



Equipment  
Condition  
Monitoring for IIoT  
& Industry 4.0

# Equipment Condition Monitoring – Table of Contents



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# Why Condition Monitoring?



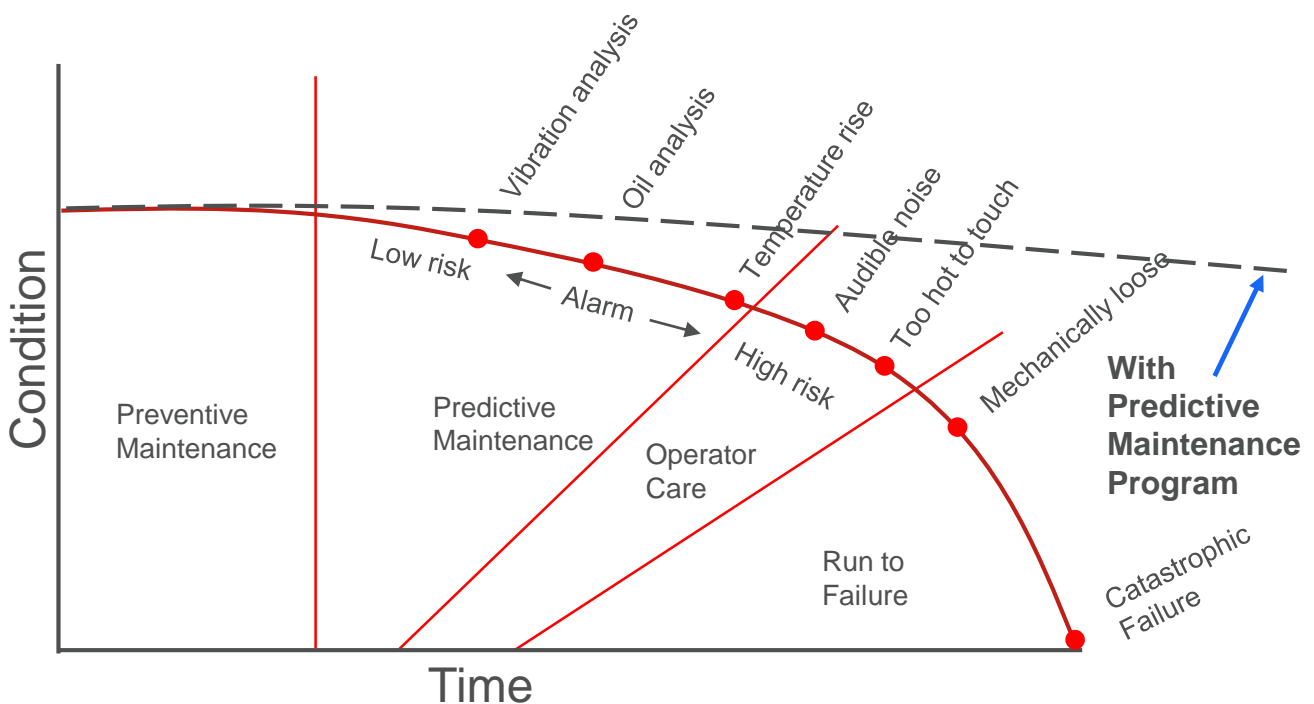
- Monitoring characteristics such as vibration reduces downtime, thereby increasing productivity and saves money.
- Use condition monitoring within predictive maintenance programs to effectively predict machine failure before it becomes catastrophic.
- Plan maintenance more efficiently - determine when to schedule routine maintenance and sourcing of replacement parts.
- Monitor machine run time – sensors can be used to accurately determine machine runtime without tying into the machine's control system. This is very useful to determine when necessary maintenance or overhauls should be planned.
- Prevent catastrophic machine damage and prevent related results such as fire, fumes, etc.



# Why Condition Monitoring?



- Within plant maintenance operations, we see the continuum from “fix it when it’s broken” all the way up to planned equipment replacement and obsolescence.
- The Health Degradation Curve (red line) shows the effect on machine health based on these maintenance choices.
- Starting from the right side of the curve is the “run to failure” mindset. This often results in badly worn components or catastrophic failure. The ramifications are extensive downtime and very costly repairs.
- Moving left along the curve is “operator care” where maintenance staff listen to machine operators, depending on feedback from them to guide equipment maintenance decisions. A good operator can tell you if his/her machine is running badly from across the room just by the sound it makes. The bad thing is that once the machine is making excessive noise or components are too hot to touch, it is often too late and the machine is at risk.
- Next up the chain is a proactive maintenance program that brings in experts for vibration analysis, oil analysis, and temperature inspections. This is good, however, are these being done too frequently, driving up costs? Conversely, are they too infrequent allowing the machinery to be at risk?
- Good practices of preventive maintenance are always the best. Lubricating, cleaning, and planned rebuilds go a long way to avoiding unplanned equipment downtime.
- Vibration monitoring can help determine when planned maintenance should be done. Does preventive maintenance need to be done once a month or once a week?



## ■ Typical Asset Types to Monitor

- Pallet Linear Actuator
- Fan (exhaust, HVAC, etc.)
- Gearbox/Motor
- Pump / Compressor
  - Hydraulic/Coolant Pump
- Rotary Table (gearbox/motor)
- Lead Screw
- Robot Articulation Joints, Transfers, etc.
- Spindle on Machining Center

## ■ Condition Monitoring Methods

- Vibration and Temperature
  - 2-axis Vibration and Temperature in one sensor
- Temperature (contact)
- Infrared Temperature (non-contact)
- Ambient Air Temperature and Relative Humidity
- Tank or Bulk Tote Level
- Analog Sensors
  - Current draw
  - Voltage
  - Vibration, Ultrasonic
  - Pressure
  - Flow

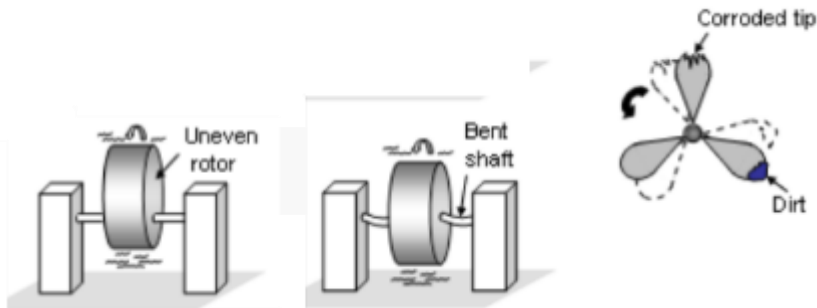


# Condition Monitoring: Vibration Common Causes



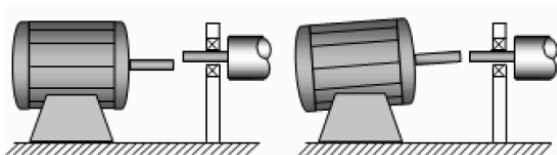
## Imbalance

- A “heavy spot” in a rotating component will cause vibration when the unbalanced weight rotates around the machine’s axis, creating a centrifugal force
- Caused by machining errors, casting flaws, deformed or dirty fan blades



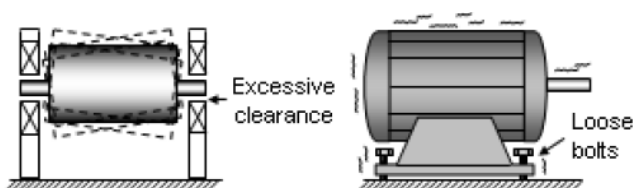
## Misalignment / Shaft Runout

- Angular misalignment occurs when the axes of (for example) a motor and pump are not parallel
- Misalignment may be caused during assembly or develop over time, due to thermal expansion, components shifting or improper reassembly after maintenance



## Looseness

- Vibration may become destructive if the component that is vibrating has loose bearings or is loosely attached to its mounts
- Looseness can allow any vibration present to cause damage, such as further bearing wear, fatigue in equipment mounts, etc.



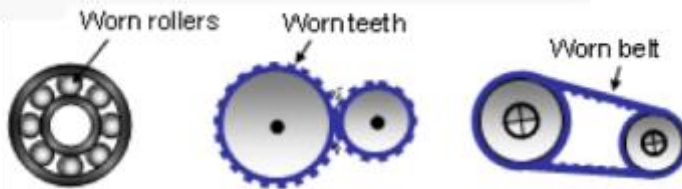


# Condition Monitoring: Vibration Common Causes



## Wear

- As components such as ball bearings, drive belts, or gears become worn, they cause vibration
- When a bearing race becomes pitted, the bearing rollers will cause a vibration each time they travel over the damaged area
- A gear tooth that is heavily chipped or worn, or a drive belt that is breaking down, can also produce these impulses

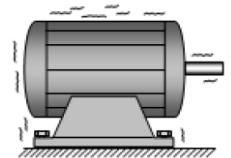


## Typical situations which cause machine failures:

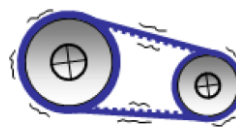
- Excessive loads
- Overheating of bearings/wear items
- Typical wear/fatigue failure
- Reverse loading
- Contamination
- Lubrication failure
- Bearing corrosion/pitted running surfaces
- Misaligned bearings and loads
- Loose mounts
- Tight fitting couplings



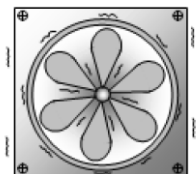
Vibrating Pumps



Vibrating Motors



Vibrating Belts



Vibrating Fans

# Vibration/Temperature Methods



- How much vibration/temperature is acceptable depends on the machine/application
- These are the recommended vibration characteristics to monitor and the frequencies across which they are measured:

## • RMS Velocity ( $V_{RMS}$ )

- 10–1000 Hz
- X and Z axis
  - Measured in mm/s or in/s
  - Reference the ISO 10816 Vibration Severity chart
  - Indicates issues such as an unbalanced load, loose mounting, misalignment, soft foot, etc.

## • High Frequency RMS Acceleration (HF $A_{RMS}$ )

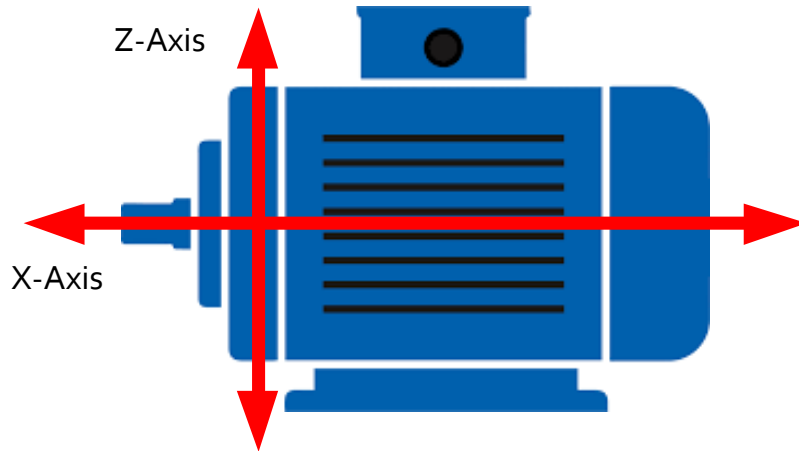
- 1–4 kHz
- X and Z axis
  - Measured in G's
  - Indicates early bearing failure

| Machine |      | Class I        | Class II        | Class III              | Class IV              |
|---------|------|----------------|-----------------|------------------------|-----------------------|
| in/s    | mm/s | Small Machines | Medium Machines | Large Rigid Foundation | Large Soft Foundation |
| 0.01    | 0.28 |                |                 |                        |                       |
| 0.02    | 0.45 |                |                 |                        |                       |
| 0.03    | 0.71 |                | good            |                        |                       |
| 0.04    | 1.12 |                |                 |                        |                       |
| 0.07    | 1.80 |                |                 |                        |                       |
| 0.11    | 2.80 |                | satisfactory    |                        |                       |
| 0.18    | 4.50 |                |                 |                        |                       |
| 0.28    | 7.10 |                | unsatisfactory  |                        |                       |
| 0.44    | 11.2 |                |                 |                        |                       |
| 0.70    | 18.0 |                |                 |                        |                       |
| 1.10    | 28.0 |                | unacceptable    |                        |                       |
| 1.77    | 45.9 |                |                 |                        |                       |

Figure 1. Vibration Severity per ISO 10816



# ISO Guidelines / Installation Recommendations



## ISO 10816-1 Guidelines

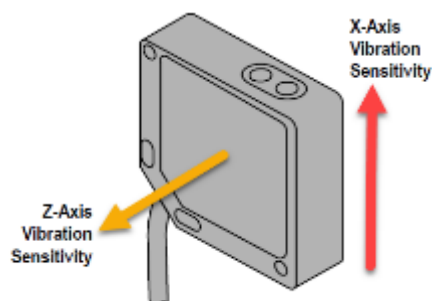
- The requirement for operational monitoring is usually met by performing one measurement in the radial direction (i.e. horizontal-transverse to the shaft) supplemented by an axial measurement which is of prime significance at thrust bearing locations where direct axial dynamic forces are transmitted (such as lead screw type applications)

## Where to Mount the sensor?

- On a safe stationary element, as close as possible to the bearings

## Which equipment to monitor?

- Historical maintenance information is a valuable tool
- What equipment is causing the greatest amount of downtime?
- Knowing more about the equipment that brings your production to a stop is the best reason to start monitoring
- Even if it is only a “trigger point” or “check engine light” approach that pin points more directed exploration

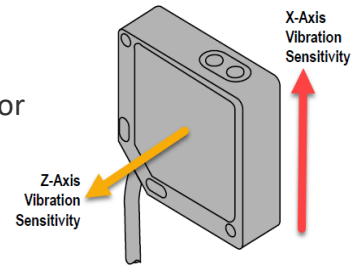






# Vibration/Temperature Sensor Mounting

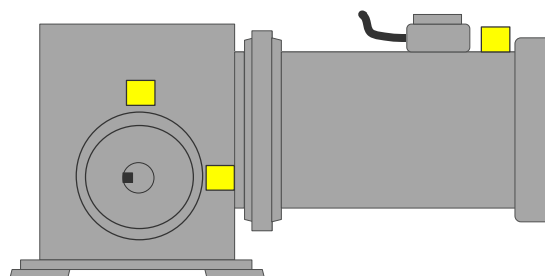



## Installation of the Sensor:

- The vibration sensors have an X and Z Axis indication on the face of the sensor
  - Install the X-axis in line with the shaft of the motor (axial)
  - Install the Z-axis to go into or through the motor (radial)
- Install the sensor as close to the motor bearing of interest as possible
- If not possible, install the sensor on a surface that is in rigid connection with the vibration characteristics of the asset
- Using a fan or belt cover shroud or other flexible mounting location may result in reduced accuracy
- Secure any and all excess cable away from the sensor to eliminate vibration induced through cable
- Be sure to use thread sealant to properly secure all fasteners
- Mounting options below are shown from less to most effective related to full vibration transfer



| Mounting Options  | Bracket   | Application Description  |
|---|---|--|
| BWA-HW-057<br>Thermal Conductive Adhesive Tape<br>(Ships with sensor)   |   | Single use flexible mounting option, but can introduce flex that reduces accuracy.   |
| BWA-BK-001<br>Flat magnet sensor bracket  |  | Highly flexible and re-usable, flat magnetic mount for larger diameter surfaces or flat surface.   |
| BWA-BK-008<br>Center mounting bracket with curved surface magnet attached to sensor bracket (includes BWK-BK-005) |  | Curved surface magnet mounts are best suited to smaller curved surfaces. Orient in the correct direction for the strongest mount. Offers flexibility for future sensor placement and provides sensor thermal isolation from surface temperature up to approximately 150 °F (65 °C) .                                   |
| BWA-BK-005<br>Center mounting bracket – accepts any #4 or M6 flathead screw (Ships with sensor)                   |  | Flat bracket permanently epoxied to motor and sensor screwed to bracket (very effective) or flat bracket with direct screw mount to motor and sensor (most effective). Ensures best sensor accuracy and frequency response. Recommend epoxy designed for accelerometer mounting: Loctite Depend 330 and 7388 activator |



 QM42VT\*  
Mounting locations

# Sensor Operation & Vibration Parameter Definitions



The Banner QM42VT1 and QM42VT2 sensors have a sampling window of 400 ms during which 8,000 individual samples of the vibration waveform are taken at a 20 kHz rate across the spectrum (10 Hz – 4 kHz). The sensor then requires an additional 1.5 seconds to process the acquired waveform and update all vibration characteristics (scalar result values).

## ■ RMS Velocity

– The RMS velocity is the root mean square velocity over the most recent data sample.

## ■ RMS Acceleration

– The RMS acceleration is the root mean square acceleration over the most recent data sample.

## ■ Peak Acceleration

– The peak Acceleration is the highest acceleration measured within the most recent data sample.

## ■ Peak Velocity

– The peak velocity is the highest point velocity recorded within the most recent data sample.

## ■ Peak Velocity Component Frequency

– The peak frequency is the highest vibration frequency within the most recent data set acquired by the sensor.

## ■ Crest Factor (Acceleration)

– The crest acceleration is the maximum peak value divided by the RMS (average) value. Optimal values for good bearings usually range from 3 to 4.

## ■ Kurtosis

– Kurtosis is the measure of the impulse (factor) acquired by the sensor.



# System Overview – Condition Monitoring Utilizing Wireless Sensors



Analytics / Visualization

Dashboard / Alarms

Cloud Server / AWS



## INTERNET

LAN or Cellular

SCADA / DCS system



Local PLC / HMI



LTE / GSM Wireless



Ethernet TCP/IP

Edge Devices

DXM100



-OR-

DXM100 w/  
cellular



Wireless Sensors

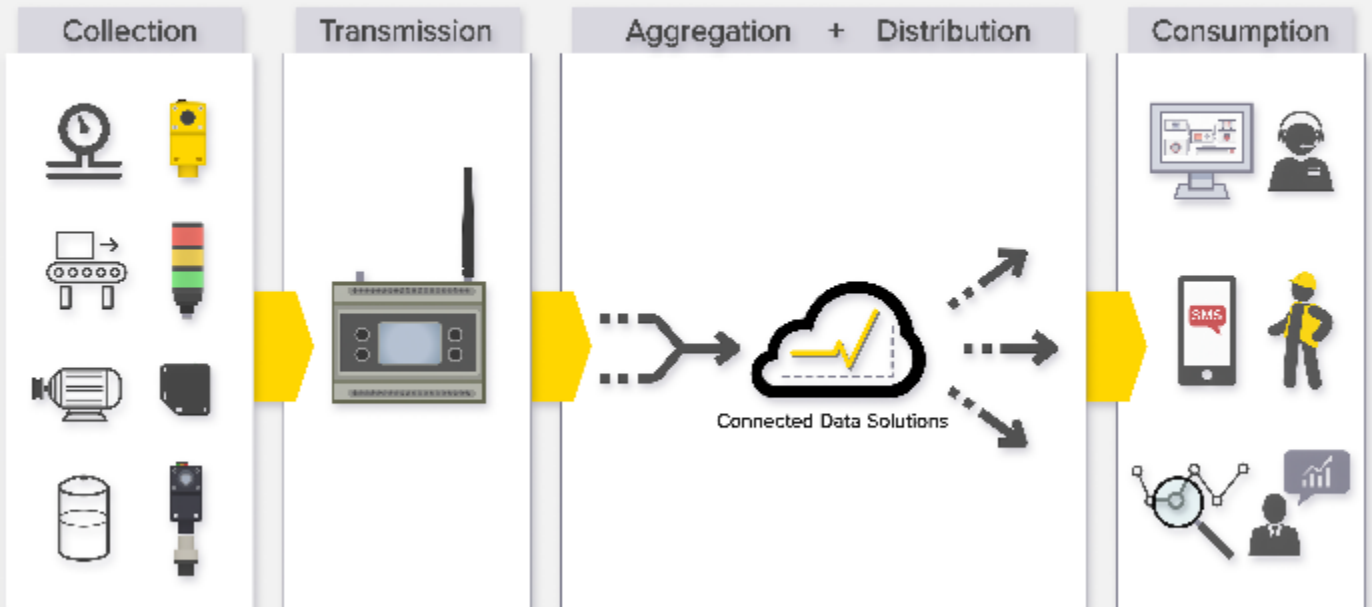
Banner 900MHz / 2.4 GHz  
Proprietary Wireless Protocol



# System Overview – Industrial IoT



## Industrial Internet of Things End-to-End Solutions



Remote monitoring data collection from Banner sensors

Data is sent wirelessly to the DXM Gateway/Controller

It is then aggregated in the cloud by Banner CDS and distributed for consumption

Consumed through dashboards, alerts, and long term data analysis

- All of the critical components of IIoT condition monitoring are provided by Banner Engineering and designed to work seamlessly together.
- Solution Kits and Solution Guides are available that make it easy to setup a complete system in days, not weeks or months.
- Banner Connected Data Solutions (CDS) cloud software provides a codeless environment and easily interfaces with the DXM controller to receive data from Banner sensors via wireless nodes.
- Data can be consumed via dashboards, text or email alerts, and analyzing data to improve production efficiency.

# Cloud Software for Data Storage, Alerts, and Visualization



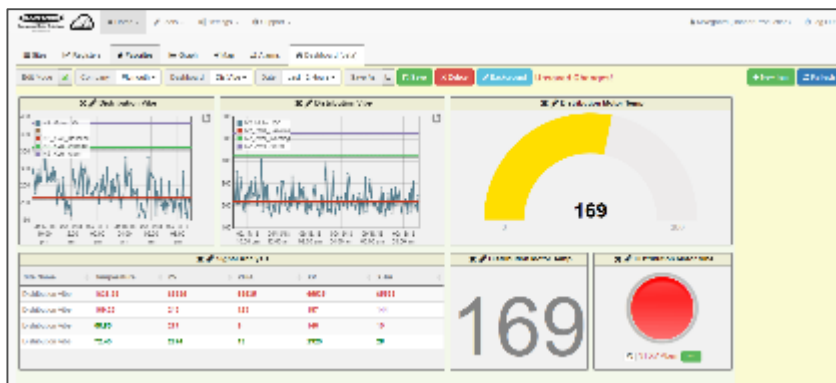
## Connected Data Solutions



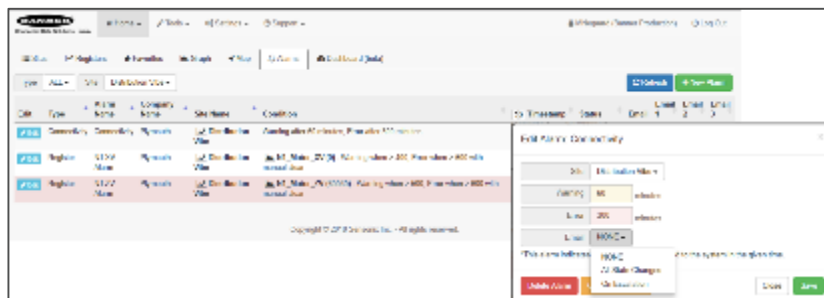
Banner CDS is a cloud based software that allows users to access, store, protect and export critical data collected by Banner wired and wireless sensors.



### Banner CDS Features:



Customizable and codeless dashboards

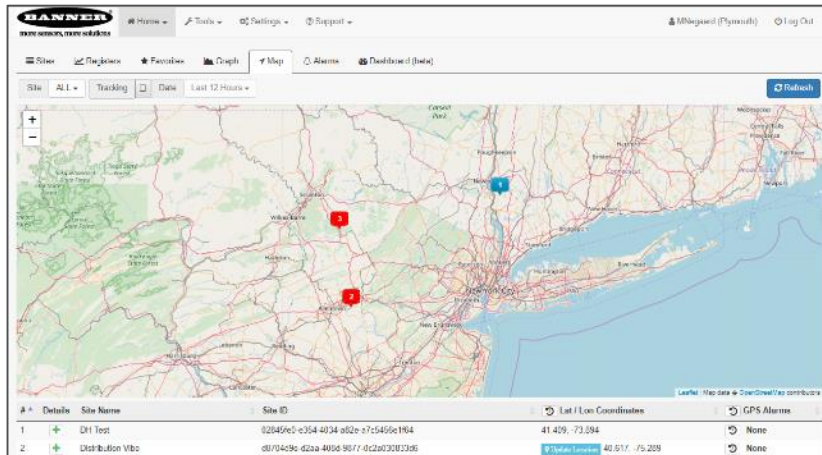


Condition-based alerts and notifications (e-mail, SMS)

# Cloud Software for Data Storage, Alerts, and Visualization



Connected Data Solutions



Device geo information with health status

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| Edit                                | Site Name | Report Type | Run Frequency | FTP Address      |
|-------------------------------------|-----------|-------------|---------------|------------------|
| <input checked="" type="checkbox"/> | ALL       | Alarms      | Weekly        | ftp.sensonix.net |
| <input checked="" type="checkbox"/> | ALL       | Registers   | Weekly        | ftp.sensonix.net |
| <input checked="" type="checkbox"/> | ALL       | Upload Logs | Weekly        | ftp.sensonix.net |

**Edit FTP**

Report Type: Alarms

Site Name: ALL

Run Frequency: Weekly

FTP Address: ftp.sensonix.net

User Name: ken

Update Password:

Buttons: Delete, Close, Save

- Long term data storage and offloading via FTP
- User permissions with fine-grained access control



# Cloud Software for Data Storage, Alerts, and Visualization



Connected Data Solutions



Custom graphing with alert baselines

The screenshot displays a 'Users' management page in the Banner software. A table lists various production sites. The table has the following columns: Edit, Conglomerate, Company, Data Retained, Points (last hour), Used Points/Max Points, Emails (last hour), Competitive, Users, Sites, Banner, Account Number, and Contact Name. The data rows include: Banner Production (Banner Production), Banner Production (Aberdeen), Banner Production (Huron), Banner Production (Plymouth), and Banner Production (US Test). A modal window titled 'Edit Company Aberdeen' is open on the right, showing fields for: Conglomerate (Banner Production), Company Name (Aberdeen), Days Data Retained (365), Max Data Points (1000000), Points per hour (12000), Max Users (5), Max Sites (100), Emails per hour (300), Time Zone Offset (0 UTC), Banner Image (Choose File), Account Number, Contact Name (Greg LaLiberte), and Contact Email. The modal window also has 'Delete', 'Close', and 'Save' buttons.

Conglomerate/Business management tools

# Sensor Solutions for Condition Monitoring



- **Vibration and Temperature Sensors**

- QM42VT1 (1-wire serial)
- QM42VT2 (Modbus RS-485 serial)
- DX80N9Q45VA
- DX80N2Q45VA



QM42VT\*



Q45VA

- **Ultrasonic Level/Distance Sensors**

- K50UX1ARA (1-wire serial, 1 m range)
- K50UX2ARA (RS-485 serial, 1 m range)
- K50UX1CRA (1-wire serial, 3 m range)
- K50UX2CRA (RS-485 serial, 3 m range)



K50UX\*\*RA

- **Ambient Temperature and Humidity**

- M12FTH4Q (1-wire serial)
- M12FTH3Q (RS-485 serial)



M12FTH\*Q

- **Infrared Non-contact Temperature**

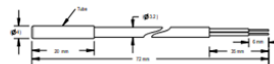
- M18TIP14Q



M18TIP14Q

- **Contact Temperature (Thermistor)**

- BWA-THERMISTOR PROBE-001



BWA-THERMISTOR-PROBE-001

- **Additional Sensors**

- Typically either 4-20 mA or 0-10 Vdc outputs or discrete/pulse outputs
  - » Current (CT)
  - » Pressure/Flow
  - » Acoustic vibration monitoring
  - » Oil condition

# Vibration & Temperature Monitoring



## ■ QM42VT1 and QM42VT2 Digital Sensors

- Provides both radial and axial vibration readings in one housing
- High accuracy temperature monitoring
- Robust zinc alloy housing with optional M12 quick disconnect
- Digital sensor that operates as a serial slave to the radio node
- Programmable sample/reporting rates
- Ability to set operating bands through RPM or Frequency (VT2 only)
- Connects to either a remote radio or directly to DXM



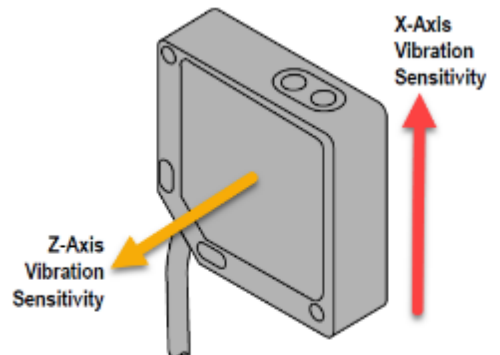
ISO 10816 provides guidance for evaluating vibration velocity severity motors, pumps, fans, compressors, gear boxes, blowers, dryers, presses, and other machines that operate in the 10 to 1000 Hz frequency range.



Figure 1. Vibration Severity per ISO 10816

| Modbus Register Alias Address | Modbus Register Address | Description   | I/O Range                          |        | Holding Register Representation |           |
|-------------------------------|-------------------------|---|------------------------------------|--------|---------------------------------|-----------|
|                               |                         |   | Min                                | Max    | Min (dec)                       | Max (dec) |
| 45201                         | 42401                   | Z-Axis RMS Velocity (in/sec) 1, 5   | 0                                  | 6.5535 | 0                               | 65535     |
| 45202                         | 42403                   | Z-Axis RMS Velocity (mm/sec) 2, 5   | 0                                  | 65.535 | 0                               | 65535     |
| 45203                         | 40049                   | Temperature (F) 3   | -327.68                            | 327.67 | 32768                           | 32767     |
| 45204                         | 40043                   | Temperature (C) 3   | -327.68                            | 327.67 | 32768                           | 32767     |
| 45205                         | 42451                   | X-Axis RMS Velocity (in/sec) 1, 5   | 0                                  | 6.5535 | 0                               | 65535     |
| 45206                         | 42453                   | X-Axis RMS Velocity (mm/sec) 2, 5   | 0                                  | 65.535 | 0                               | 65535     |
| 45207                         | 42407                   | Z-Axis Peak Acceleration (G) 2, 6   | 0                                  | 65.535 | 0                               | 65535     |
| 45208                         | 42457                   | X-Axis Peak Acceleration (G) 2, 6   | 0                                  | 65.535 | 0                               | 65535     |
| 45209                         | 42405                   | Z-Axis Peak Velocity Component Frequency (Hz) 4, 5  | 0                                  | 6553.5 | 0                               | 65535     |
| 45210                         | 42455                   | X-Axis Peak Velocity Component Frequency (Hz) 4, 5  | 0                                  | 6553.5 | 0                               | 65535     |
| 45211                         | 42406                   | Z-Axis RMS Acceleration (G) 2, 5  | 0                                  | 65.535 | 0                               | 65535     |
| 45212                         | 42456                   | X-Axis RMS Acceleration (G) 2, 5  | 0                                  | 65.535 | 0                               | 65535     |
| 45213                         | 42409                   | Z-Axis Kurtosis 2, 6  | 0                                  | 65.535 | 0                               | 65535     |
| 45214                         | 42459                   | X-Axis Kurtosis 2, 6  | 0                                  | 65.535 | 0                               | 65535     |
| 45215                         | 42408                   | Z-Axis Crest Factor 2, 6  | 0                                  | 65.535 | 0                               | 65535     |
| 45216                         | 42458                   | X-Axis Crest Factor 2, 6  | 0                                  | 65.535 | 0                               | 65535     |
| 45217                         | 42402                   | Z-Axis Peak Velocity (in/sec) 1, 5  | 0                                  | 6.5535 | 0                               | 65535     |
| 45218                         | 42404                   | Z-Axis Peak Velocity (mm/sec) 2, 5  | 0                                  | 65.535 | 0                               | 65535     |
| 45219                         | 42452                   | X-Axis Peak Velocity (in/sec) 1, 5  | 0                                  | 6.5535 | 0                               | 65535     |
| 45220                         | 42454                   | X-Axis Peak Velocity (mm/sec) 2, 5  | 0                                  | 65.535 | 0                               | 65535     |
| 45221                         | 42410                   | Z-Axis High-Frequency RMS Acceleration (G) 2, 6   | 0                                  | 65.535 | 0                               | 65535     |
| 45222                         | 42460                   | X-Axis High-Frequency RMS Acceleration (G) 2, 6   | 0                                  | 65.535 | 0                               | 65535     |
| 46101                         |                         | Baud  | 0=9.6k, 1=19.2k (default), 2=38.4k |        |                                 |           |
| 46102                         |                         | Parity  | 0=none (default), 1=odd, 2=even    |        |                                 |           |
| 46103                         |                         | Modbus Slave Address  | 1 (default) through 247            |        |                                 |           |
| 42601                         |                         | Rotational Speed (RPM) (default = 1725 RPM) -- Used in vibration spectral band measurements | 0                                  | 65535  | 0                               | 65535     |
| 42602                         |                         | Rotational Speed (Hz) (default = 29 Hz) -- Used in vibration spectral band measurements     | 0                                  | 65535  | 0                               | 65535     |

Key Items to Monitor are RMS Velocity and High-Frequency RMS Acceleration



# Vibration All-in-One Sensor + Node

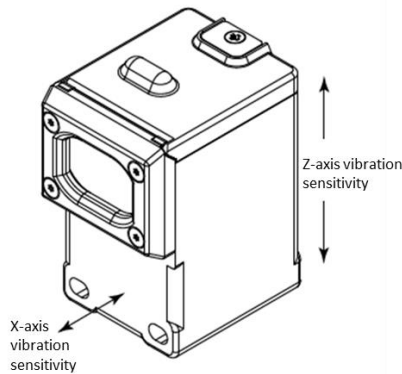


## ■ DX80N\*Q45VA All-in-One Sensor + Node

- Combines the QM42VT1 vibration sensor with the Q45VT wireless node into one compact package
- Provides radial and axial vibration measurements
- Only one part to order
- Easy to deploy, battery powered for “peel & stick” functionality
- DIP switches for user configuration of sample intervals and vibration characteristics
- 2+ years of battery life at default sample rates



Select vibration characteristics to monitor using DIP switches



| I/O Configurations (Set by DIP Switches 2, 3, and 4) |        |                                     |                       |                                     |  |                                      |                                     |
|--|--------|-------------------------------------|-----------------------|-------------------------------------|--|--------------------------------------|-------------------------------------|
| Input Register                                       |        | Default I/O                         | I/O Configuration 1   | I/O Configuration 2                 | I/O Configuration 3                    | I/O Configuration 4                  | I/O Configuration 5                 |
| 1  | Z-Axis | RMS Velocity (in/sec)               | RMS Velocity (in/sec) | High-Frequency RMS Acceleration (G) | RMS Velocity (in/sec)                  | Full Bandwidth RMS Acceleration (G)  | RMS Velocity (in/sec)               |
| 2  |        | High-Frequency RMS Acceleration (G) | Peak Acceleration (G) | Peak Acceleration (G)               | Peak Velocity Component Frequency (Hz) | Full Bandwidth Peak Acceleration (G) | Full Bandwidth RMS Acceleration (G) |
| 3  | -      | Reserved                            | Reserved              | Reserved                            | Reserved                               | Reserved                             | Reserved                            |
| 4  | -      | Reserved                            | Reserved              | Reserved                            | Reserved                               | Reserved                             | Reserved                            |
| 5  | X-Axis | RMS Velocity (in/sec)               | RMS Velocity (in/sec) | High-Frequency RMS Acceleration (G) | RMS Velocity (in/sec)                  | Full Bandwidth RMS Acceleration (G)  | RMS Velocity (in/sec)               |
| 6  |        | High-Frequency RMS Acceleration (G) | Peak Acceleration (G) | Peak Acceleration (G)               | Peak Velocity Component Frequency (Hz) | Full Bandwidth Peak Acceleration (G) | Full Bandwidth RMS Acceleration (G) |

# Tank / Bulk Tote Level Monitoring



## ■ K50U Digital Ultrasonic Sensor

- Measures distance ranges from 300mm (11.8") to 3000mm (118")
  - Reports digital value in mm and inches
- Temperature (ambient)
  - Report in C and F
- Operates as a serial slave device
- 1 ¼" threaded barrel design with rugged NEMA 6 rating
- Connects to either a remote radio or directly to DXM



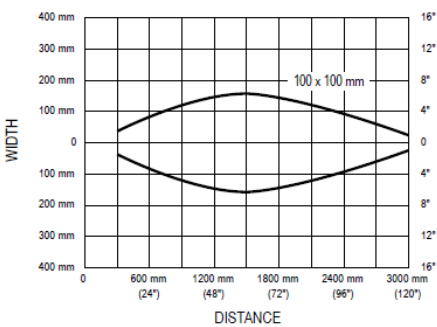
## ■ DX80N9Q45UAC All-in-one Ultrasonic Sensor Node

- Measures distance ranges from 300mm (11.8") to 3000mm (118")
- Operates on two internal 3.6 V AA lithium batteries
- 900 MHz or 2.4 GHz ISM band radio
- Utilizes Frequency Hopping Spread Spectrum
- Four Color LED indicator light on front
- 1 ¼" threaded barrel design with rugged NEMA 6 rating

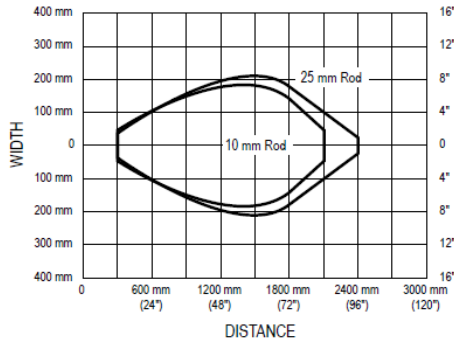


### 3 Meter Models

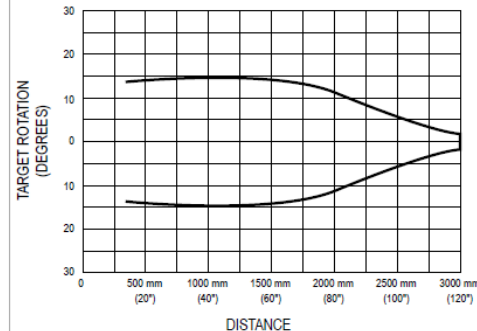
#### With Plate Target (Typical)



#### With Rod Target (Typical)



#### Maximum Target Rotation Angle

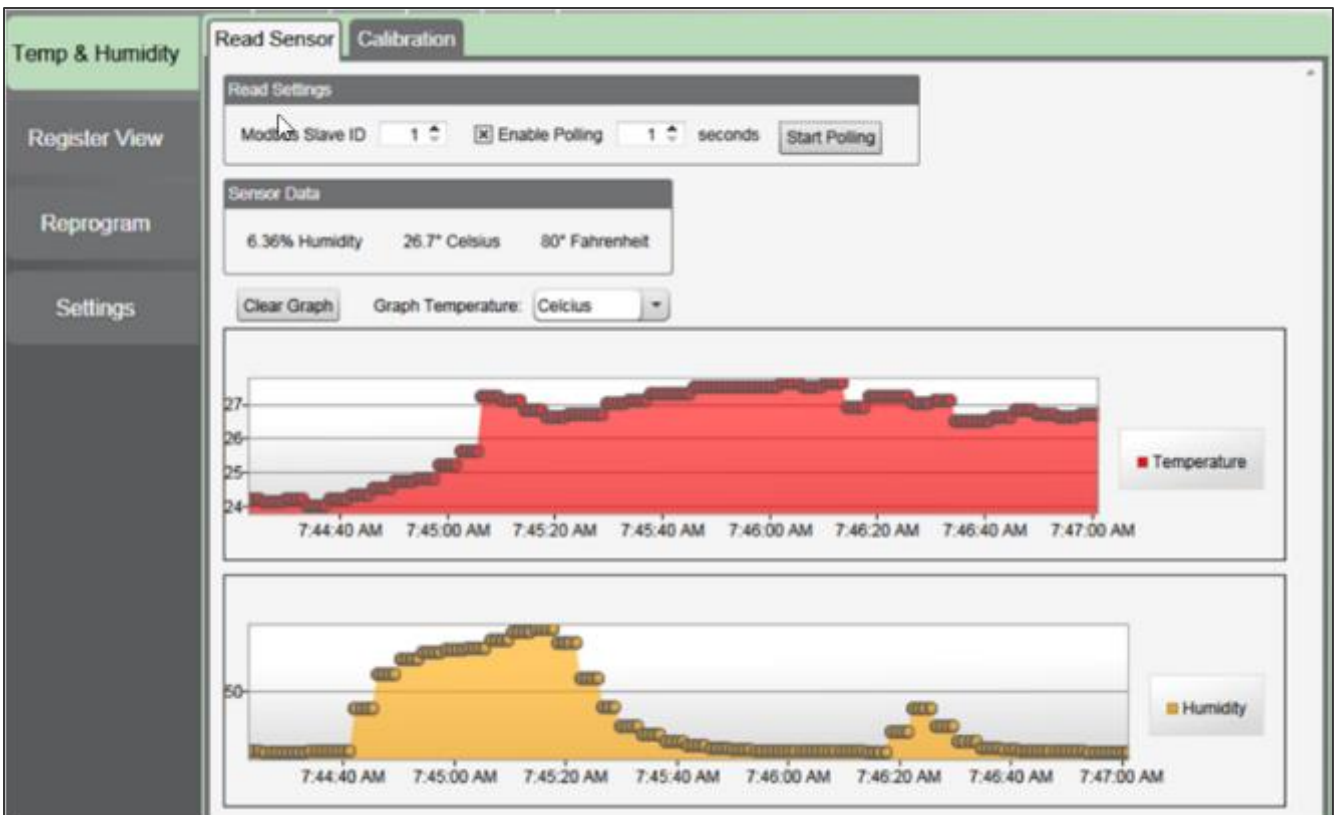


# Ambient Temperature & Relative Humidity (RH) Monitoring



## ■ M12FTH\*Q Sensor

- Relative humidity, temperature in Fahrenheit and Celsius
  - Also available as temperature only
- Operating voltage of 12 to 24 Vdc
- Operating range of  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  ( $-40^{\circ}\text{F}$  to  $+185^{\circ}\text{F}$ )
- Accuracy of  $0.4^{\circ}\text{C}$
- Operates as a serial slave device
- 12mm threaded barrel design with NEMA 6 rated housing
- Connects to either a remote radio or directly to DXM



## Accessories

### Temperature-Humidity Filter Caps

#### FTH-FIL-001

- Aluminum grill filter cap (factory default, ships with M12FTH\*Q sensors)



#### FTH-FIL-002

- Stainless steel, sintered to 10 micrometer porosity (for high dust environments.)



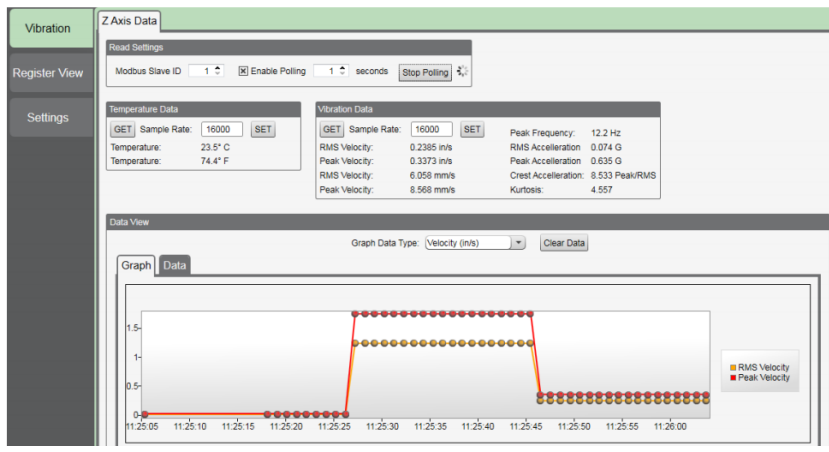


# Infrared (non-contact) Temperature Monitoring



## ■ T-GAGE M18TIP14Q Thermal Sensor

- 12-30 Vdc operating power
- 4-20 mA output plus PNP discrete alarm output
- 14:1 distance to spot ratio (other models with larger spot sizes are available)
  - 25 mm / 1" spot size when sensor is 356 mm / 14" from target
- Detection temperature range of 0 °C to +300 °C (+32 °F to +572 °F)
- Set analog range or discrete alarm output via the push button or configuration software
- Small self-contained NEMA 6 rated package, fully encapsulated housing for harsh environments
- Connects directly to analog input



Example of Software Configuration Software

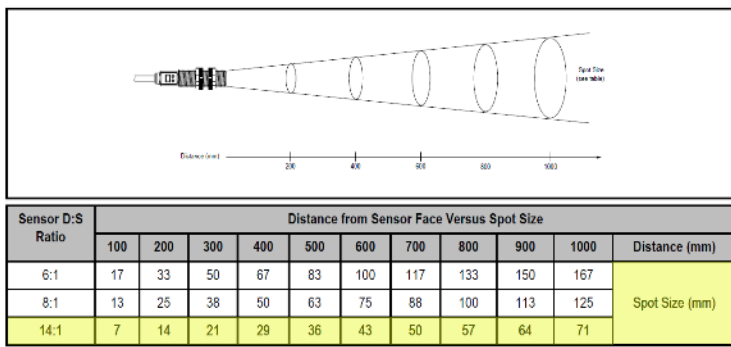


Figure 2. Detection spot size versus distance from sensor



| Brackets       |  |
|----------------|--|
| Model          | Description  |
| <b>SMB16A</b>  | <ul style="list-style-type: none"> <li>Right-angle mounting bracket with a curved slot for variable orientation</li> <li>1/2" springs stainless steel, 18 mm diameter mounting hole</li> <li>Clearance for M4 (R4) hardware</li> </ul> |
| <b>SMB16UR</b> | <ul style="list-style-type: none"> <li>2-piece swivel bracket</li> <li>304 series stainless steel, 18 mm sensor mounting hole</li> <li>Stainless steel swivel locking hardware included</li> </ul>                                     |
| <b>SMB16SF</b> | <ul style="list-style-type: none"> <li>18 mm swivel bracket with M16 x 1 internal thread</li> <li>Black thermoplastic polyester</li> <li>Stainless steel swivel locking hardware included</li> </ul>                                   |

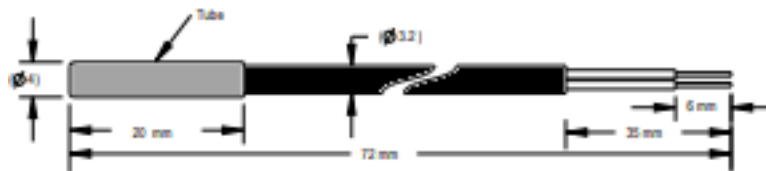


# Contact Temperature Monitoring



## ■ BWA-THERMISTOR-PROBE-001 Sensor

- Contact based temperature probe for tight locations
- Thermistor technology
- Accuracy 0.2%
- Operating temperature of  $-20\text{ }^{\circ}\text{C}$  to  $+105\text{ }^{\circ}\text{C}$  ( $-4\text{ }^{\circ}\text{F}$  to  $+221\text{ }^{\circ}\text{F}$ )
- Plated nickel finish, PVC Insulation
- 2 m potted in cable with flying leads
- Connects to either a remote radio or directly to DXM

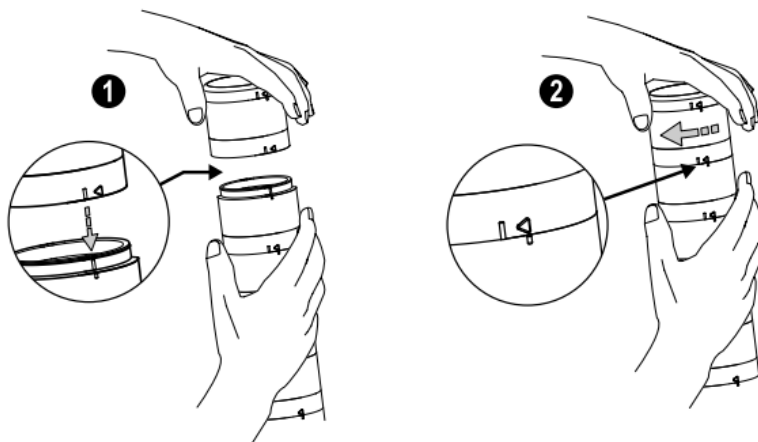


# Remote Indication Options



## ■ TL70 Modular Stack Light

- Wired or wireless versions
- Modular light segments snap/lock together
- Available with audible alert segment
- Available as either Node or MultiHop repeater/slave radio
- Operates on 12-30 Vdc
- Up to 6 colors or 5 colors plus audible
- Rugged IP65 water-resistant housing
- Indicators are gray when not energized
- Two way radio unit allows for inputs at the stack light's position
- Internal flash patterns adjusted via DIP-Switches
- Communicates directly with DXM controller utilizing Banner proprietary wiring



# Banner Wireless Radio Networks for Condition Monitoring



Banner's network radios provide the backbone of a very flexible and highly expandable wireless network for industrial environments. Simple wire replacement products easily replace discrete, analog, serial, and ethernet signal wires with no setup software needed. The Performance Series centers around a Gateway and up to 47 remotely located Nodes with multiple I/O options. The MultiHop Series uses repeaters to extend the range of the network using multiple "hops" to cover larger distances or to circumvent obstacles (trees, buildings, topology, etc.).

## ■ Scalable

- Banner wireless networks grow with your needs. Simple wire replacement products are preconfigured to support up to six Nodes and can be expanded to accommodate as many as 47 Nodes using the configuration software.

## ■ Reliable

- Good signal strength assures uninterrupted communication. Banner offers an integrated site survey capability to evaluate and ensure good radio signal strength prior to installation.

## ■ Long Range

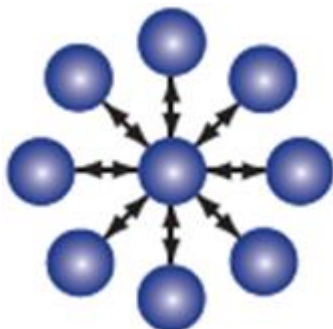
- Designed for long distance applications, Banner wireless networks are capable of up to six miles (9.7 km) of line-of-sight coverage, making them an ideal solution for applications in remote and difficult to access locations or where running wire or conduit is impractical or too expensive.

## ■ Easy-to-Use

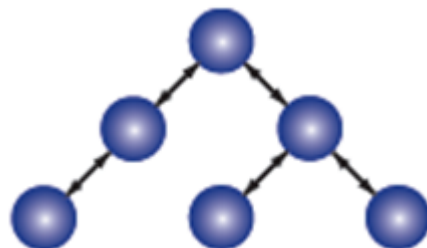
- Banner's Simple Wire Replacement product line provides flexible networks that are easy to set up without software. Setting up a basic point-to-point network is as easy as pairing a cell phone to a headset.

## ■ Secure

- Binding radio Nodes in a network locks them to a specific Gateway. After the devices are bound, each Gateway only accepts data from the Nodes that are bound to it.



Performance (Star) Network



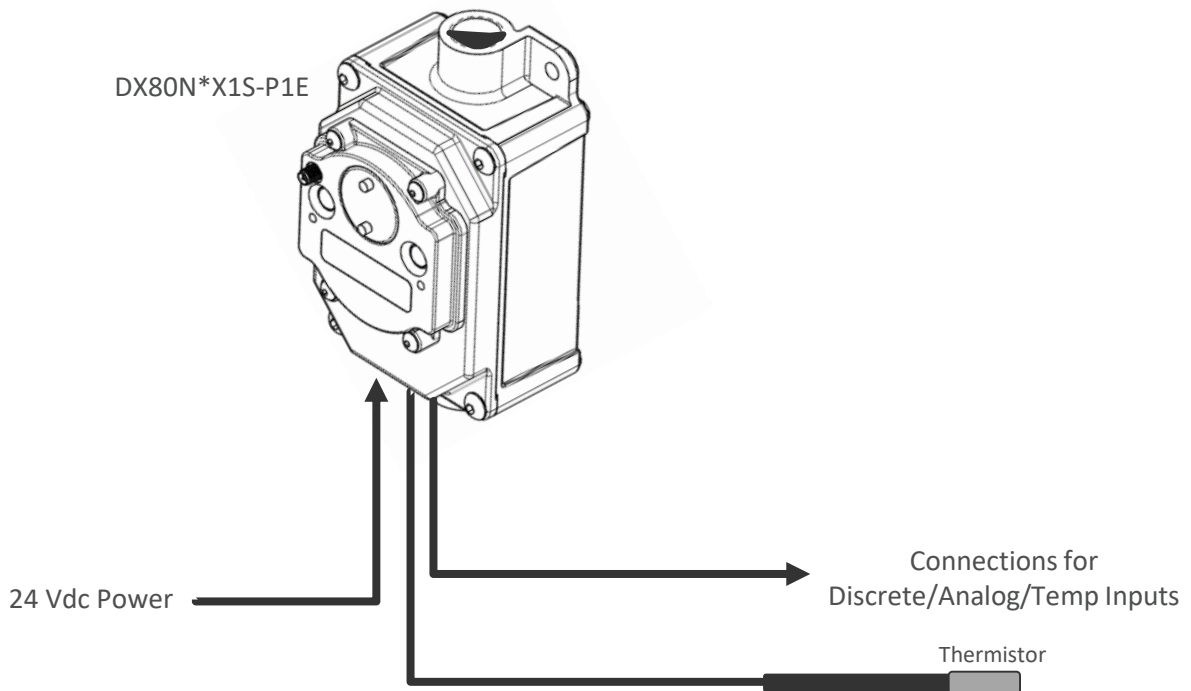
MultiHop (Tree) Network

# Remote Radio for Sensor Connections (Star Network Topology)



## DX80N\*X1S-P1E Node

- 2 discrete inputs / 2 discrete outputs
- 2 analog inputs (4-20 mA or 0-10 V)
- 2 thermistor inputs (for contact style temperature probes)
- Operates on 10-30 Vdc or internal 3.6 V lithium battery
- 900 MHz or 2.4 GHz ISM band radio
- Utilizes Frequency Hopping Spread Spectrum
- Built-in site survey mode enables rapid assessment of a location's RF transmission



# Remote Radio for Sensor Connections (Star Network Topology)

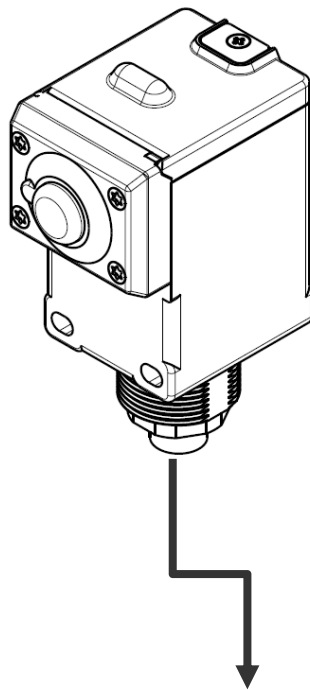


## DX80N\*Q45U Node

- 1-wire serial interface
- Operates on internal 3.6 V lithium batteries
- 900 MHz or 2.4 GHz ISM band radio
- Utilizes Frequency Hopping Spread Spectrum
- Built-in site survey mode enables rapid assessment of a location's RF transmission



DX80N\*Q45U



Connections for 1-wire serial sensor

# Remote Radio for Sensor Connections (MultiHop Network Topology)

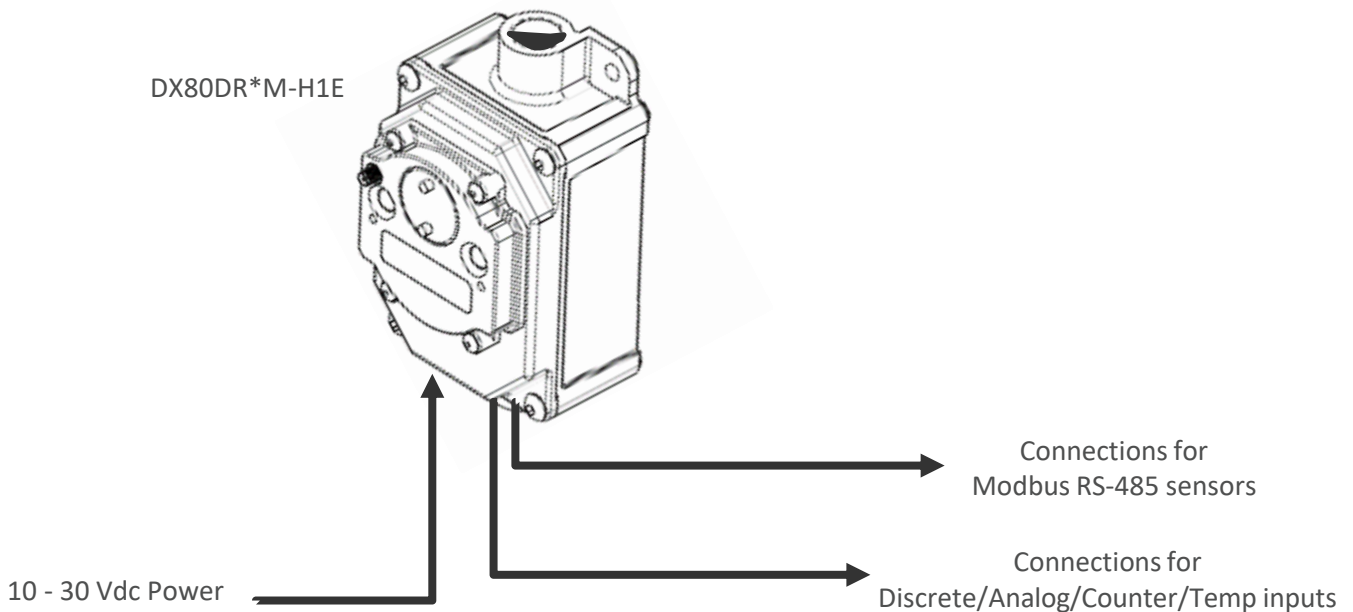


## DX80DR\*M-H1E Slave

- MultiHop radio with Modbus RS-485 communications
- 4 NPN discrete inputs / 2 NMOS discrete outputs
- 2 analog inputs 4-20 mA
- 1 thermistor input
- Operates on lithium battery or 10-30 Vdc supply
- 900 MHz or 2.4 GHz ISM band radio
- Self-forming, self-healing auto-routing RF network with multiple hops extends network range
- Can be set as either Repeater or Slave via DIP-switches
- Utilizes Frequency Hopping Spread Spectrum
- Built-in site survey mode enables rapid assessment of a location's RF transmission
- Can be polled based on conditional settings as well to only monitor when equipment is in motion



DX80DR\*M-H1E



# Remote Radio for Sensor Connections (MultiHop Network Topology)

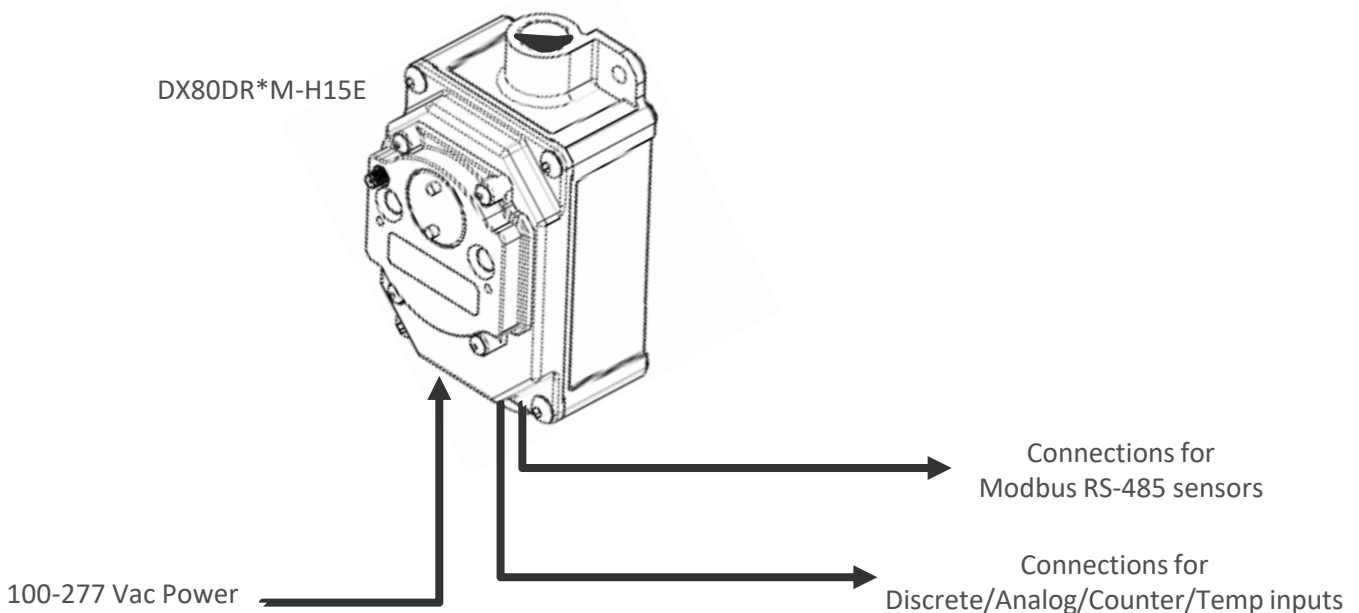


## DX80DR\*M-H15E Slave

- MultiHop radio with Modbus RS-485 communications
- 2 PNP discrete inputs / 2 PNP discrete outputs
- 2 Form C 10 A relay outputs
- 2 analog inputs 4-20 mA
- 2 analog outputs 0-10 Vdc
- Operates on 100-277 Vac-30 Vdc supply
- Provides courtesy 24 Vdc power (25 W)
- 900 MHz or 2.4 GHz ISM band radio
- Self-forming, self-healing auto-routing RF network with multiple hops extends network range
- Can be set as either Repeater or Slave via DIP-switches
- Utilizes Frequency Hopping Spread Spectrum
- Built-in site survey mode enables rapid assessment of a location's RF transmission
- Can be polled based on conditional settings as well to only monitor when equipment is in motion



DX80DR\*M-H15E





# Gateway Radio (Edge Device)



## ■ DXM100 or DXM150

- Optional internal RF module communicates to remote radios via proprietary Banner protocol
- Star network topology or MultiHop (mesh) network topology
- Onboard wired I/O including universal inputs supporting analog / temp
- Multiple Modbus 485 RTU communication ports
- Backup battery system
- On-board communications include Ethernet/IP, Modbus RTU, Modbus TCP, J1939 CAN, and LTE/GSM cellular
- Ability to communicate with cloud servers via push API
- Locally trigger alarms based on immediate data, trended data, or multiple conditions
- SMS / e-mail messaging
- Store operational data from each sensor being monitored to microSD card
- Log anomalies with date and timestamp information
- Stores data locally until the controller can communicate with server
- Store and email out on a fixed time schedule
- On-board display allows for equipment setup as well as troubleshooting tools for communications connectivity, individual radio performance and sensor performance



# Wireless Solutions Kits



## Wireless Solutions Kits

- Wireless solutions kits are fully integrated and easy to use solutions for monitoring assets and solving specific applications
- Users of any experience can setup a wireless network, collect remote data, and create visualization tools, warnings and alarms
- No programming required. Plug in the box, bind the nodes through the HMI screen, install sensors and nodes, begin collecting data
- Includes a pre-programmed DXM controller (with machine learning algorithm for vibration models), pre-programmed 10.1 inch touchscreen HMI, and 5-port industrial ethernet switch
- HMI provides graphical displays of collected data, baselines, thresholds, warnings, and alarms
- Access raw data right on the HMI or via the cloud from any network accessible location
- View up to 7 days of data history on the HMI screen and archive over 30 days of logged data in CSV files



Vibration Monitoring Solutions Kit

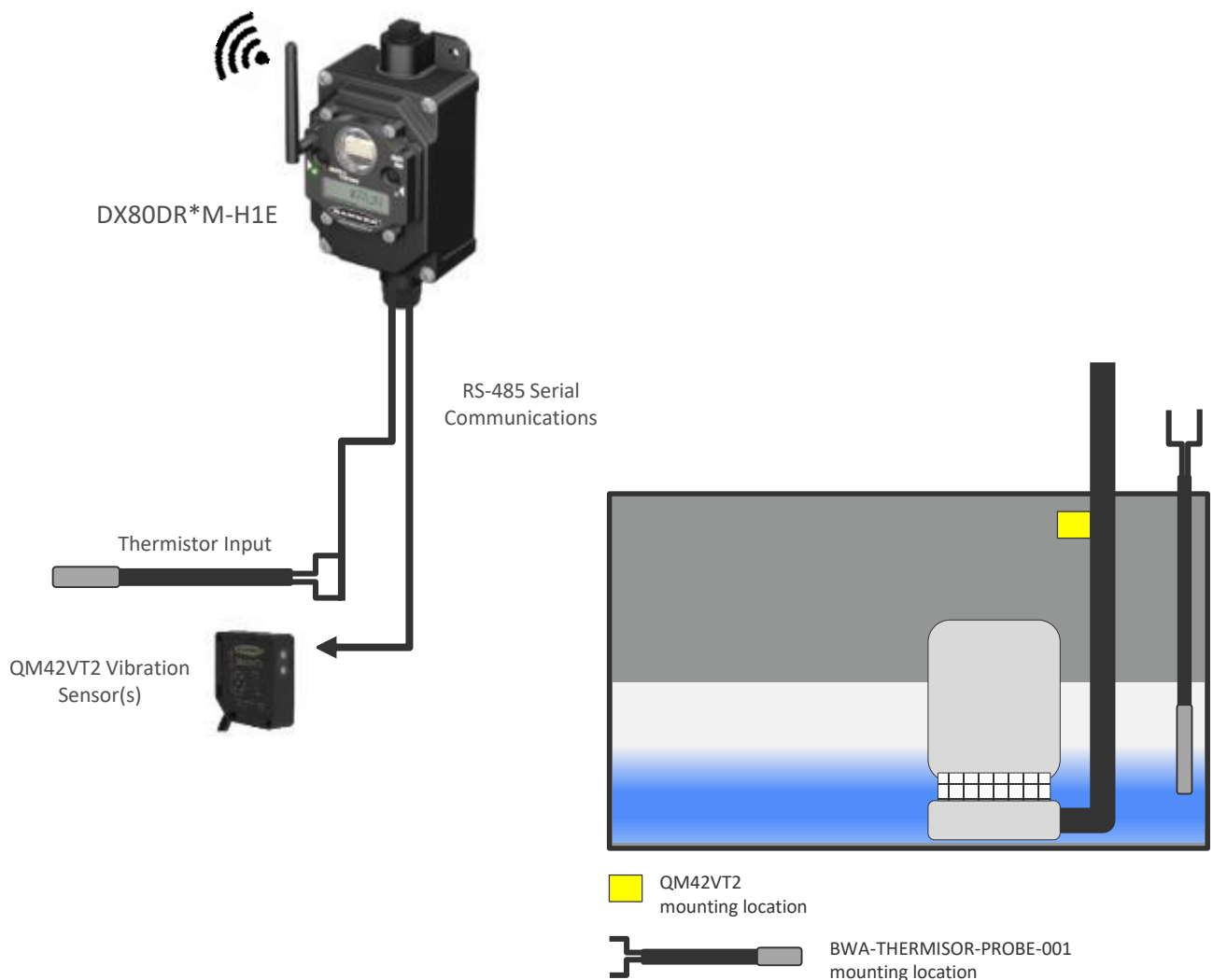


Tank Level Monitoring Solutions Kit

# Application – Monitoring Coolant Recirc Pump (Automotive Plant)



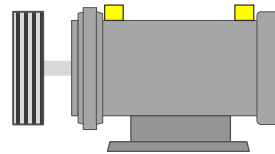
- CNC machining centers require continuously recirculated cutting fluids
- Monitor vibration and temperature of pump/motor assembly with the QM42VT\* sensor
- The vibration sensor will provide protection against plugged or deteriorating flow capabilities
- Monitor the temperature of the coolant with a submerged thermistor (BWA-THERMISTOR-PROBE-001) to better understand content and cooling ability of older cutting fluids
  - Additionally, it can be used to monitor the temperature of the motor or pump housings for determining failing internal components or heat generating events such as pump cavitation



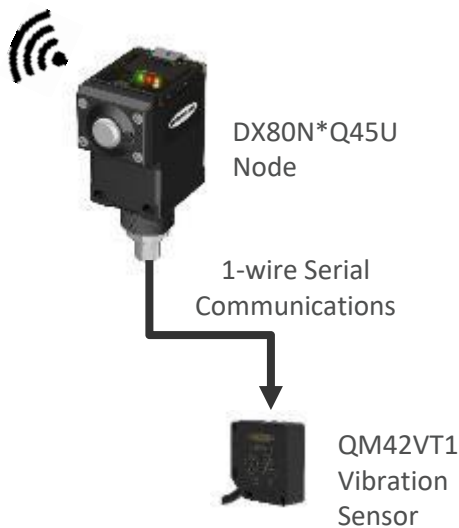
# Application – Monitoring Cooling Fans (Commercial Printer)



- Large-scale printing company needs to minimize downtime on commercial printing presses
- Continuously monitor cooling fan motors cantilevered above printing machines to identify bearing or blade issues prior to catastrophic failure
- QM42VT1 vibration sensors connected to wireless nodes are mounted on cooling fan motors and collect continuous vibration values
- Data is wirelessly transmitted to a DXM100 controller containing action rules that define thresholds
- Eliminate cost and time of manual sampling set up
- Easy retrofit installation
- Eliminate machine downtime



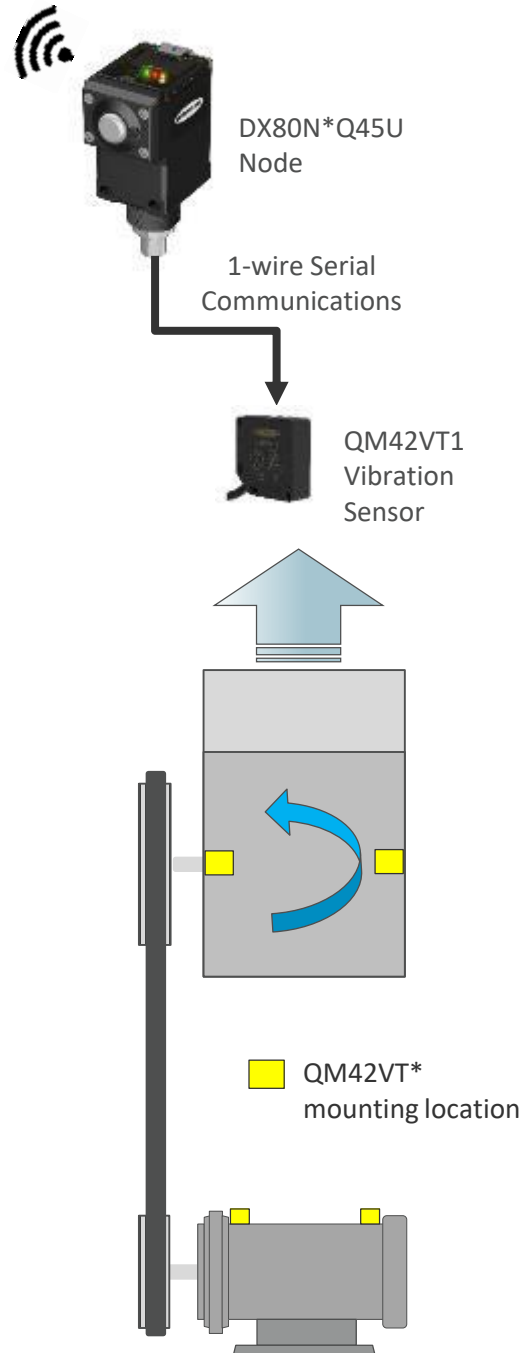
■ QM42VT1  
mounting locations



# Application – Monitoring Baghouse / Exhaust Fans (Scrap Steel Processor)



- Monitoring the vibration and temperature of bearings in the fans
- Early indication of issues on the motor or fan assembly bearings, misalignment

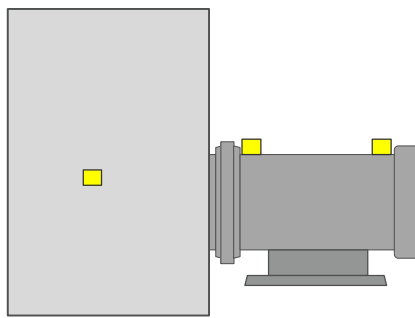





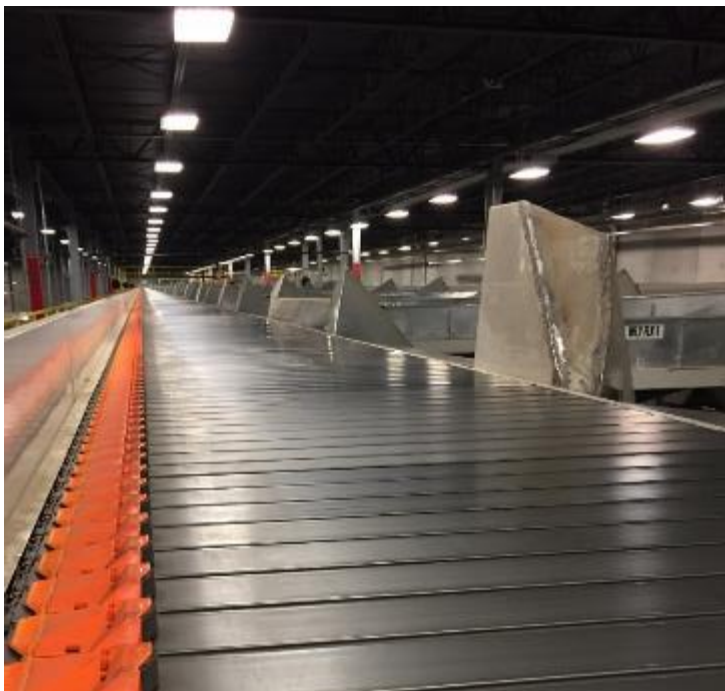
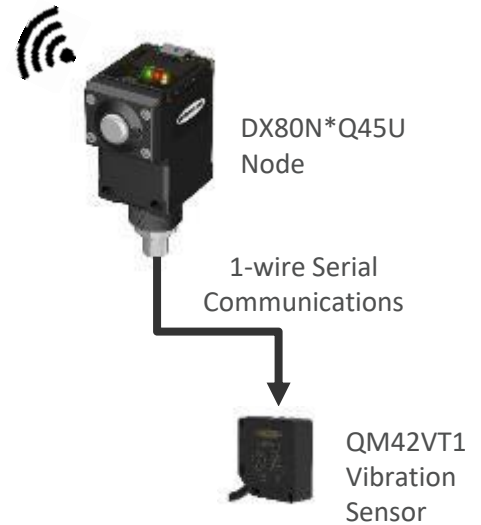
# Application – Monitoring Conveyor Motors and Gearboxes (Package Handler)



- Large distribution centers with conveyors and box/package sortation equipment
- Customer cannot tolerate down time due to motor or gearbox failures
- Can plan maintenance more efficiently
- QM42VT\* vibration sensor and RF node are magnetically mounted for ease of installation



 QM42VT1 mounting locations



# Application – Monitoring CNC Cutting Fluid Tank Levels

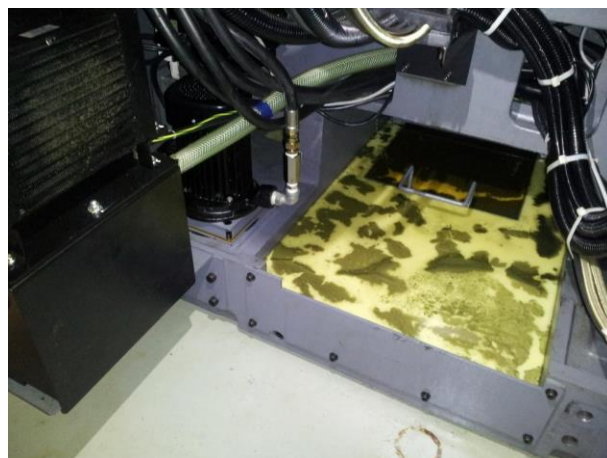


- A major supplier to the automotive industry needs to ensure that proper levels of cutting fluids are being maintained for their CNC machines
- Customer needed an easy to deploy tank level monitoring solution that can provide direct alerts to operators, support personnel, and supervisors
- K50U ultrasonic sensors connected to Q45U nodes are mounted on each CNC machine's cutting fluid tank
- The data is wirelessly sent to a DXM100 controller that sets thresholds and sends alerts to the appropriate personnel
- Tank level data is collected in the cloud for historical trending to analyze and better predict fluid needs



DX80N\*Q45UAC

K50UX1\*RA +  
DX80N\*Q45U +  
BWA-BK-006

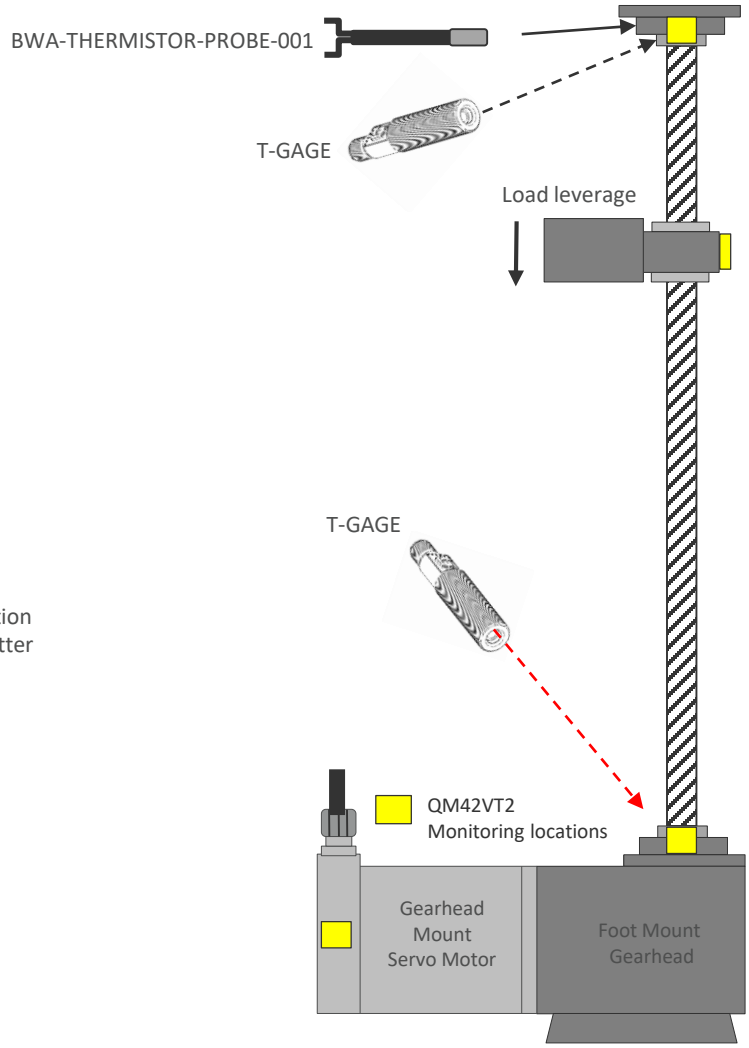
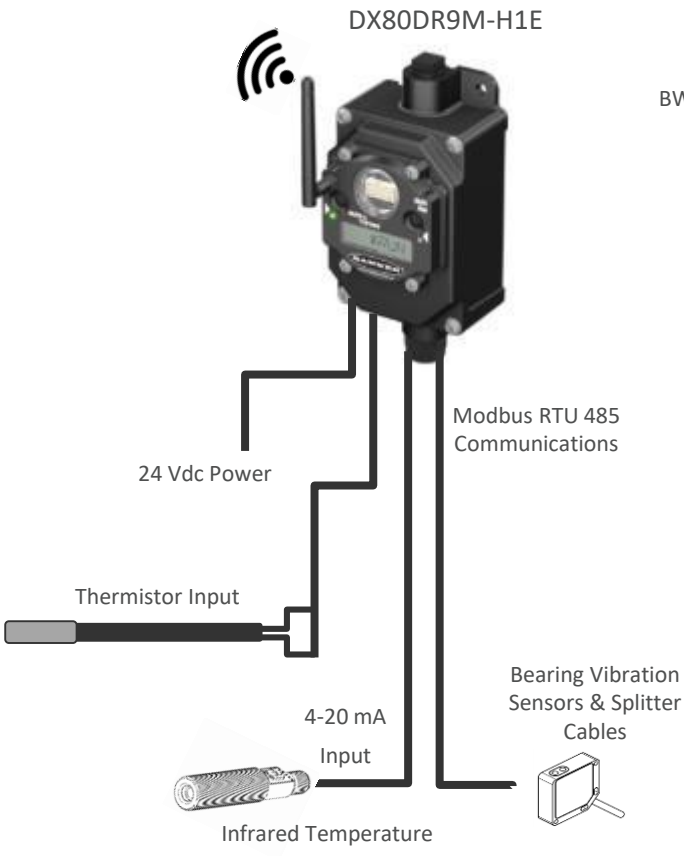




# Application – Monitoring Gearbox Locating Leadscrews (Automotive Plant)



- Monitor the X, Y and two Z-axis lead screws on the gearbox locating/transfer control
- Utilizing a combination of technologies such as vibration/temperature, infrared non-contact and contact point thermistors for monitoring the support bearings and lead nut bearings
- There are 3 vibration monitoring points per leadscrew as well as an additional monitoring point on the servo motor



# Application – Environmental Condition Monitoring (Semiconductor Fab)



- A semiconductor fab needs to monitor temperature, relative humidity, and oxygen levels at multiple points within their processing plant, along a 2 kilometer long process piping system.
- Installing cable to each monitoring location is cost prohibitive
- Monitor temperature and relative humidity with the M12FTHQ3 Temperature and Humidity Sensor
- Using DX80DR\*M-H15E MultiHop radios configured as repeaters allows for covering the entire 2 km of process piping
- Communicates via Modbus RTU which is a universally accepted protocol for most HMI, PLC, or SCADA systems
- The repeaters provide a junction for wired 3<sup>rd</sup> party Modbus slave devices and has built-in analog I/O
- Operates on 100-277 Vac or 30 Vdc supply and provides courtesy 24 Vdc power for external devices



DX80DR\*M-H15E



M12FTH3Q



CL50YXXAPQ



## **How does the QM42VT\* measure vibration?**

It uses a 2-axis MEMS based accelerometer as its core sensing element and advanced signal processing techniques to output a digital signal that represents a true RMS velocity between 10 and 1,000 Hz.

## **Why does the QM42VT\* measure velocity?**

Velocity is considered a universal measure of machine integrity because it provides the most uniform measurements over a wide range of machine frequencies.

## **What does RMS velocity mean?**

RMS is the Root-Mean-Square of the velocity. It is in essence an averaging operation that conveys the effective energy produced by the vibration of the machine. It is the most common and effective measure of machine vibration severity in rotating equipment.

## **Over what frequency range can the QM42VT\* measure RMS velocity?**

The QM42VT1 and QM42VT2 sensors measure RMS velocity between 10 Hz and 1,000 Hz (1 KHz).

## **Is there any vibration analysis that is needed with the data provided by the QM42VT\*?**

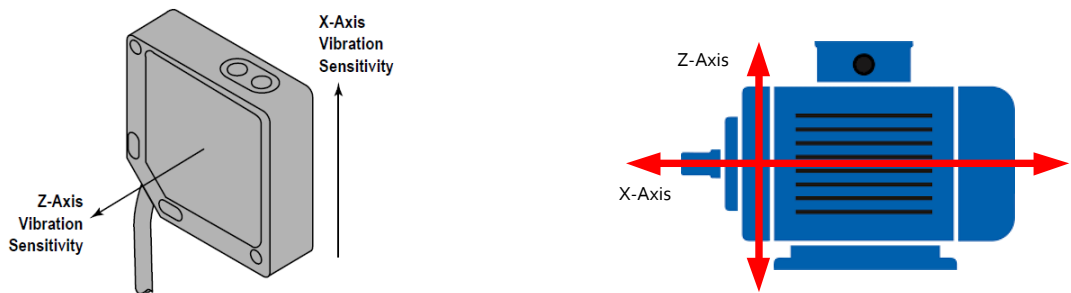
No, the sensors take periodic waveform "snapshots" which are immediately (real time) processed, allowing the sensor's microcontroller to calculate scalar vibration characteristics such as RMS velocity.

## Where should the QM42VT\* be mounted?

Mounting it as close as possible to the bearings will provide the most accurate measurements.

## In how many axes does the QM42VT\* measure vibration?

It measures in two axes, the z-axis (radial) and x-axis (axial):



## How often does the QM42VT1 take a vibration measurement?

The default sample rate is 5 minutes. Every 5 minutes, the sensor will capture 400 milliseconds of vibration waveform data at a 20 kHz rate, resulting in an 8,192 point record length.

## How do I determine where to set vibration thresholds?

The ISO 10816 Vibration Severity Chart (see datasheet) is an excellent resource for guidance on where to set vibration thresholds. It is a well-established standard that is based on historical machine vibration data. However, machine vibration can vary based on many factors including type of machine, mounting, etc.

An alternative way to determine where to set thresholds is to use Banner's machine learning algorithm running on a DXM controller / edge gateway device. The algorithm not only automates the process of establishing a baseline for each vibration characteristic being monitored, but also the placement of warning and critical alarm levels.

### **What is the temperature measuring range of the QM42VT\*?**

The temperature measuring range is -40 to +105°C (-40 to +221°F)

### **Can the QM42VT\* housing withstand tough industrial environments?**

The QM42VT\* has a robust zinc alloy housing and is rated IP67 for demanding industrial environments.

### **How long will the radio's internal batteries last?**

At a 5 minute sample rate, the batteries will last 3+ years on the Q45 node and the -P6 & -H6 nodes at the 250 mW RF power setting. On the 1 W setting, the -P6 and -H6 will last 2 ½ years at a 5 minute sample rate. See the product datasheets for detailed life curves.

### **How do I know when it is time to change the batteries?**

Because lithium batteries don't lose power gradually over time, but rather maintain their power and die very quickly at the end of their life, it is not very useful to be able to check the power level of the battery. The most effective way to ensure that the battery will not die unexpectedly is to put the battery on a regular maintenance schedule based on its expected life according to the sample rate. See the QM42VT\* datasheets for details.

### **Is there a line powered (10-30 V dc) node available?**

Yes, for the QM42VT1 sensor use the DX80N9X6S-P6 and DX80N2X6S-P6. Alternatively, use the DX80DR9M-H6D and DX80DR2M-H6D for multihop network topology.

### **How long can the cable be between the QM42VT1 and the node?**

The cable that comes with the QM42VT\* is 3 meters long (9.8 feet). If a longer cable is needed in your application, the cable should not exceed 10 meters (32.8 feet).

### **How many monitoring points can there be in the network?**

Banner wireless networks are extremely flexible. The Performance Series (star topology) can easily expand to 47 monitoring points and the MultiHop Series (mesh topology) can handle 50+ monitoring points.

### **Does the wireless network interfere with existing wireless networks?**

To prevent networks from interfering with each other, the gateway and all its nodes exchange a binding code that prevents radios outside the network from communicating with the gateway (similar to pairing a headset to a phone, but more secure). Additionally, gateways and nodes are configured for multiple channel hop patterns to eliminate data collisions.

### **Can the K50UX\*\*RA ultrasonic sensor be installed in hazardous areas?**

No, these products do not carry the necessary hazardous area approvals (Class I, Division 1, Zone 0, etc).

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