



Equipment  
Condition  
Monitoring for IIoT  
& Industry 4.0

# Equipment Condition Monitoring – Table of Contents



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# Why Condition Monitoring?



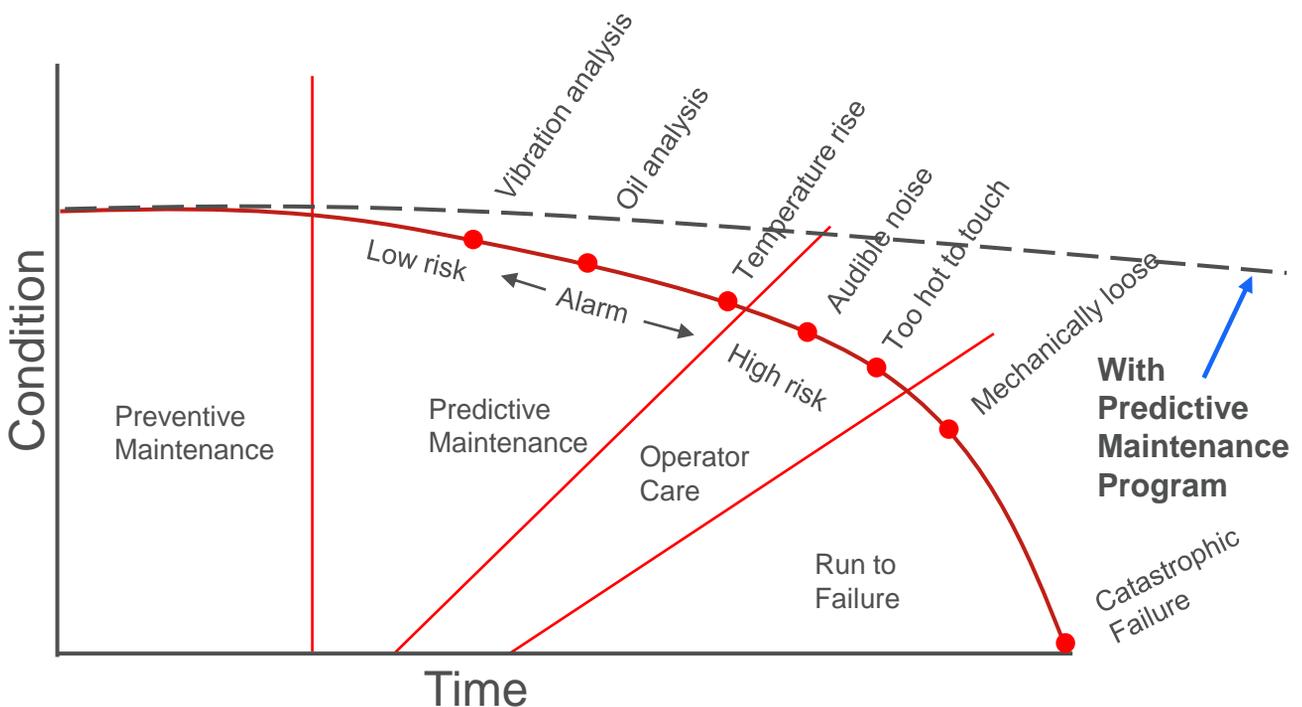
- Monitoring characteristics such as vibration reduces downtime, thereby increasing productivity and saves money.
- Use condition monitoring within predictive maintenance programs to effectively predict machine failure before it becomes catastrophic.
- Plan maintenance more efficiently - determine when 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

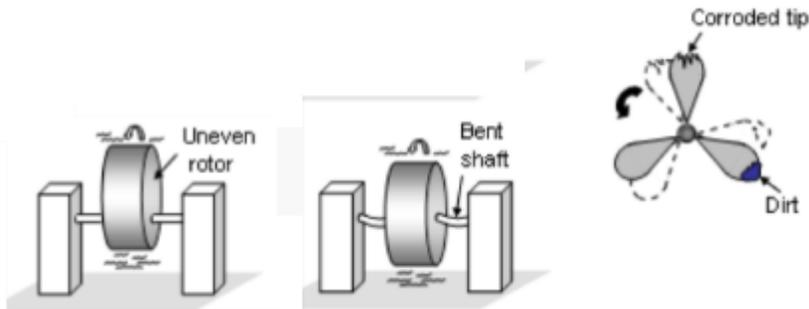


# Condition Monitoring: Vibration Common Causes



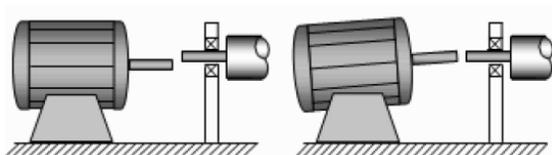
## Imbalance

- 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



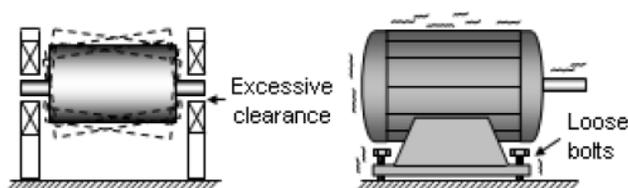
## Misalignment / Shaft Runout

- 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.

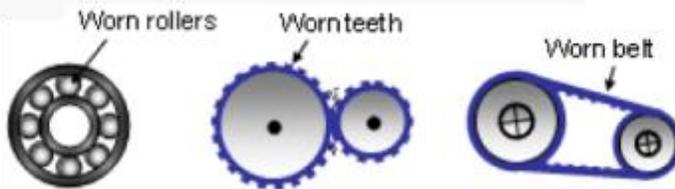


# Condition Monitoring: Vibration Common Causes



## 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

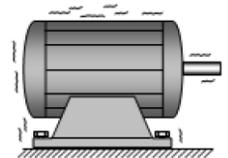


## Typical situations which cause machine failures:

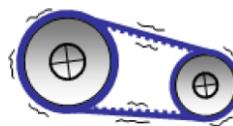
- Excessive loads
- Overheating of bearings/wear items
- Typical wear/fatigue failure
- Reverse loading
- Contamination
- Lubrication failure
- Bearing corrosion/pitted running surfaces
- Misaligned bearings and loads
- Loose mounts
- Tight fitting couplings



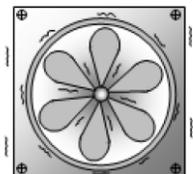
Vibrating Pumps



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.

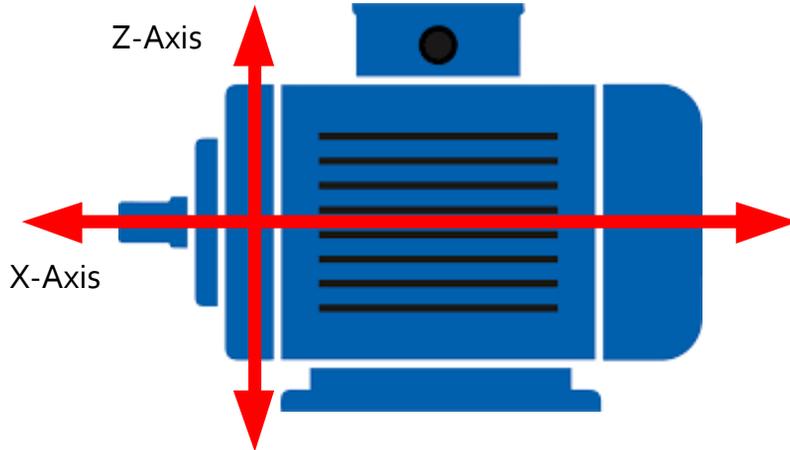
- **High Frequency RMS Acceleration (HF  $A_{RMS}$ )**

- 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

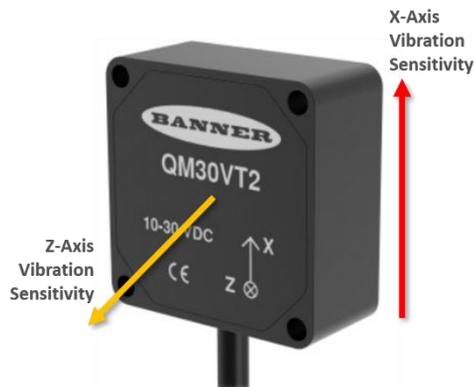
- The requirement for operational monitoring is usually met by performing one measurement in the radial direction (i.e. horizontal-transverse to the shaft) supplemented by an axial measurement which is of prime significance at thrust bearing locations where direct axial dynamic forces are transmitted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

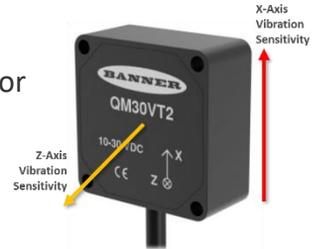


# Vibration/Temperature Sensor Mounting

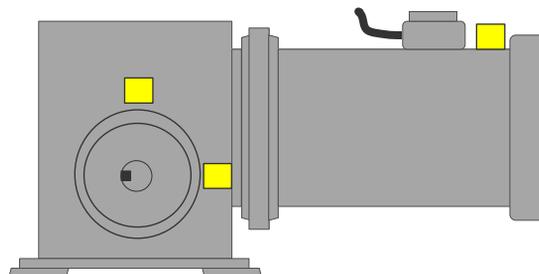


## Installation of the Sensor:

- 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-BK-013<br>Flat magnet sensor bracket   |         | Highly flexible and re-usable, flat magnetic mount for larger diameter surfaces or flat surfaces   |
| BWA-BK-019<br>Curved surface magnet bracket                                      |         | Curved surface magnet mounts are best suited to smaller curved surfaces. Attention should be made to orient in the correct direction for the strongest mount. Offers flexibility for future sensor placement   |
| BWA-BK-014<br>Center mounting bracket – M4 x 0.7 screw mount (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.<br><i>Recommend epoxy designed for accelerometer mounting: Loctite Depend 330 and 7388 activator</i> |



QM30VT\*  
Mounting locations

# Sensor Operation & Vibration Parameter Definitions



The Banner QM30VT1 and QM30VT2 sensors have a sampling window of 400 ms during which 8,000 individual samples per axis 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

SCADA / DCS system



Local PLC / HMI



Ethernet TCP/IP

LTE / GSM Wireless



LAN or Cellular

Edge Devices

DXM700



-OR-

DXM700 w/  
cellular



Banner 900MHz / 2.4 GHz  
Proprietary Wireless Protocol

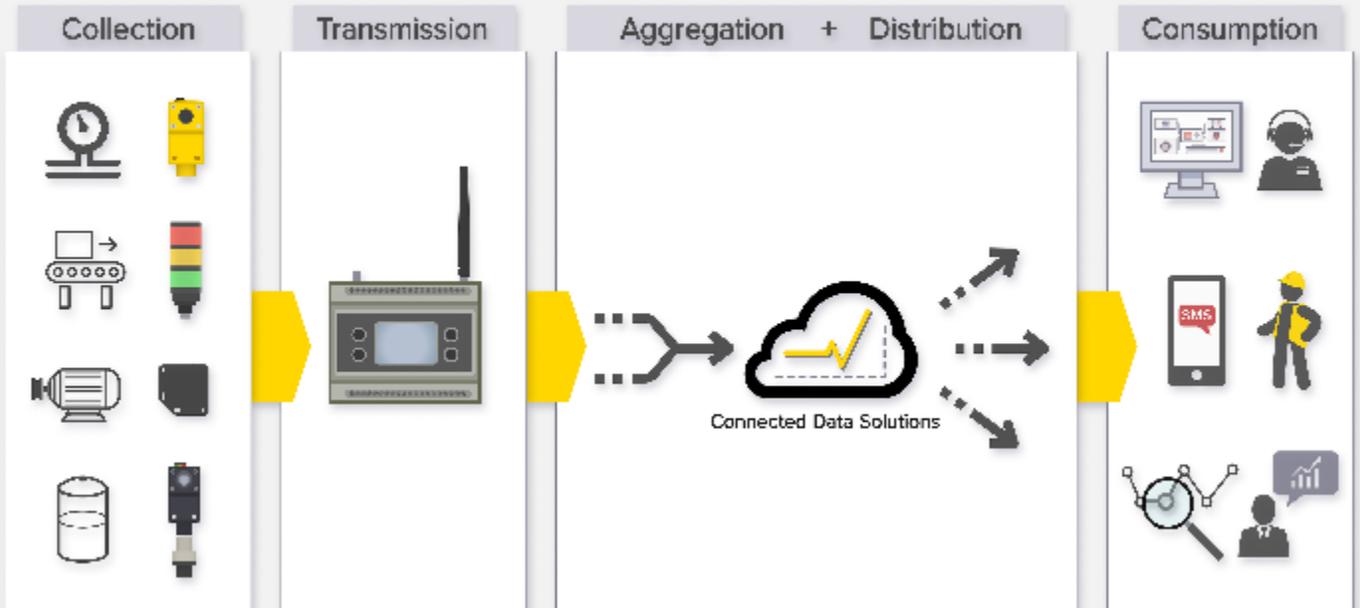
Wireless Sensors



# 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



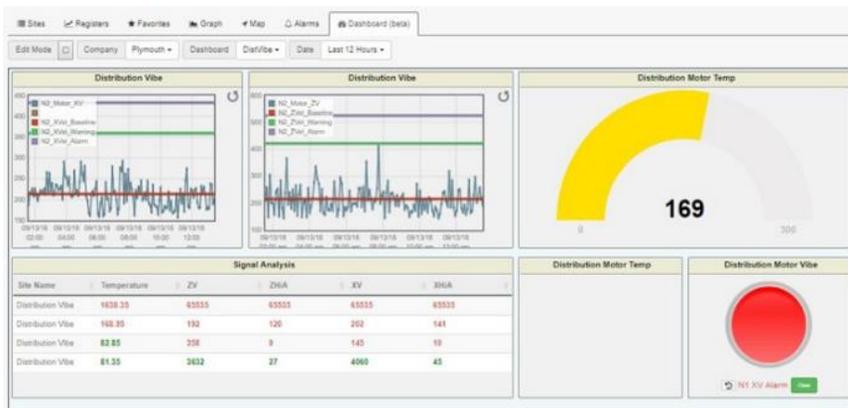
## Connected Data Solutions



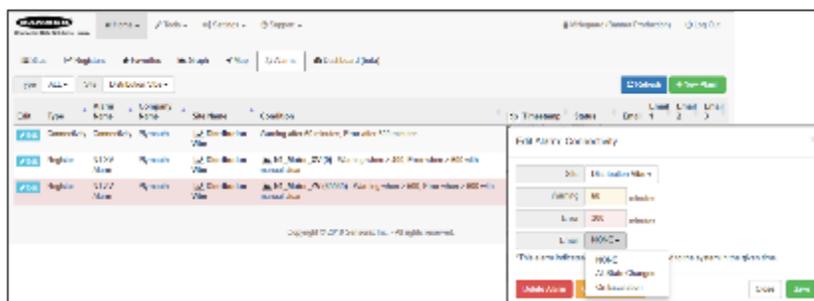
[BannerCDS.com](http://BannerCDS.com) is a cloud based software that allows users to access, store, protect and export critical data collected by Banner wired and wireless sensors.



## Banner CDS Features:



Customizable and codeless dashboards

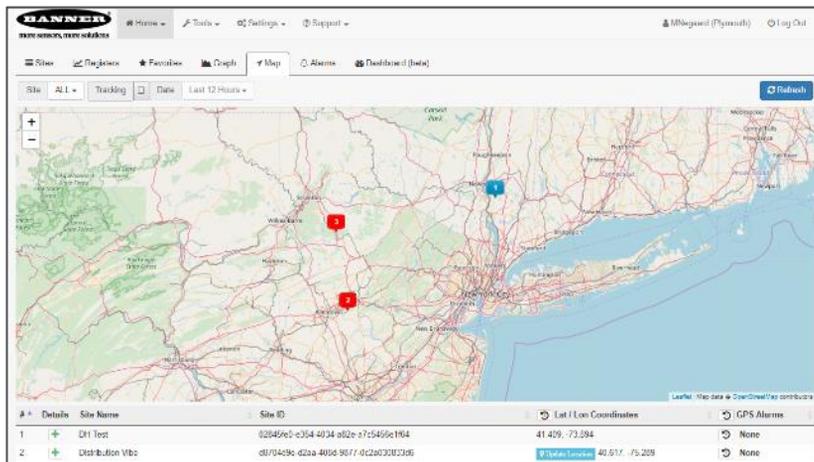


Condition-based alerts and notifications (e-mail, SMS)

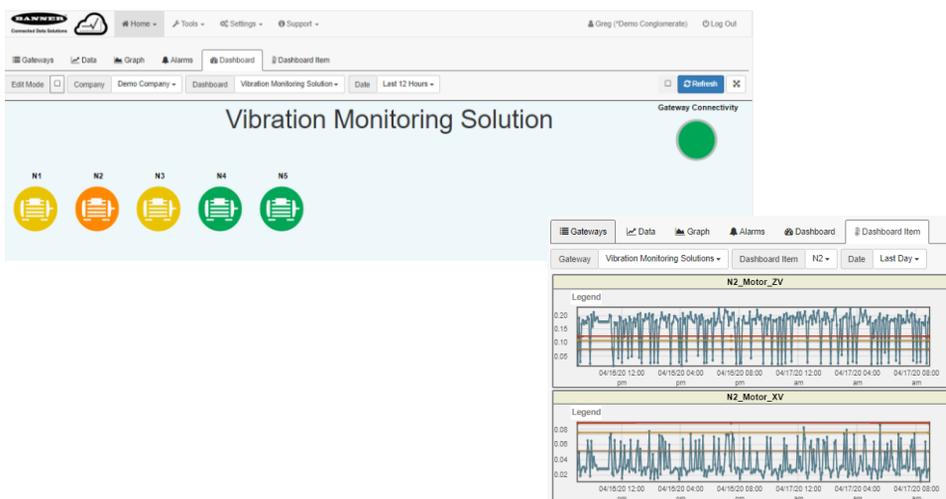
# Cloud Software for Data Storage, Alerts, and Visualization



## Connected Data Solutions



View health status of alarms and sites of all facilities with the map feature



- Auto-Generated Dashboard Solutions with click through visualizations
- 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

| Id  | Conglomerate      | Company           | Data Related | Points (last hour) | Used Points/Max Points  | Emails (last hour) | Competitive | Users        | Sites   | Banner | Account Number | Contact Name   |
|-----|-------------------|-------------------|--------------|--------------------|-------------------------|--------------------|-------------|--------------|---------|--------|----------------|----------------|
| 638 | Banner Production | Banner Production |              | 2,610 / 12,000     | 36,462,464 / 50,000,000 | 0 / 300            | 4 / 5       | 17 / 10 / 50 | 100     |        |                | Greg LaLiberte |
| 638 | Banner Production | Aberdeen          | 365 days     | 18 / 12,000        | 133,390 / 10,000,000    | 0 / 300            |             | 3 / 5        | 1 / 100 |        |                | Greg LaLiberte |
| 638 | Banner Production | Huron             | 365 days     | 0 / 12,000         | 0 / 10,000,000          | 0 / 300            |             | 0 / 5        | 0 / 100 |        |                | Greg LaLiberte |
| 638 | Banner Production | Plymouth          | 365 days     | 1,932 / 12,000     | 24,995,762 / 50,000,000 | 0 / 300            |             | 10 / 50      | 7 / 100 |        |                | Greg LaLiberte |
| 638 | Banner Production | US Test           | 365 days     | 660 / 12,000       | 11,333,315 / 20,000,000 | 0 / 300            |             | 3 / 5        | 2 / 5   |        |                | Greg LaLiberte |

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**Edit Company Aberdeen**

Conglomerate: Banner Production  
Company Name: Aberdeen  
Days Data Retrieved: 365  
Max Data Points: 10000000  
Points per hour: 12000  
Max Users: 5  
Max Sites: 100  
Emails per hour: 300  
Time Zone Offset: 0: UTC  
Banner Image: Choose File (No file chosen)  
Account Number:   
Contact Name: Greg LaLiberte  
Contact Email:

Buttons: Delete, Close, Save

Conglomerate/Business management tools

# Sensor Solutions for Condition Monitoring



- **Vibration and Temperature Sensors**

- QM30VT1 (1-wire serial)
- QM30VT2 (Modbus RS-485 serial)
- DX80N9Q45VA (all-in-one sensor/radio)
- DX80N2Q45VA (all-in-one sensor/radio)



QM30VT\*



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)
- DX80N9Q45UAC (3m range all-in-one)
- DX80N2Q45UAC (3m range all-in-one)



K50UX\*\*RA



Q45UAC

- **Ambient Temperature and Humidity**

- M12FTH4Q (1-wire serial)
- M12FTH3Q (RS-485 serial)
- DX80N9Q45THA (all-in-one)



M12FTH\*Q



Q45THA

- **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



## ■ QM30VT1 and QM30VT2 Digital Sensors

- Provides both radial and axial vibration readings in one housing
- High accuracy temperature monitoring
- Robust aluminum or stainless 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 (MultiHop system only)
- Connects to either a remote radio or directly to DXM



QM30VT\*

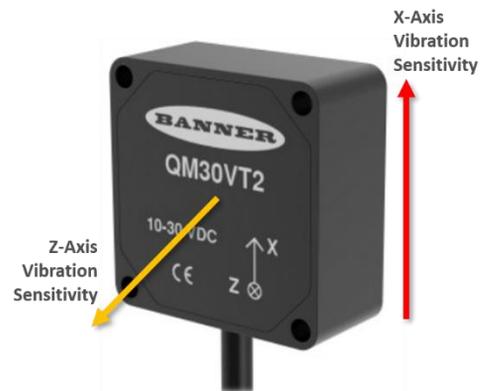
ISO 10816 provides guidance for evaluating vibration velocity severity motors, pumps, fans, compressors, gear boxes, blowers, dryers, presses, and other machines that operate in the 10 to 1000 Hz frequency range.



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

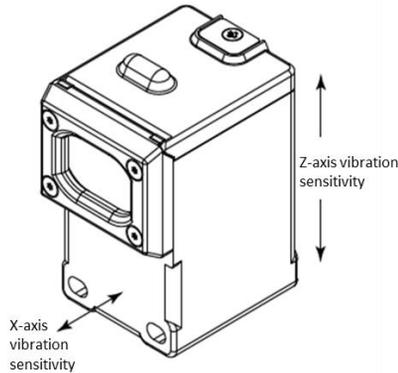


## ■ DX80N\*Q45VA All-in-One Sensor + Node

- Combines the QM30VT1 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 100mm (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



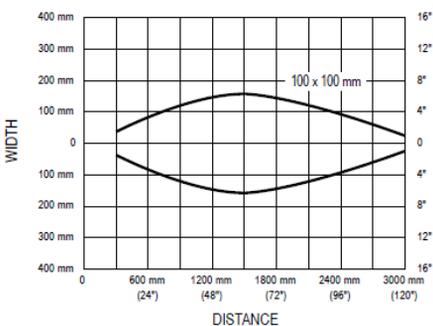
## ■ DX80N\*Q45UAC All-in-one Ultrasonic Sensor Node

- Measures distance ranges from 300mm (11.8”) to 3000mm (118”)
  - Two internal 3.6 V AA lithium batteries (2.5 years battery life)
- 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

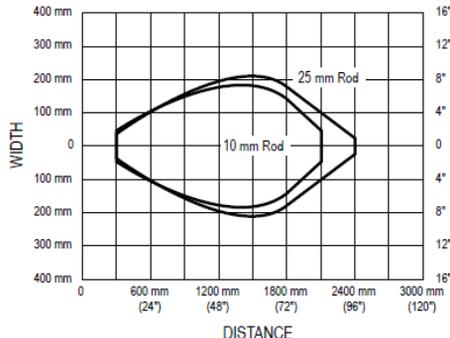


### 3 Meter Models

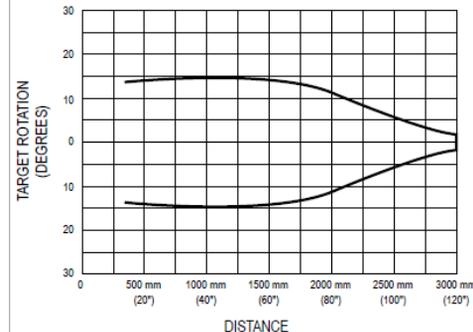
#### With Plate Target (Typical)



#### With Rod Target (Typical)



#### Maximum Target Rotation Angle



# Ambient Temperature & Relative Humidity (RH) Monitoring



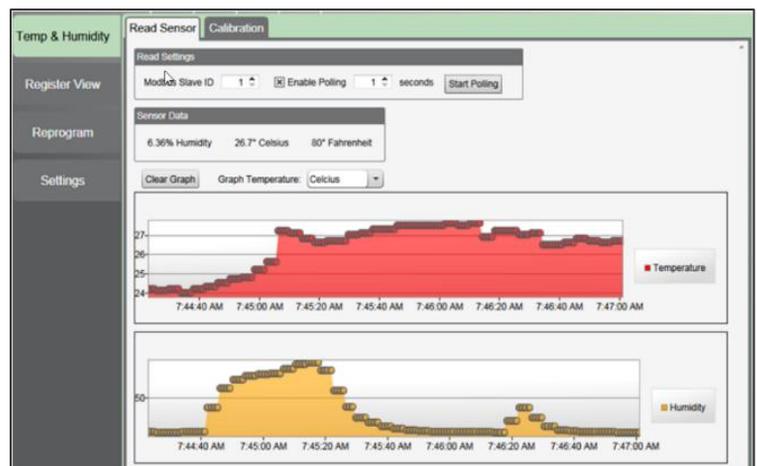
## ■ M12FTH\*Q Sensor

- 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



## ■ DX80N\*Q45THA All-in-one Temp & Humidity Node

- Operating range of  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  ( $-40^{\circ}\text{F}$  to  $+185^{\circ}\text{F}$ )
- Accuracy of  $0.4^{\circ}\text{C}$
- Two internal 3.6 V AA lithium batteries (2.5 years battery life)
- 900 MHz or 2.4 GHz ISM band radio
- Utilizes Frequency Hopping Spread Spectrum



## 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.)

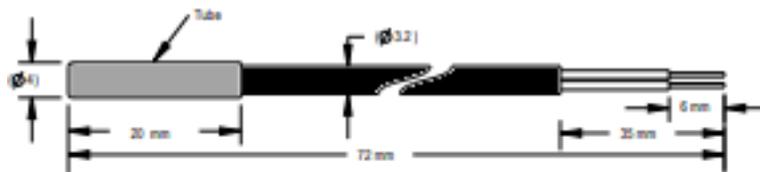


# Contact Temperature Monitoring



## ■ 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

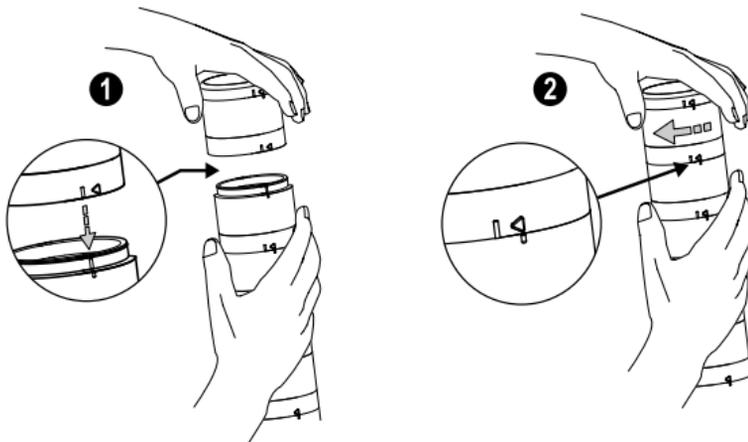


# Remote Indication Options



## ■ 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

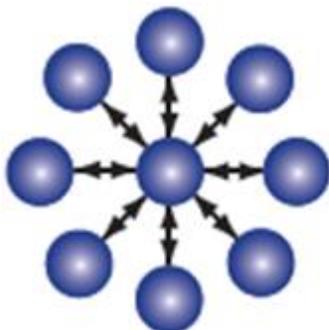
- Designed for long distance applications, Banner wireless networks are capable of up to six miles (9.7 km) of line-of-sight coverage, making them an ideal solution for applications in remote and difficult to access locations or where running wire or conduit is impractical or too expensive.

## ■ Easy-to-Use

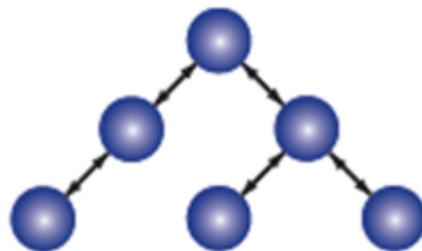
- Banner's Simple Wire Replacement product line provides flexible networks that are easy to set up without software. Setting up a basic point-to-point network is as easy as pairing a cell phone to a headset.

## ■ 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

# DXM Wireless Controller/Gateway (Edge Device)



## ■ DXM700, 1200, 1000, 100 or DXM150

- Wireless controller/gateway for Banner Wireless radio communication and local I/O or wired sensor communication
- Performance (star) network or MultiHop (tree) network topology
- Onboard wired I/O options, including universal inputs supporting analog / temp
- Modbus RS485 RTU Master and Slave communication ports
- Backup battery charging system (DXM100, DXM1000, and DXM150)
- On-board communications include Ethernet/IP, Modbus RTU(RS485), Modbus TCP, J1939 CAN(some models), and LTE/GSM cellular for PLC, SCADA, historian or cloud communications
- Cloud communications (ethernet or cellular) to BannerCDS.com or 3<sup>rd</sup> party cloud servers
- Fully customizable with action rules and scripting capability or use Banner's solutions for specific applications like vibration, tank level, temperature/humidity and more
- Locally trigger alarms based on immediate data, trended data, or math/logic rules
- Trigger email alerts and SMS alerts (some models)
- Advanced scheduler for event triggers
- On-board display allows for equipment setup as well as troubleshooting tools for communications connectivity, individual radio performance and sensor performance



DXM1200 IP67  
Enclosure



DXM1000



DXM700



DXM150



DXM100

# 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 DXM700 controller, 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



### Vibration Monitoring Solutions Kit

- Machine learning algorithm auto generates alert thresholds
- Performance or MultiHop
- Monitor up to 40 sensors per kit



### Tank Level Monitoring Solutions Kit

- Monitor up to 16 sensors per kit



### Temp & Humidity Monitoring Solutions Kit

- Monitor up to 40 sensors per kit



### Pressure Monitoring Solutions Kit

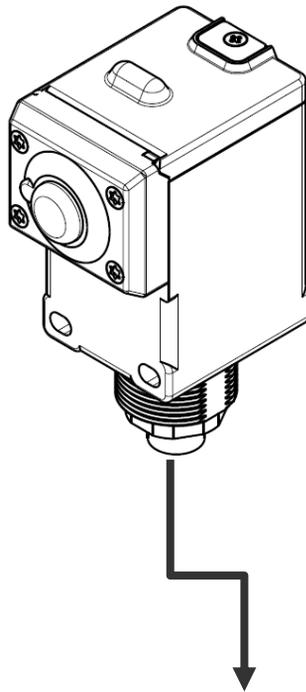
- Monitor up to 40 pressure sensors per kit

# Remote Radio for Sensor Connections (Performance Network Topology)



## DX80N\*Q45U/VTP/TH Node

- 1-wire serial interface
- Operates on two internal 3.6 V lithium batteries (2-3 years battery life)
- 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
- \*U represents universal for 1 wire serial sensors
- \*VTP represents vibration & temperature pre-configured
- \*TH represents temperature & humidity



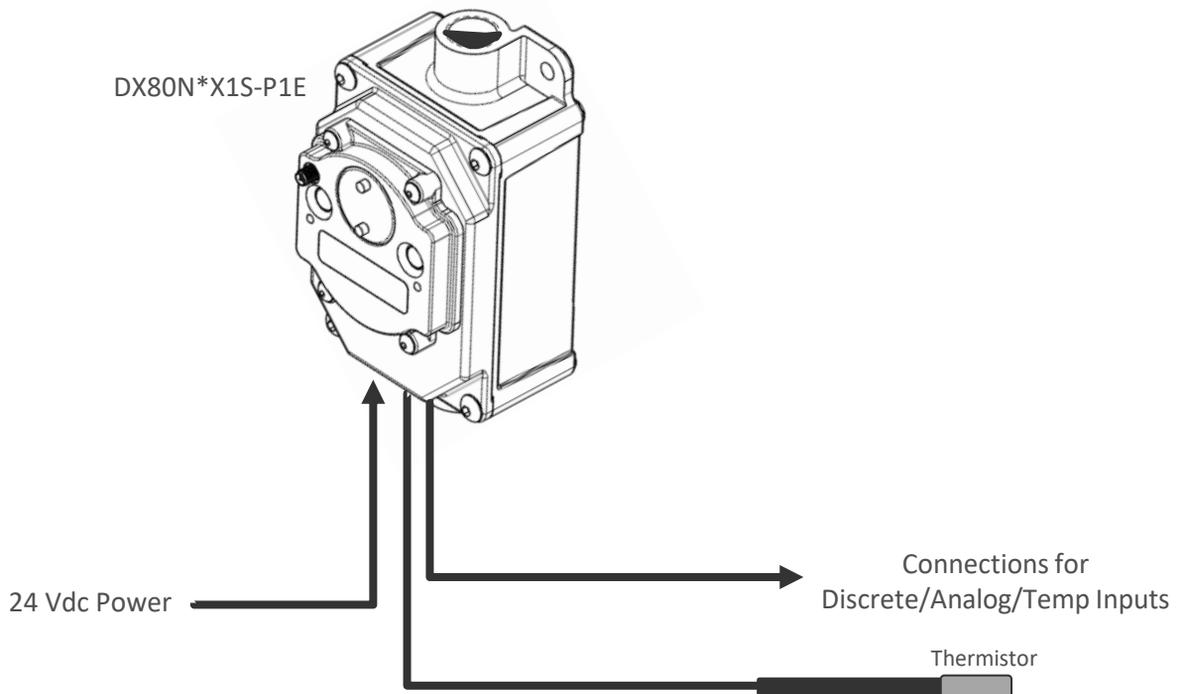
Connections for 1-wire serial sensor

# Remote Radio for Sensor Connections (Performance 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 (MultiHop Network Topology)

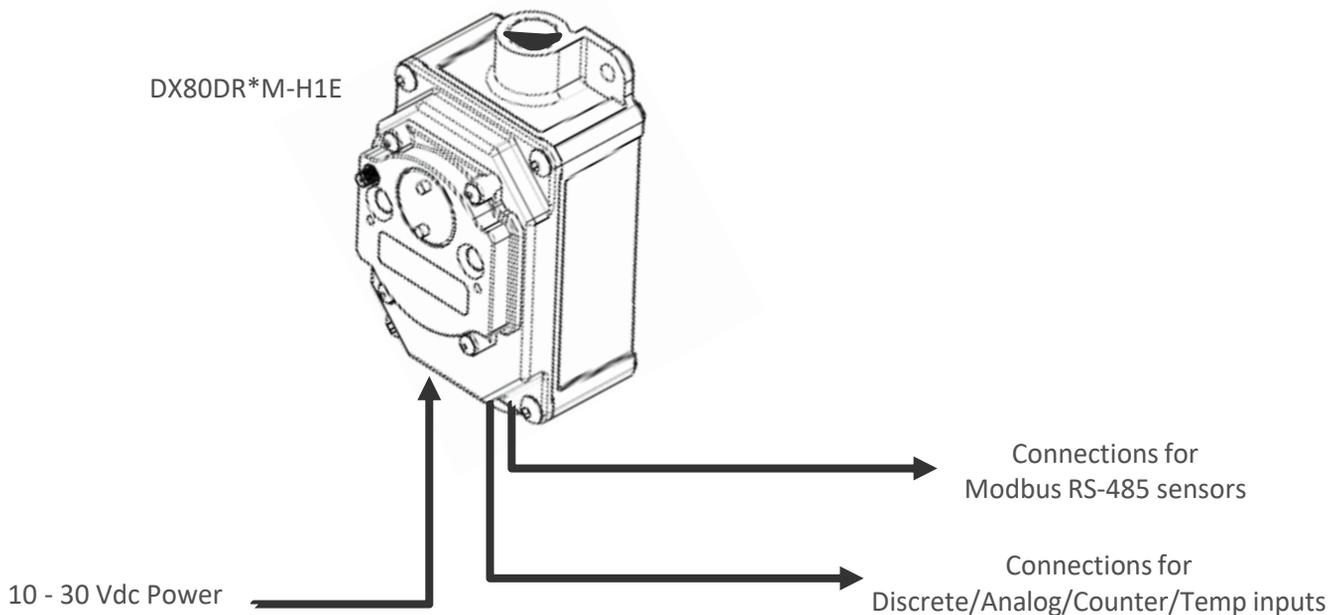


## DX80DR\*M-H1E Slave

- 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)

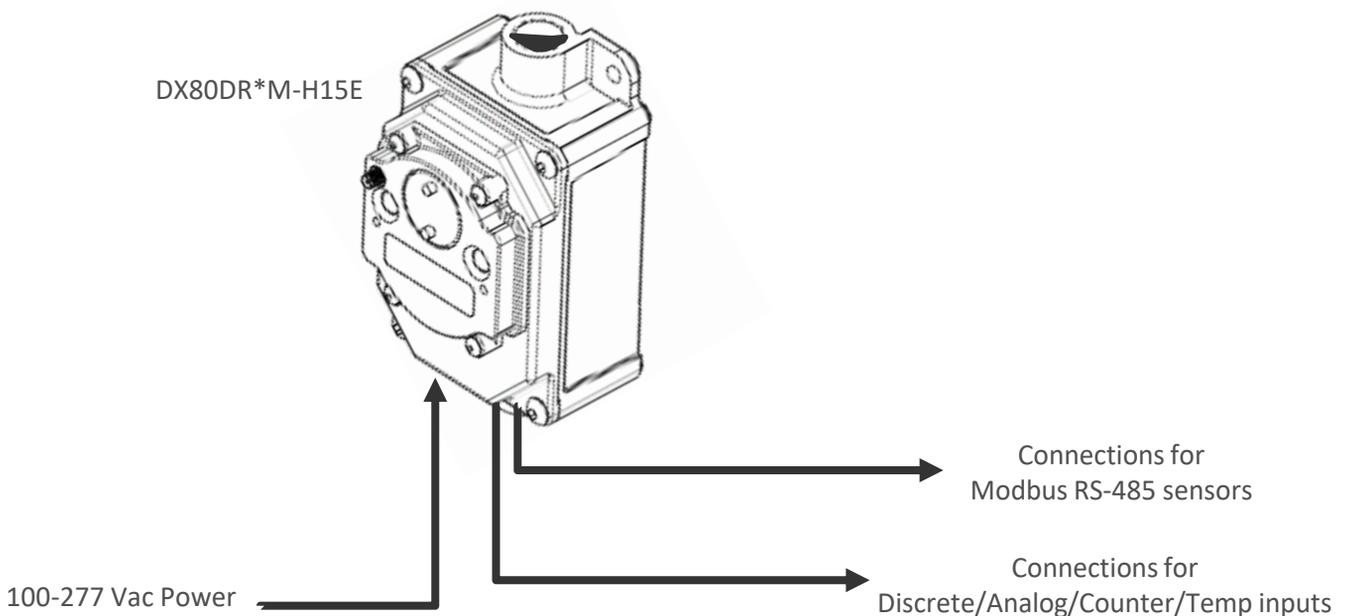


## DX80DR\*M-H15E Slave

- 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



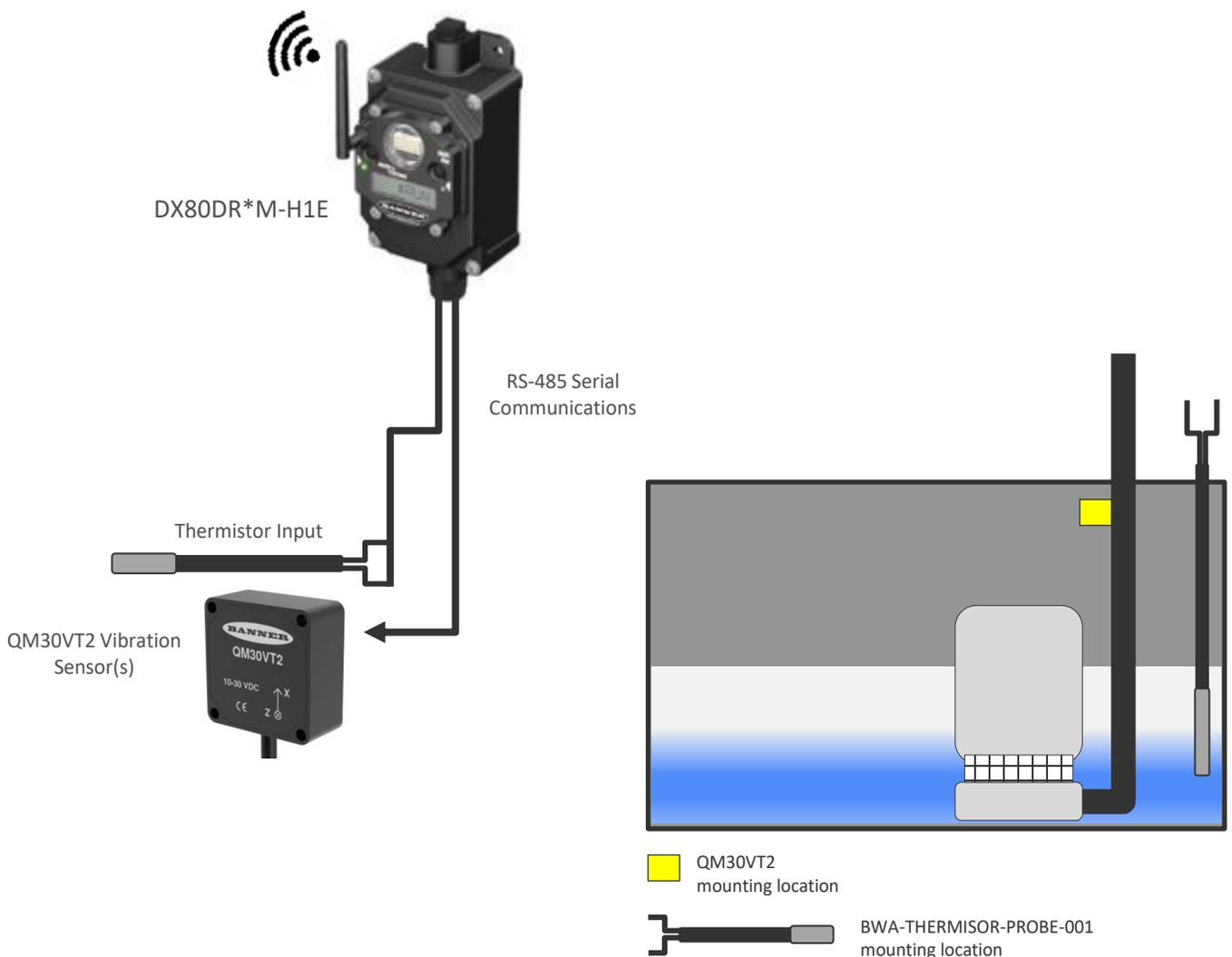
DX80DR\*M-H15E



# Application – Monitoring Coolant Recirc Pump (Automotive Plant)



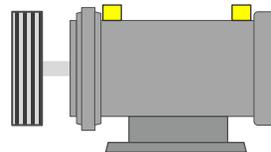
- CNC machining centers require continuously recirculated cutting fluids
- Monitor vibration and temperature of pump/motor assembly with the QM30VT\* sensor
- The vibration sensor will provide protection against plugged or deteriorating flow capabilities
- Monitor the temperature of the coolant with 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



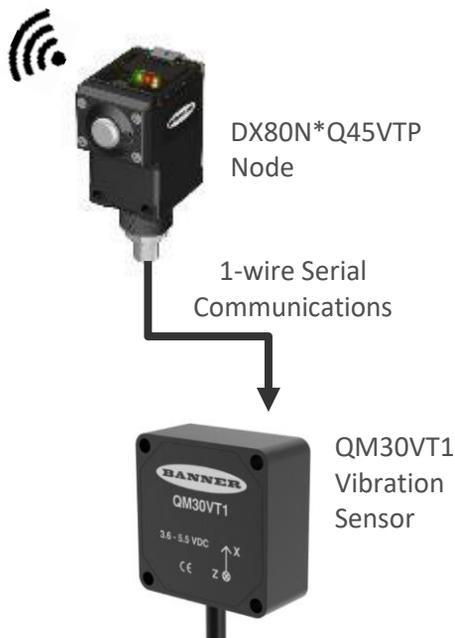
# Application – Monitoring Cooling Fans (Commercial Printer)



- 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
- QM30VT1 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



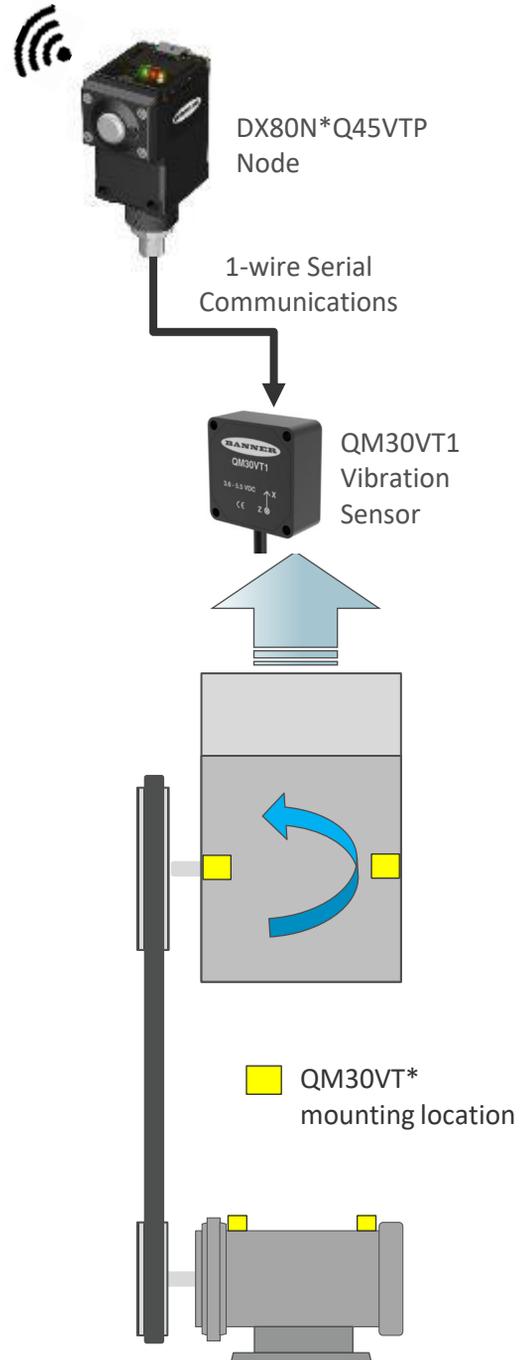
■ QM30VT1  
mounting locations



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



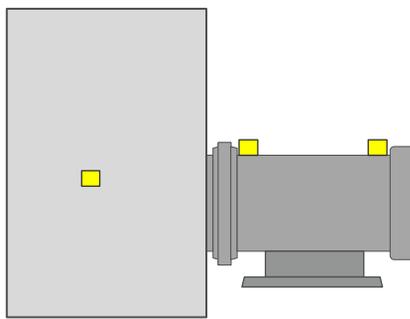
- Monitoring the vibration and temperature of bearings in the fans
- Early indication of issues on the motor or fan assembly bearings, misalignment



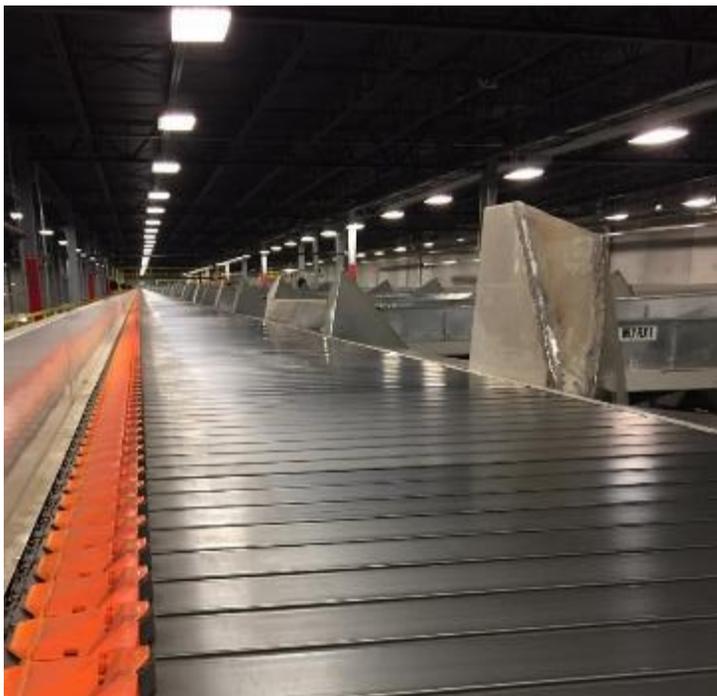
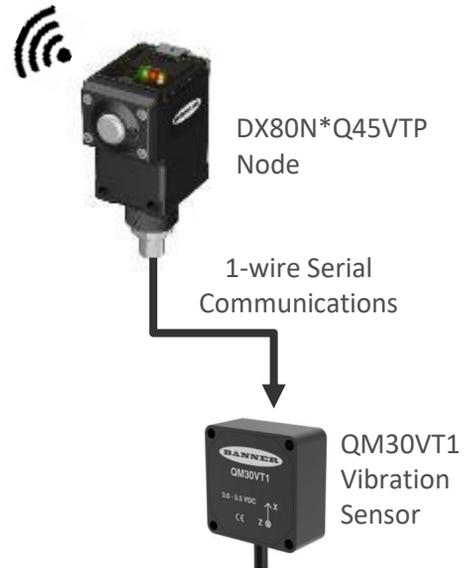
# Application – Monitoring Conveyor Motors and Gearboxes (Package Handler)



- 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
- QM30VT\* vibration sensor and RF node are magnetically mounted for ease of installation



■ QM30VT1 mounting locations



# Application – Monitoring CNC Cutting Fluid Tank Levels

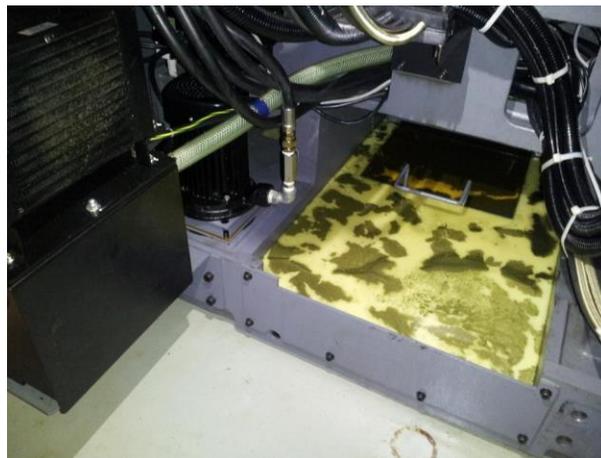


- A major supplier to the automotive industry needs to ensure that proper levels of cutting fluids are being maintained for their CNC machines
- Customer needed an easy to deploy tank level monitoring solution that can provide direct alerts to operators, support personnel, and supervisors
- K50U ultrasonic 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

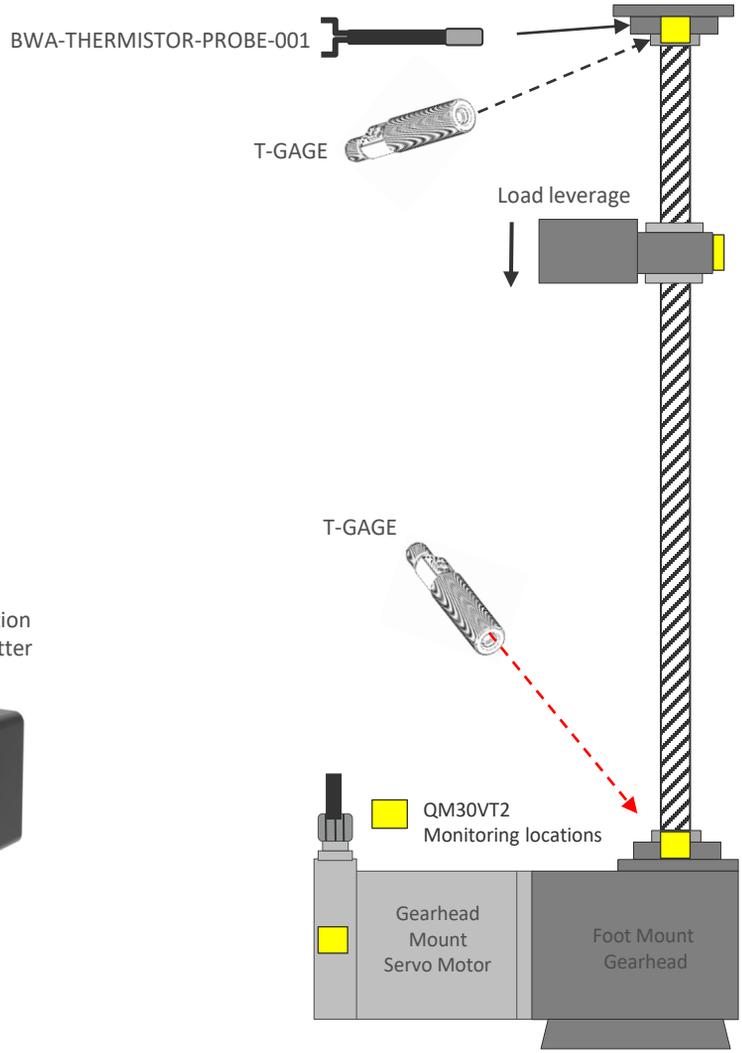
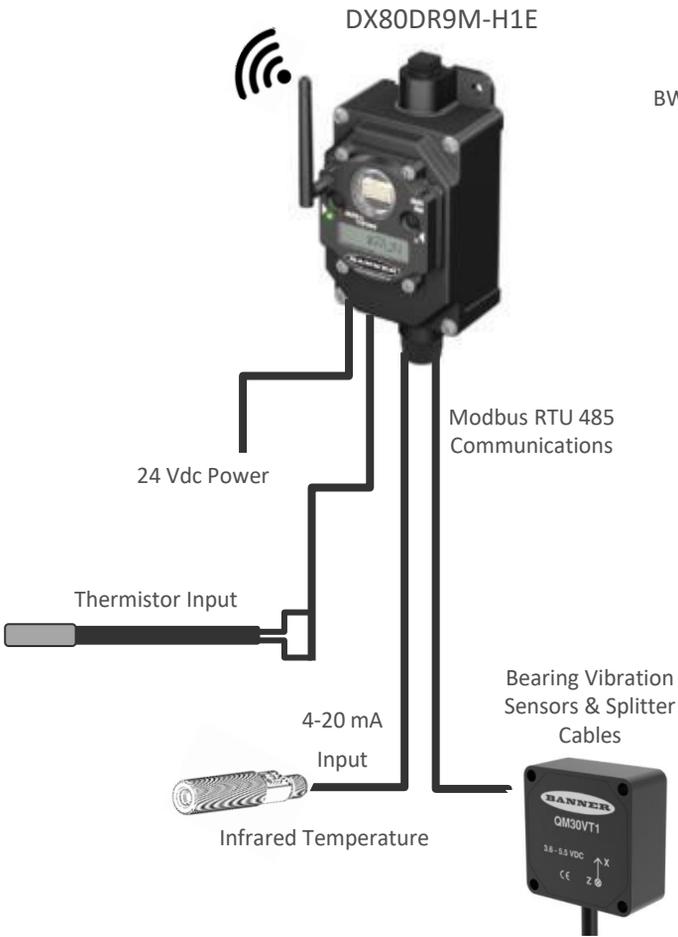
K50UX1\*RA +  
DX80N\*Q45U +  
BWA-BK-006



# 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 km 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 QM30VT\* 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 of vibration characteristics from 10-4000Hz.

### **Why does the QM30VT\* 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. RMS Velocity can be an indication of faults such as imbalance, looseness, misalignment and more

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

RMS is the Root-Mean-Square of the velocity. It is 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 QM30VT\* measure RMS velocity?**

The QM30VT1 and QM30VT2 sensors measure RMS velocity between 10 Hz and 1,000 Hz (1 KHz).

### **Why does the QM30VT\* measure high frequency acceleration?**

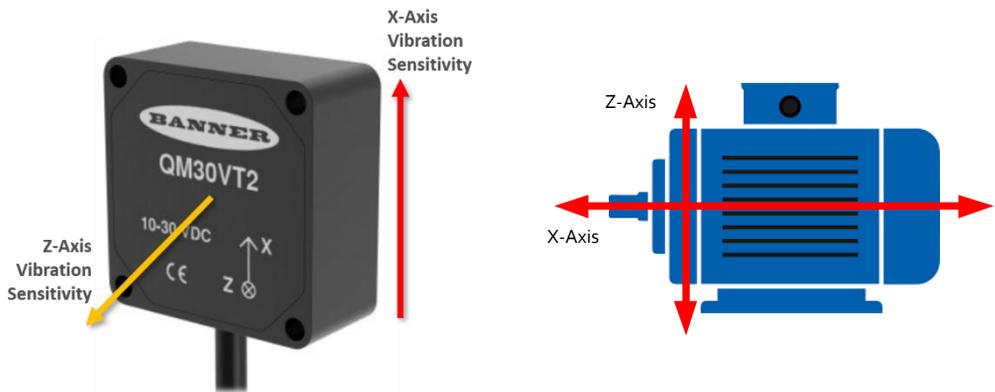
High frequency acceleration is measured within a filtered bandwidth of 1000-4000Hz and is used for indicating early bearing failure, high side gear mesh, and cavitation.

## Where should the QM30VT\* be mounted?

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

## In how many axes does the QM30VT\* measure vibration?

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



## How often does the QM30VT1 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 per axis.

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

Banner's Vibration Monitoring Solutions Kit or Solutions Guide uses a machine learning algorithm to baseline and auto generate warning and alarm thresholds for the key vibration characteristics.

The ISO 10816 Vibration Severity Chart (see datasheet) is another 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 QM30VT\*?**

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

### **Can the QM30VT\* housing withstand tough industrial environments?**

The QM30VT\* has a robust aluminum housing and is rated IP67 for demanding industrial environments. It is also available in a stainless steel IP69K construction.

### **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 QM30VT\* datasheets for details.

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

Yes, for the QM30VT1 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 QM30VT1 and the node?**

The cable that comes with the QM30VT\* 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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