitoring across an entire plant floor.

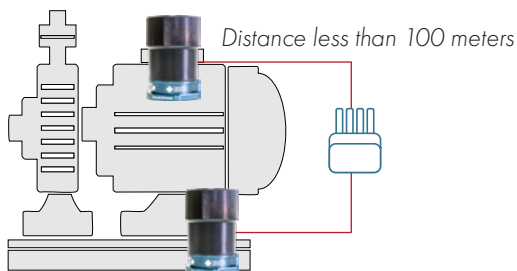
Optimized Power Efficiency

Ruby's ultra-low-power design allows sensors to remain in deep-sleep mode between measurements, consuming only microamps of current. Powered by a standard D-size lithium battery, each sensor can operate for up to two years without replacement.

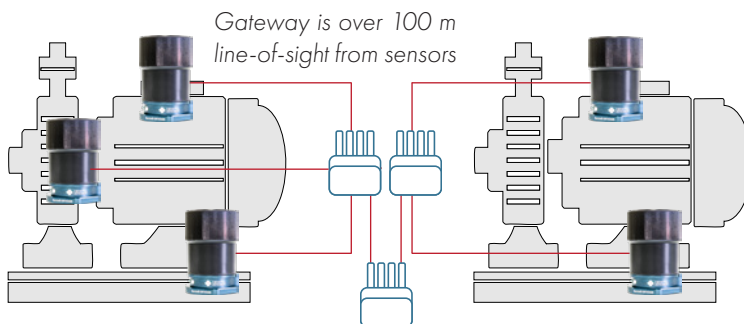
Low EMI Operation

To meet strict electromagnetic compatibility (EMC) requirements, Ruby sensors can be activated in batches and transmit data in coordinated time slots—minimizing EMI and maintaining interference-free operation even in sensitive environments.

Configure your ISA-100.11a sensor network:

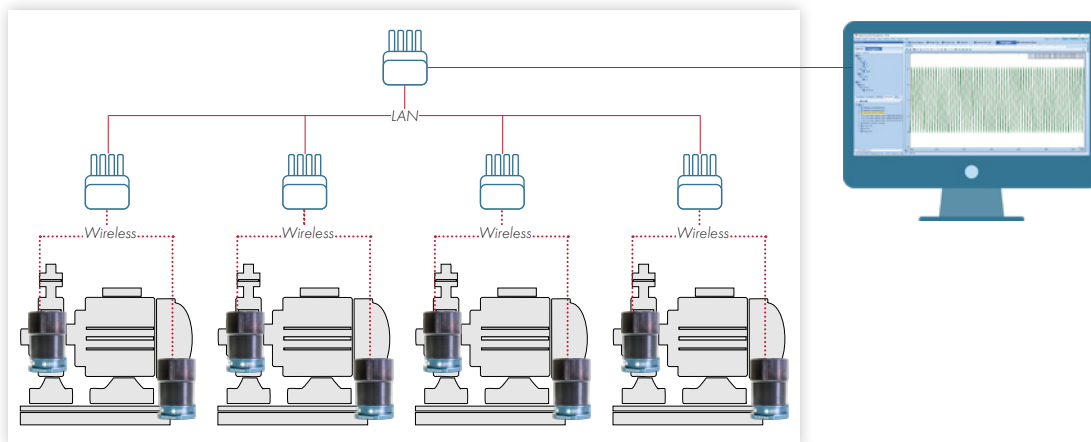


1. Gateway is within 100 m line-of-sight of sensors.



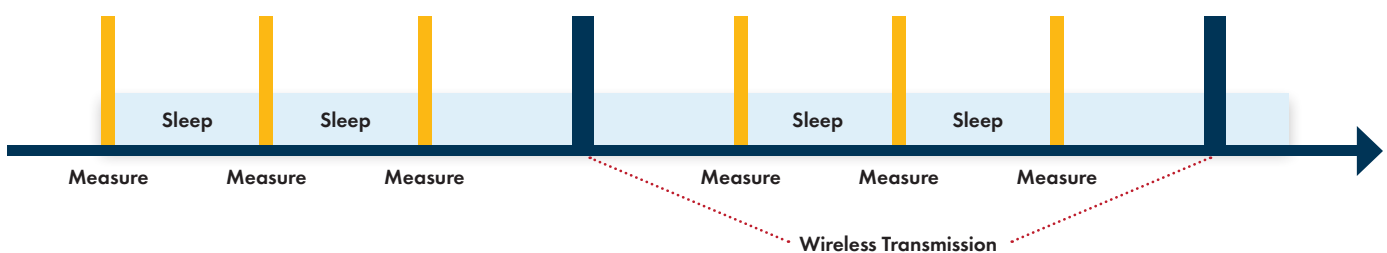
2. If the gateway is over 100 m line-of-sight from the sensors, an additional gateway is needed.

3. With multiple pieces of equipment, place gateways so each sensor is within the range of the gateway.



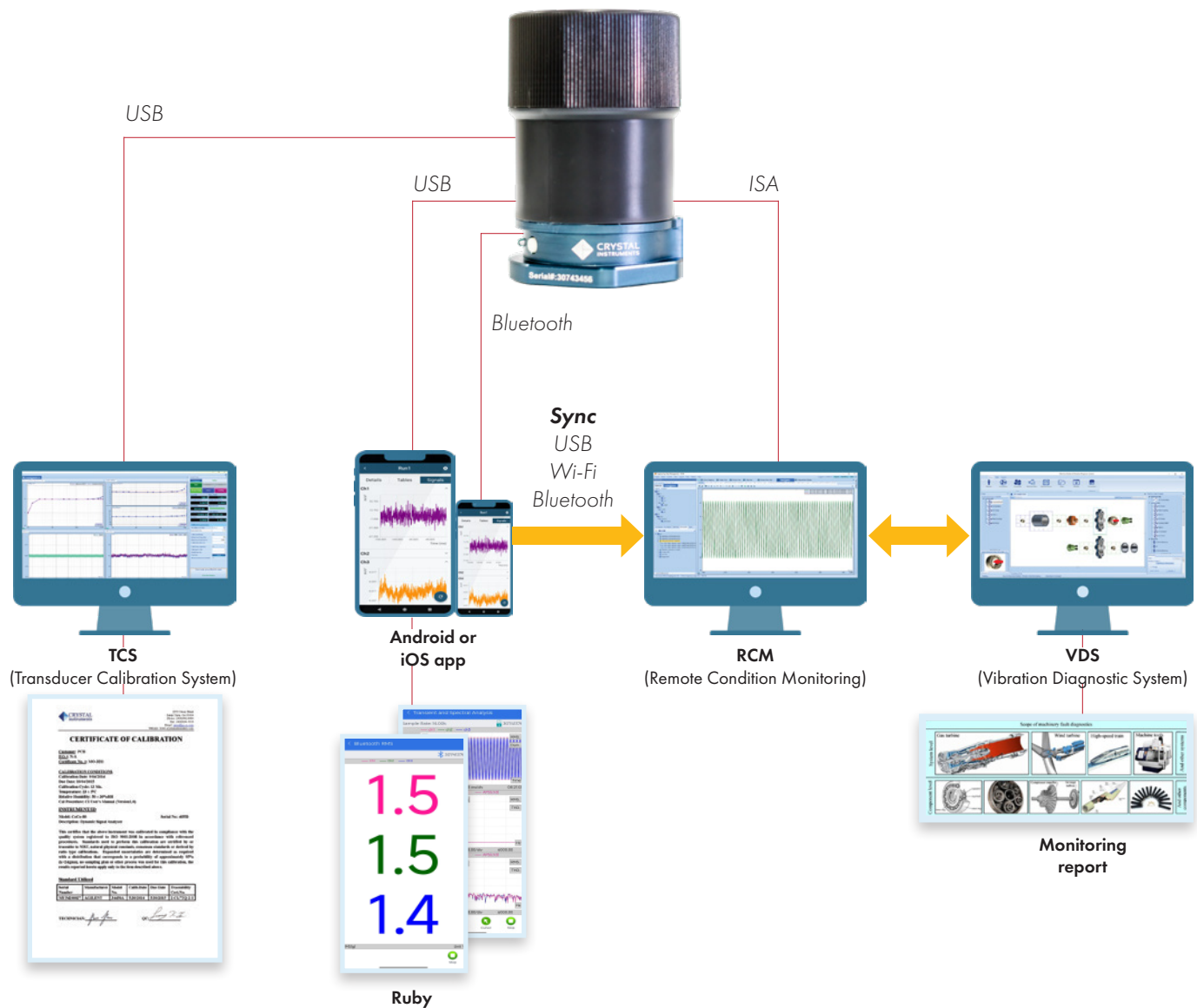
ISA100 Features and Advantages

- **Reliable and robust for industrial communications** — Designed specifically for industrial environments to ensure high reliability, deterministic performance, and stable connections under harsh conditions.
- **Interference management** — Incorporates advanced coexistence mechanisms to operate effectively in areas with multiple wireless networks or RF interference.
- **Mesh networking scalability** — Supports deployment of thousands of devices in large-scale networks while maintaining reliable communication through mesh networking.
- **Long-distance communication** — Optimized for reliable operation across extended distances, ideal for distributed sensor networks in large industrial plants.
- **Strong security** — Provides industrial-grade encryption, authentication, and secure key management for data integrity and confidentiality.
- **Power efficiency** — Enables long-term operation on standard batteries, minimizing maintenance and replacement frequency.
- **Flexible and easy deployment** — Includes network management and provisioning tools; new devices can be added seamlessly to existing mesh networks.
- **Low latency** — Offers deterministic, low-latency communication for real-time data delivery.
- **Cost-effective** — Significantly reduces installation and maintenance costs compared to wired or alternative wireless systems.
- **Interoperable** — As an IEC 62734 international standard, ISA100 ensures compatibility with other systems, including Modbus-based infrastructure.
- **Certified and compliant** — All ISA100 devices are validated by the ISA100 Compliance Institute for performance, security, and interoperability.



Ruby's independent measurement and transmission scheduling further enhances **battery efficiency**, allowing sensors to take periodic measurements (e.g., weekly) and transmit data at longer intervals (e.g., monthly) while staying in low-power sleep mode between operations.

Ruby Software Applications



IP67 SEAL RATING

Ruggedized Design

Ruby meets the IP67 seal rating. The IP67 seal rating is a standard defined by the Ingress Protection (IP) Code under IEC 60529. The Ruby is fully protected against dust and can survive submersion in water up to 1 meter for 30 minutes.

ISA-100 PROTOCOL

RCM (Remote Condition Monitoring) Software

RCM (Remote condition monitoring) software is designed for configuring the Ruby sensor network and acquiring data using the ISA-100 protocol.

Ruby Mobile App

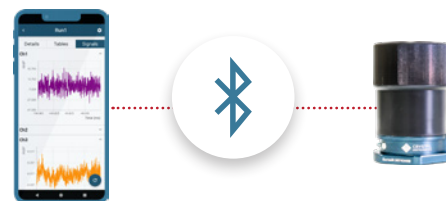
Supported Mobile Devices

Conveniently supports both Android and iOS operating systems for phones or tablets.



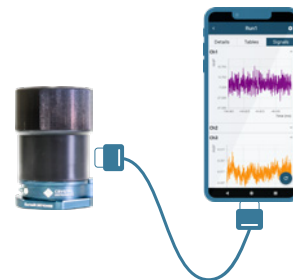
Bluetooth Communication Mode

Users can instantly access the Ruby configuration and test parameters. View the RMS and spectra in real-time.



USB Communication Mode

Operate like a dynamic signal analyzer with real-time spectral analysis. Download the recorded files, triggered data, and spectra to the RCM software.

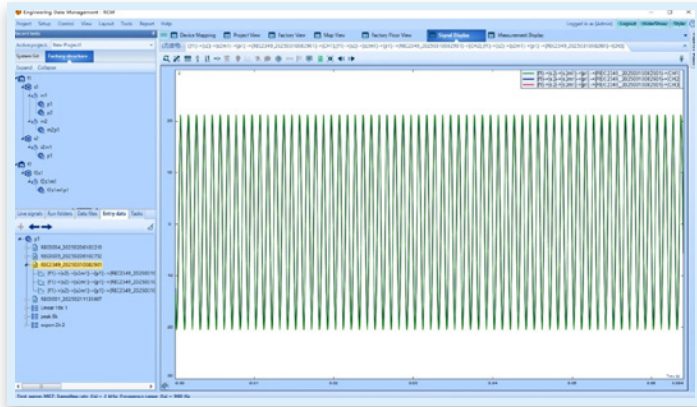


Convenient Standard D-size Batteries

Users can purchase standard D-size batteries online or at local retailers for replacement.



RCM (Remote Condition Monitoring) Software



The screenshot shows the 'Devices View' of the RCM software. It displays a table of devices connected to the system.

Device Name	SN	Factory	Space	Machine	Point
H2X2 TEST	30741408	Test Factory B	Space B	Machine B	Point B1
Test Power	30741280	Test Factory B	Space B	Machine B	Point B2
T0810C1C20000357	30741376	Test Factory A	Space A	Machine A	Point A2
H2X2 TEST	30741896	Test Factory A	Space A	Machine A	Point A4
03A5	30741316	Test Factory A	Space A	Machine C	Point C1
Test Power	30741344	Test Factory A	Space A	Machine C	Point C3

Smart Management for Ruby Wireless Networks

RCM software configures and manages the Ruby sensor network using the ISA-100 protocol. It enables engineers to set up, schedule, and control hundreds of sensors from one interface. Each Ruby operates autonomously—waking to collect data, transmitting results, and returning to sleep to extend battery life. All recorded signals are securely sent to the RCM workstation for analysis or export to VDS software.

Continuous Condition Monitoring
(Vibration, Temperature & Pressure)

0 - 100 Hz

Diagnosis on Demand

0 - 10 kHz

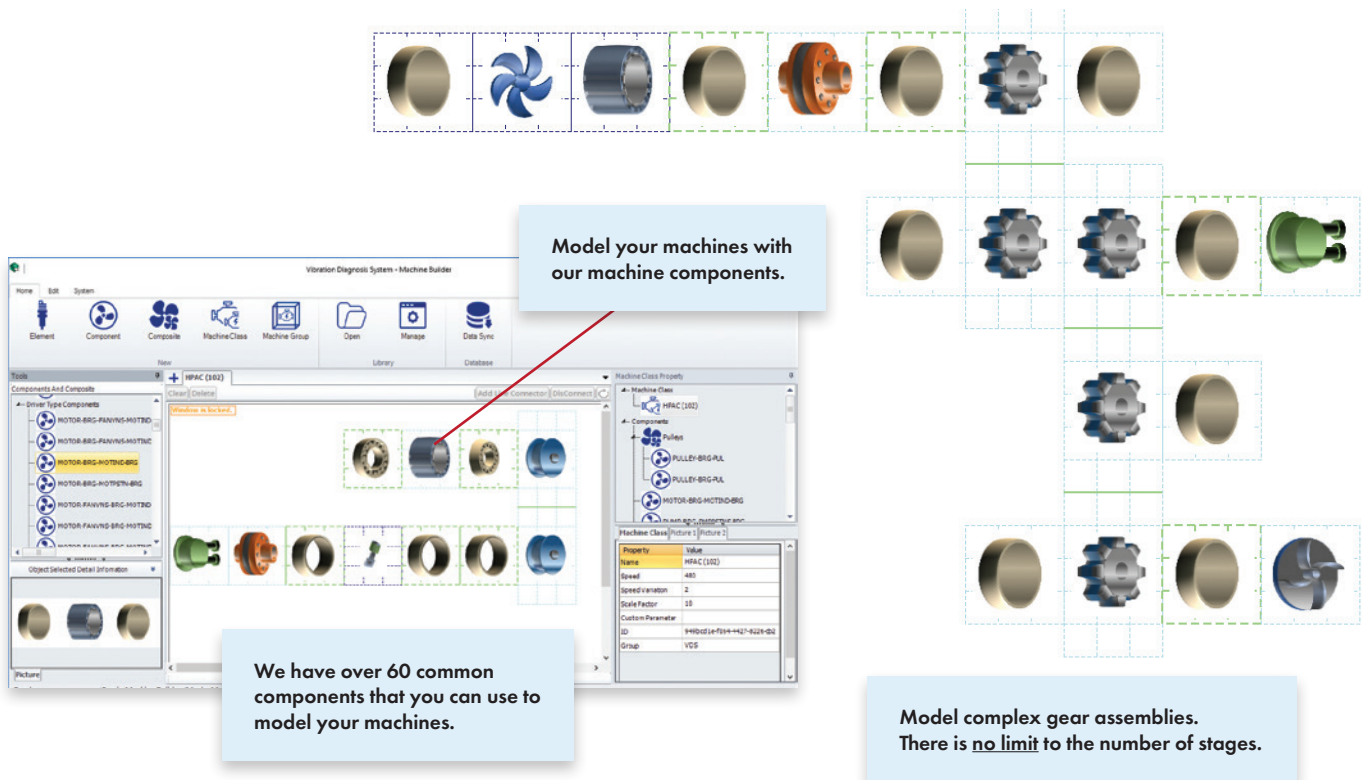
Structural Health Monitoring on Demand

0 - 5 Hz

Continuous Ground Vibration Monitoring

1 - 100 Hz

Vibration Diagnostic System Software for Post Processing



The screenshot displays the 'Vibration Diagnostic System - Machine Builder' software interface. The main workspace shows a grid of various machine components, including motors, gears, and shafts, which can be used to build a machine model. A callout box points to this grid with the text: 'Model your machines with our machine components.' Another callout box points to the 'Machine Class' dropdown menu, stating: 'We have over 60 common components that you can use to model your machines.' A third callout box points to the 'Machine Class' dropdown menu, stating: 'Model complex gear assemblies. There is no limit to the number of stages.' The interface also includes a 'Tools' menu, a 'Machine Class' dropdown, and a 'Machine Properties' panel on the right.

Model your machines with our machine components.

We have over 60 common components that you can use to model your machines.

Model complex gear assemblies. There is no limit to the number of stages.

Intelligent Fault Detection and Analysis

VDS software turns vibration data into diagnostic insight. It models machines, compares measurements to baseline signatures, and applies rule-based analysis to identify faults and recommend corrective actions. With its advanced spectral tools, VDS enables predictive maintenance and reduces downtime across complex machinery systems.

Factory Calibration and Service



The vibration sensor calibration system uses the vibration comparison method to determine the sensitivity, frequency response curve, and amplitude linearity of the acceleration and velocity sensors. At the same time, the system provides calibration functions to ensure the accuracy of the calibration system.



Scan to visit Ruby webpage

Parameters	Description
Axis	3-axis, X, Y, Z
Full acceleration range	± 25 g, ± 50 g, ± 100 g depending on models selected.
Sensor usable bandwidth	0.5 Hz to 6.5 kHz for Z axis 0.5 Hz to 4 kHz for X and Y axis
Tolerance of Frequency Response for Z axis	0.5 Hz to 6,500 Hz: ± 1.0 dB
Tolerance of Frequency Response for X or Y axis	0.5 Hz to 4,000 Hz: ± 1.0 dB
Typical Noise Density (100 Hz, 1 kHz) RMS	$< 60 \mu\text{g} / \sqrt{\text{Hz}}$
Amplitude Accuracy	2%
Internal A/D resolution	24 bits
Non-volatile memory	• 256 MB (store the measurement data)
Signal Processing capability	Raw time waveforms, Digital filters, data window, FFT spectrum, averaging, simple order extraction, demodulation spectrum that required by the VDS software
Data sampling rate	16 kHz, 8 kHz, 4 kHz, 2 kHz, 1 kHz, 500 Hz, 250 Hz, 125 Hz
Data recording	• Total usable recording size: 62 million points. • Longest recording duration is roughly 3,900 seconds for single axis, at 16 kHz sampling frequency, or 1,300 seconds for 3-axis
Number of FFT lines per block	• 112, 225, 450, 900, 1800
FFT block size	• 256, 512, 1024, 2048, 4096
Measurement modes	• Scheduled data save, on-demand data save, continuous recording
Data transfer	• Receive and send the measurement configuration such as frequency range or spectrum lines. • Acquire and send the measurement data in a predetermined period (minutes, hours, days) • Acquire and send the measurement data based on host commands transmitted by the wireless network



Communications	
Supported Communication Protocols	ISA100.11a, BLE 5.0, USB
Encryption in Wireless communications	Encrypted using AES-128 (ISA 100.11a and BLE 5.0)
Encryption Compliance	FIPS 140-2 compliant encryption for ISA and BLE modes
Default Communications Protocol	ISA100.11a, periodic low power data transfers using ISA100.11a mesh network
ISA100.11a frequency bands	2.4 GHz ISM Band
ISA 100.11a Max Data Rate	250 kbps
Typical ISA Wireless Range	100 meters sensors to ISA-100 gateways; 80 meters sensor to sensor, line of sight (Actual range depends on obstacles present, gateway antenna type, etc.)
USB Interface	USB-OTG, used to set up the sensor, calibration and download the data to a local PC. Can be used as a simple vibration data collector
Bluetooth	BLE 5.0
Bluetooth Wireless Range	Typically between 10 to 100 meters indoor
Battery and Electrical	
Battery type	Replaceable D size 3.6V
Typical battery life for periodic data collection	36 months ¹
Battery life for continuous data collection	170 hours
Electrical isolation	> 10 ⁸ Ohm
Physical	
Weight	365 grams (including battery)
Dimensions	63 mm (bottom, hexagon shape) x 94.2 mm (height)
Push buttons	Switch modes from ISA100, Bluetooth, USB
LED indicator	0.5s Blink: ISA100 1s Blink: Bluetooth Solid Green: USB
Mounting	5/16" -24 UNF-2B female

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